



Mojave Desert Network I&M Program

Aspen Monitoring Protocol Implementation Plan

Standard Operating Procedures v 1.0



Mojave Desert Network I&M Program

Aspen Monitoring Protocol Implementation Plan for Great Basin National Park and Grand-Canyon Parashant National Monument

Standard Operating Procedures v 1.0

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ON THE COVER

Aspen (*Populus tremuloides*) stand in Grand-Canyon Parashant National Monument in October 2017.
Photo from Nicole Hupp, NPS.

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Background

This document provides detailed information on how to monitor aspen in two parks in the Mojave Desert Network Inventory & Monitoring Program, Great Basin National Park (GRBA) and Grand-Canyon Parashant National Monument (PARA). This Protocol Implementation Plan (PIP) adapts objectives, sampling design, and SOPs from the Upper Columbia Basin Network (UCBN) Aspen Monitoring Protocol Narrative and SOPs (Strand et al. 2009) to MOJN parks. These SOPs are difficult to fully understand without the accompanying narrative; while some of the main components of the protocol are included here, refer to the narrative for clarity and rationale.

Quaking aspen (*Populus tremuloides*, Michx.) is a species of interest for GRBA and PARA because of its biological, aesthetic, and cultural significance. Aspen clones are among the most biologically rich plant communities in the Intermountain West and act as a keystone species (Kay 1997). Aspen stands provide forage for wildlife and domestic livestock in western landscapes, and declining aspen habitats has been shown to result in losses of vertebrate species and vascular plants as well as invertebrates and nonvascular organisms (Campbell and Bartos 2001). Aspen is also an important attraction for campers, naturalists, and recreationists in the otherwise semi-arid landscapes of GRBA and PARA.

This document is a Protocol Implementation Plan (PIP) which, like a protocol, specifies a long-term monitoring program however, unlike a protocol, a PIP is based on an already existing protocol. This PIP adapts objectives, sampling design, standard operating procedures (SOPs), and other components from the Upper Columbia Basin Network (UCBN) Aspen Monitoring Protocol Narrative and SOPs (Strand et al. 2009) to MOJN parks. The methods outlined in this document have been tested and utilized in two parks in the UCBN (City of Rocks National Reserve and Craters of the Moon National Monument) since 2007 (Strand et al. 2009). However, climate conditions in GRBA and PARA are different than in the UCBN parks, as are the spatial distribution and accessibility of aspen stands. The Strand et al. (2009) protocol has been modified here to account for those differences.

The objectives of this PIP pursue broad ecological questions about the population ecology of aspen, such as the relationship between aspen regeneration and live and dead stem density, and trends in climate variables (e.g., annual precipitation, temperature, growing degree-days, snow pack) within the context of predicted climate change. Long-term monitoring data in GRBA and PARA will more broadly address the following fundamental questions that continue to drive inquiry of aspen population age structure and ecology in semi-arid ecosystems:

- Are the aspen populations stable, declining, or increasing?
- Are aspen clones regenerating and at what level? What is the long-term trend in regeneration of park aspen populations and in individual stands?
- What is the density of live and dead aspen stems? Is the live and dead stem density declining or increasing in the parks and in individual stands?
- What is the status and trend in conifer density within aspen stands?

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- What is the variability of regeneration in plots within an aspen stand and between different aspen stands?

In light of these questions and the broader goals outlined above, this protocol will address the following specific measurable monitoring objectives:

- Estimate status and long-term trend in regeneration of park aspen populations as well as individual stands within GRBA and PARA.
- Estimate status and trend in aspen abundance, as measured by stem density (in size classes) of size classed live and dead trees, within selected aspen stands.
- Estimate the status and trend in density of dead standing aspen stems by size class within selected aspen stands.
- Estimate the status and trend in conifer density by size class within selected aspen stands.

This PIP will use the same statistical sampling objectives developed for UCBN parks (Strand et al. 2009):

- Estimate with 90% confidence the mean, $\hat{\mu}$, within $\pm 25\%$ of the true mean, μ , for aspen stem density (stems/ha) of suckers, regeneration, mature trees, and dead stems.
- Detect with $>80\%$ certainty (power, or $1-\beta$) a change $\geq 25\%$ between any two sequential time periods (5 years) of mean aspen live or dead stem density estimates with a 0.10 acceptable false-change (α) error rate.

The standard operating procedures documented here and the methods described in the associated protocol narrative will be used to monitor aspen on a five-year revisit cycle, with one year of sampling in PARA, and three subsequent years in GRBA.

Standard Operating Procedure (SOP) 1: Preparation for the Field Season

Version 1.0

Revision History

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This SOP describes the step-by-step procedures to prepare for field work and organize field equipment prior to the start of the field season.

Annual Review

Preparation for the field season begins at the close-out of the previous season. Network and park staff will conduct an annual review of the protocol and SOPs prior to spring preparations. Staff will review training and field procedures, recruitment of participating field technicians, data management, analysis, and reporting, as well as fundamental design issues. Most importantly, the overall confidence in results should be carefully considered. The adequacy of sampling efforts must be evaluated. Any necessary changes should be made to the protocol and SOPs with enough time to circulate updated material to key staff.

Introduction and Procedures

Before the start of the field season, the Protocol Lead, Data Management Team, and/or Crew Lead must invest a few weeks in preparation. These preparations are broken into in three main steps: 1) Generating transect and plot locations with the project GIS; 2) Scheduling and organizing fieldwork; 3) Equipment preparation. Step 1 was completed at the time this protocol was created and does not need to be re-created. However, we included the steps here in case others may want to replicate this monitoring. Also, it is important for future field crews, Protocol Lead, or others to understand how the plots were generated before the protocol can be implemented.

Step 1: Generating Transect and Plot Locations in ArcGIS

The sample selection for the two parks, GRBA and PARA, is slightly different. In PARA, there was no suitable vegetation map at the time of plot selection (circa 2017) on which to base sample selection. Therefore, since there are few aspen stands in PARA, all stands large enough to sample are included in this protocol (8 stands total, described in Appendix C). We created polygons for these stands, and chose a random location in each of these stands to begin the transect (described in the steps below).

GRBA is approximately 27% aspen forest and is too extensive to census. Therefore, we employ a spatially balanced random sampling method using the Generalized Random Tessellation Stratification (GRTS) design (see Appendix A). GRTS is an algorithm developed by Stevens and Olsen (2004) used to select random locations with an unstructured, equal-probability, spatially balanced approach. This method is widely used in the NPS I&M Program because of its flexible, efficient, and statistically robust approach that accommodates many of the difficulties commonly encountered in field sampling. Most importantly, it allows sites to be rejected or replaced if needed. Using the GRTS method, plots were selected within aspen-dominated vegetation classes as defined in the GRBA vegetation map (Cogen et al. 2012).

The GRTS draw in GRBA and the random sample selection in PARA were conducted in 2017. These steps will not be completed at the start of every field season. However, since this process is the backbone of this monitoring protocol, this process should be reviewed and understood by all field personnel. We outline the procedures below for how we selected samples, in the event that it must be redone, expanded, or used again for another park.

Prior to sample selection, we mapped the aspen stands within GRBA and PARA, and verified those maps through field reconnaissance. The stand boundaries are stored in a geographic information system (GIS) in vector format (polygons), i.e., shapefiles.

The spatial data used or generated by this protocol are stored in the Universal Transverse Mercator (UTM) map projection, NAD83 datum, and zone 11 (GRBA) or zone 12 (PARA). A random sampling extension for ArcGIS must be installed prior to drawing samples. Hawth's Tools, available at the following url: <http://www.spatialecology.com/index.php> or the NPS AlaskaPak extension both offer flexible sampling tools <http://www.nps.gov/akso/gis/>.

Permanent transect locations for GRBA were generated via the procedure outlined below in 2017. Unless the monitoring protocol is modified, these points will be unchanged for each sampling period. These procedures will be used if new sets of randomly generated start points for transects must be created or if additional stands are added to the sampling frames. These procedures can also be followed to establish long term monitoring of aspen stands in other parks or areas.

- 1) Load the appropriate ArcMap project file (GRBAstandsyear.mxd or PARASTandsyear.mxd).
- 2) Select the target population polygon (e.g. MOJN_AspenStands_year.shp or MOJN_AspenStands_year.shp).
- 3) Open the random sampling tool extension and select to draw a sample for the selected features only. The number of random transect start locations is defined by the attribute Transects in the polygon boundary shapefiles for GRBA and PARA. Enforce a minimum distance of 25 m between points.
- 4) Name the output shapefile according to standard MOJN naming conventions (e.g., MOJN_AspenSamples_GRBAPopulationA_0410_2017.shp). Because only permanent monitoring plots are implemented as part of this monitoring protocol, these files will be very similar from year to

year. Update the projection file for this output file, and add UTM easting (X) and northing (Y) coordinates to each point.

5) Display the stand file boundary and the transect start locations in ArcMap. Each transect should contain four 4-m radius plots oriented in a bearing according to the shape of the stand. If possible, place the plots along the transect in the north-south or east-west direction. Orienting transects in the north-south or east-west direction is desirable because it makes it easier for the field staff to locate plots along transects where the easting or northing is constant along the transect. 4-m radius plots can be placed on either side of the transect start location generated in step 3 depending on the extent of the stand.

The XY coordinates for each plot location can be computed using trigonometric functions, see Figure 1.1 below.

Each plot along transects are numbered according to the following convention: S-T-P where S is the stand number, T is the transect number and P is the plot along the transect (usually but not always, there are four plots along the transect).

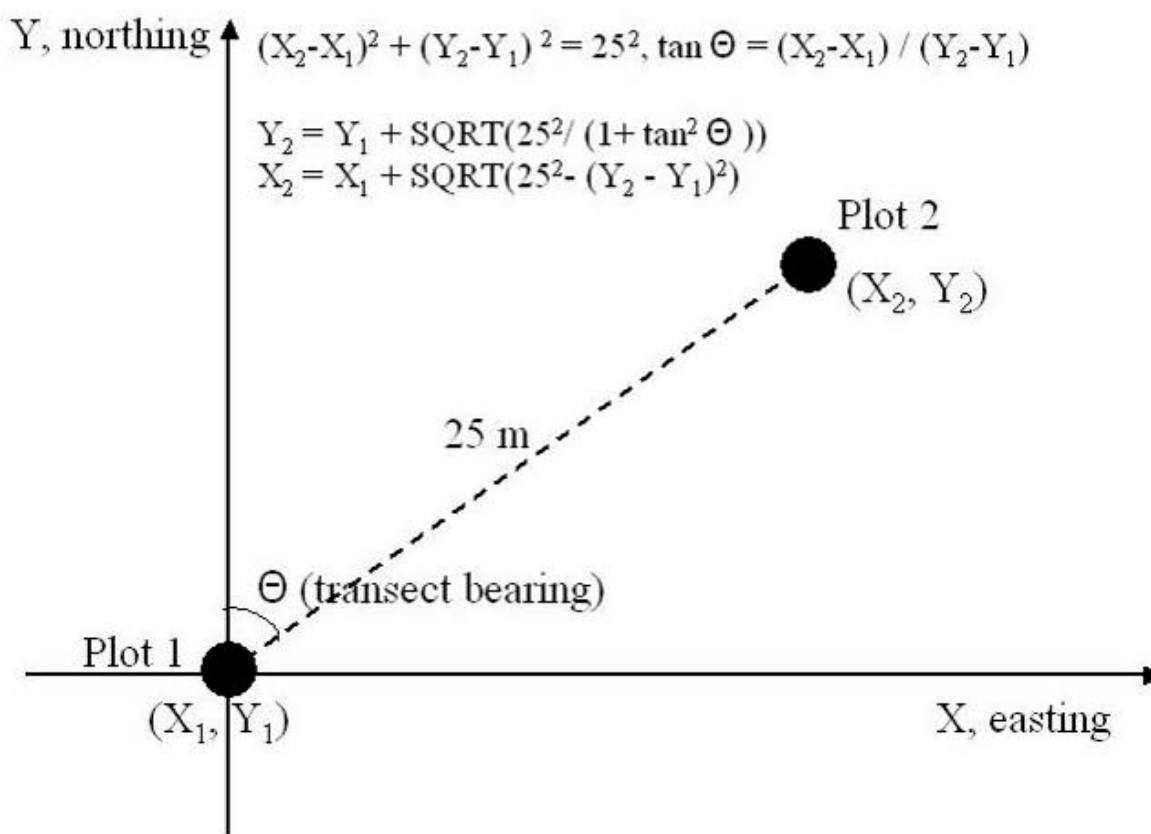


Figure 1.1. Illustration of how to compute the x and y coordinates for plots along a transect that is not oriented north-south or east-west.

6) Save the Excel spreadsheet with the plot coordinates. Open the spreadsheet in ArcMap. Display XY coordinates and save the file as a shapefile under the naming convention MOJN_AspenPlots_GRBA_2017.shp. Update the projection file for this output file, and add UTM easting (X) and northing (Y) coordinates to each point.

7) Export the coordinates for transect start locations and plot locations to a .dbf file. Import the file to Excel and print the coordinates to use in the field for establishment and relocation of permanent monuments.

8) Once permanent plots are established, make maps showing all transects and plots. Maps of all plot locations in PARA and GRBA are provided in Appendices C and D.

9) Finally, import the master sampling location list as a text file (extension .txt) to GPS waypoints following procedures outlined in the MOJN general *SOP Using Garmin 76CSx GPS Devices* (Lehman 2017).

Step 2: Scheduling and Organizing Field Work

The field portion of the aspen monitoring program may require permanent staff and hiring temporary or seasonal employees. Temporary employees must be hired well before the field season begins to undergo appropriate on-boarding and training. Fieldwork should be scheduled in early spring, and scheduling efforts should begin no later than the previous January/February. The Protocol Lead will coordinate this planning with the GRBA and PARA natural resource staff. A crew of three people working for two weeks each sampling season must be available in order to complete the field data collection.

If necessary, the Crew Lead or Protocol Lead will contact administrative staff at the GRBA or PARA to reserve a fee-waived campsite permit or backcountry camping permit for the duration of the trip.

The Protocol Lead will send a brief email to relevant park personnel with a reminder of the dates that field crews will be working in the park, the names of the field crewmembers, their vehicle descriptions and license plate numbers, as well as the locations of the stands, parking spots, and campsites that the field crews will be visiting.

Site Information Packet

Field crews will assemble site information packets for their field trips before the season begins. Though time consuming to create, these packets guide the entire week in the field and should be created carefully. Site information packets include:

1. Backcountry travel plan (see *Mojave Desert Network Inventory & Monitoring Field Safety Plan* [Tallent et al. 2017]) for each day of the trip
2. Driving and hiking route maps to each stand being visited
3. List of UTM coordinates for transect start locations, plots, and permanent photo points
4. Field data sheets (see Appendix B)
5. Emergency contact information, and the locations and phone numbers of local services, such as hospitals.

Equipment Preparation

The following equipment should be assembled each spring; allow sufficient time to order replacement equipment, particularly for items that are consumed each year, such as rebar caps, and field technology devices that require configuring, such as tablets. The amounts of individual items required are not included here, as they change according to the number of field participants and teams available. Use this list as a checklist before leaving the office for the field and before leaving the truck to hike to a stand!

Measuring Equipment

- Steel chaining pins (14” red and white painted)
- Logger’s tape
- Seamstress tape (can be purchased from a fabric supplier, hardware store, or most grocery stores, ensure that the tape is labeled in both English and metric scales.)
- Orienteering compass (1 per person)
- Clinometer (1 per person)
- Plant identification books
- Plant identification hand lenses or other tools for ID
- Laser range finder
- Digital camera
- 25 m meter tape

Navigation and Recording Equipment

- GPS unit with pre-loaded sampling location waypoints
- Tablet with data collection software (if used by this team)
- Weatherized field data sheets (Appendix B)
- Backup copies of field data sheets
- Mechanical pencils
- Write-in-the rain pens
- Clip boards
- Hard copies of relevant SOPs for field reference

Plot Establishment Field Equipment

- Digital camera
- Rebar 1.5 ft long, 1/2 in diameter (enough for each plot of each transect, plus spares)
- MOJN engraved aluminum caps to fit 1/2 in diameter rebar (enough for each plot of each transect, plus spares)
- Mallet for pounding in rebar
- Rebar cap imprint stamps

Safety Communication Devices

- inReach (make sure it is “checked out” to at least one field crewmember, and that the “check-ins” are going to appropriate parties)
- Satellite phone
- NPS hand-held radio

Miscellaneous Equipment

- Spare batteries for range finder, GPS, and camera
- 2 way radios for communication at large stands

- Tablet charger if using a tablet
- Charger for inReach
- Charger for Sat phone
- Spare vehicle keys
- Field notebook for notetaking

Preparation of Navigation and Field Data Management Equipment:

- 1) Pre-load GPS units with survey locations; pre-load an extra GPS unit to have a backup just in case of technology failure. For revisit years, download the known permanent transect locations. For plot establishment years, download the GRTS locations. Note that there will be more GRTS locations than actual numbers of plots; these are to use in case original plots must be rejected in the field. To upload locations onto the GPS unit, follow procedures outlined in MOJN general SOP *Using Garmin 76CSx GPS Devices* (Lehman 2017). [note: Instructions on how to select randomly generated points using the GRTS algorithm are described at the beginning of this SOP, and a digital text file (.txt or .dbf) created with the Stand ID, Transect ID, Plot IDs, transect azimuths, and UTM coordinates (UTM zone 11 in GRBA and zone 12 in PARA NAD83).]
- 2) Field data sheets should be revised and printed. Field Crews must consult the Protocol Lead and Data Management Team to ensure field data sheets are updated before printing. Print copies for each crew. Print some data sheets on Rite-in-the-Rain paper; print many on Rite-in-the-Rain if rain is likely to occur. A copy of the field data sheet is provided in Appendix B.
- 3) Charge all GPS units, tablets, digital cameras, and backup batteries prior to departure for the field.
- 4) Set the declination for the compasses. Each compass must be adjusted to account for magnetic declination, or magnetic variation, by adding approximately 11° E in PARA and 12° E in GRBA to the direction of “true” or grid north. The magnetic declination changes through time and the current declination can be estimated at the [National Oceanic and Atmospheric Administration](#). Orienteering-grade compass housings can be adjusted, usually by turning a small set screw, so that the fixed north arrow, usually inscribed on the bottom of the plastic housing points to 11 or 12° rather than 0°. This will ensure that when this fixed north arrow is aligned with the red end of the magnetic arrow, the compass directional arrow will actually point in the correct direction according to “true” or grid north.

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 5, Data Management, and SOP 6, Data Summary, Analysis, and Reporting. It is particularly important that adequacy of population boundaries and sampling effort has been considered, and any changes to sampling design have been made before new points are generated.
- 2) Prepare a realistic schedule of events in advance of group arrival, and circulate to crew leaders and organizers ahead of time to manage expectations and ensure timely arrival.
- 3) Apply for a research permit (<http://science.nature.nps.gov/research/ac/ResearchIndex>) well ahead of the field season, as early as February/March. Arrange with the staff at GRBA and PARA for your arrival and stay during the field season. The research cabins at PARA are usually available for MOJN research teams and campgrounds or housing can be reserved at GRBA.
- 4) *Mojave Desert Network Inventory & Monitoring Field Safety Plan* (Tallent et al 2017) should be reviewed before the field crew heads into the park.

- 5) Make sure all crew leaders know where vehicle keys are to be stored during field operations, the location of the nearest cellular phone coverage opportunity, and emergency contact and operation procedures for GRBA and PARA staff.

Standard Operating Procedure (SOP) 2: Training Observers and Plant Identification

Version 1.0

Revision History

Version #	Date of Revision	Revised By	Changes
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This SOP describes how to train crews to navigate with a compass, to record data, and how to ensure repeatability.

Procedures

Crew Organization

The Field Crew needs 2-4 personnel. Larger crew sizes are inefficient and require division into two. If two crews are hired, provide each crew with a complete set of measuring equipment, site information packets, navigation tools, and safety communication devices. Once the crew is established, maintain it throughout the duration of training and sampling in order to maintain consistency.

Safety

Safety procedures include formal and on-the-job training in communications devices, radio etiquette, and 4-wheel drive vehicles. New field crewmembers will read about previous incidents and accidents in the field that have been reported by the NPS and other agencies. They will discuss with their peers and supervisors the lessons learned from these incidents as well as specific hazards they may encounter while working in backcountry desert and mountainous environments.

Field Crewmembers must take a 16-hour wilderness first aid course, either through a certified organization (e.g., Red Cross, NOLS), or a crew of LAKE first responders. All staff and project participants are required to complete the 16-hour Operational Leadership course before participating in field activities, which covers situational awareness and good decision-making skills. A protocol readiness review and annual itinerary will be prepared and reviewed by the Protocol Lead and key park supervisory staff. For more information about safety procedures and training, refer to the *Mojave Desert Network Inventory & Monitoring Field Safety Plan* (Tallent et al. 2017).

Equipment Operation

- 1) Navigating to waypoints using Garmin 76CSx GPS units is described in detail in MOJN general SOP *Using Garmin 76CSx GPS Devices* (Lehman 2017). This document should be made available to crews and discussed as part field crew training. Sample location waypoints

should be uploaded to the unit at the beginning of the field season. This procedure is also described in the MOJN general SOP. Note that in the case of aspen monitoring it is not necessary to delete waypoints that are stored on the GPS unit at the end of the field season because all transect and plot locations are permanent and will be revisited during the next sampling season.

- 2) Compass use will be taught outside. Hold compasses flat, on an open palm, in front of and close to the user's body. To move the compass around for alignment of arrows and determination of a bearing, or azimuth, the user should move with the whole body rather than just the arm or hand. A simple mnemonic for using orienteering compasses is to "put red in the shed", where "red" is the magnetic arrow that always points to magnetic north, and the "shed" is the fixed north arrow inscribed on the bottom of the moveable housing (See Figure 2.1).



Figure 2.1. Compass displaying components used to find a bearing.

Once the "shed" is set to accommodate the magnetic declination and the "red" is in the "shed," the compass directional arrow that is inscribed on the outside of the compass housing along the end of the base plate will always point to a true bearing or azimuth. You should site line on an object ahead of you and walk towards the object. Transects should be oriented along the pre-assigned azimuth by turning the compass housing to the desired number, and then turning the body until "red is in the shed".

Field Operations

Before fieldwork begins, designate at least one full day of training, and a few days after that for very slow data collection days. Prioritize with crews the importance of consistency and ensure all crewmembers collect each piece of data in the same way. On the first day of training, and the slow-paced data collection days thereafter, follow the steps below.

- 1) Designate a lead trainer. This will typically be the Protocol Lead, if present, or the designated Field Lead. This person should be available to troubleshoot and reassign new equipment as needed.

- 2) Definitions for key field terms are presented in the following table (Table 2.1) and should be reviewed during training.

Table 2.1. Important field definitions for monitoring aspen in MOJN.

Term	Definition
Aspen sucker	An aspen stem shorter than 46 cm (1.5 ft) tall
Dead aspen	The dead stem must be standing or leaning and rooted in the soil. A stem will not be counted if lying on the ground.
“In” (for aspen or conifer stem)	The plant originates from the ground and is rooted with 50% or more of the basal stem area at the soil surface inside the plot; a plant is either in or out, never halfway. If less than 50% of the stem basal area at the soil surface is within the plot, then the plant is “out”.
Azimuth	Azimuth is the horizontal component of a compass direction. It is usually expressed in degrees.

- 3) Ensure all data collection techniques are taught to all crewmembers for consistency, even if crewmembers have done the same measurement before.
- 4) Ensure all personnel display competence using GPS navigation. If needed, teach GPS training in the field.
- 5) Review basic plant identification for local flora. All crewmembers must be very comfortable identifying the species of interest for this protocol, aspen and all conifer species (only some conifer species are included in this monitoring, yet crews must be able to tell those species from other conifers in the area). This training should include familiarizing crews with adult and juvenile individuals.
- 6) Practice locating transect start locations with GPS, maps, and compass.
- 7) Practice taking measurements and performing data entry (have extra field data sheets for this exercise).
 - a. The field crew will be trained in recording slope using a clinometer and laser range finder
- 8) Teach all field measurement operations outside. Every piece of data collected should be taught to all crewmembers, even if they have experience collecting data.
 - b. All crewmembers must be very comfortable determining aspect and angle bearings in the field since these are crucial skills for establishing and relocating plots. Practice relocating plots using a bearing.
- 9) **Emphasize clear communication practices between crewmembers during data entry.** All data recorders must repeat back to the observers each piece of data that is recorded to ensure there were no discrepancies.
- 10) Once crews are comfortable with basic operations, have them switch roles to re-measure the plots and compare results. If disparity is high, have groups repeat counting and observe closely how this is done. Identify sources of disparity. Have crewmembers pull up rebar and establish plots nearby and repeat calibration exercises. Aim for successive measurements within 5-10%. In stands where the stem count in certain aspen classes is low, miscounting one stem may lead to a large error percentage. Once this portion of training is complete, reassemble into the full group and review questions and concerns. Present the precision and reproducibility requirements at this time (RPD measurements). If the field crew breaks into two, each crew needs a crew leader who is comfortable and confident in the methods.

Plant Identification

The field crew will review plant keys and guides in the MOJN office prior to the start of the field season. To start, all crewmembers should review common plants found in GRBA and PARA in the MOJN plant guide *Common Herbaceous Plants of Great Basin National Park* (Mills 2017). In GRBA, *Flora of the North and South Snake Ranges* by Glenn Clifton (Clifton 2012) is a very useful unpublished plant ID key to assist plant identification. In addition to these two informal guides, plant naming should follow Jepson 2012.

Aspen National History



Figure 2.2. Aspen (*Populus tremuloides*). Photos: E.K. Strand

Family- Willow (Salicaceae): Aspen is a native tree 5-30 m high, but typically less than 15 m. Lateral **roots** may extend over 30 m and vertical sinker roots that may extend downward for nearly 3 m; the **bark** is typically smooth, greenish-white to gray-white, often thin and peeling, thicker and furrowed with age, especially toward the base. The tree crown is rounded and the **leaves** are simple, deciduous, broadly ovate to nearly round, 4–6 cm long, with small, rounded teeth on the margins. The **petiole** (attaches the leaf to the twig) is slender, flattened, and may vary in color from dark green and shiny above, pale green below, turning bright yellow, yellow-orange, gold, or reddish after the first frosts. The male (staminate) and female (pistillate) **flowers** are on separate trees (the species dioecious – or ‘polygamodioecious,’ because bisexual flowers may be produced at low frequencies on staminate and pistillate trees), each type of flower borne in pendent catkins. The **fruits** are narrowly ovoid to flask-shaped capsules 5-7 mm long, splitting to release the seeds; seeds ca.2 mm long, each with a tuft of long, white, silky hairs, easily blown by the wind. The common name is in reference to the shaking of the leaves in light wind.

Source: USDA NRCS National Plant Data Center & the Biota of North America Program, [available online](#).

Standard Operating Procedure (SOP) 3: Locating and Establishing Sampling Transects

Version 1.0

Revision History

Version #	Date of Revision	Revised By	Changes
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This SOP provides detailed driving directions from Boulder City, NV to GRBA and PARA, and directions to stands within the parks. At the end of this document in (Appendix D) there are 20 detailed maps of sampling all sampling locations within GRBA.

This SOP also describes the step-by-step procedures for locating and establishing permanent transects for purposes of long-term monitoring of aspen and conifer species.

Driving Directions to Parks

Accessing Great Basin National Park (GRBA)

From the MOJN I&M Office in Boulder City, NV, follow US-93 N for 280 miles. Turn right onto US-50E/US-6 E toward Baker, NV. Follow this for 30 miles. Turn right onto Lehman Caves Road in Baker, NV. There will be a sign indicating the Park entrance. This trip usually take about 5 hours.

Accessing Grand Canyon-Parashant National Monument (PARA)

From the MOJN Office in Boulder City, NV, follow US-93N for about 27 miles. Take the I-15 N exit towards Salt Lake City, and follow it for 115 miles. Take exit 2 in Utah for Southern Pkwy/UT-7 E, and follow for 3 miles. Take exit for River Road and turn right onto BLM Route 5/Mount Trumbull Loop. Follow this for about 50 miles, then turn left to stay on BLM 5, and follow for another 10 miles. This will put you at the Mt. Trumbull Cabins, a central location to all aspen worksites in the park. This trip usually takes about 6 hours.

Procedures for Establishing Transects

- 1) Field Crews will use pre-prepared site information packets (see SOP 1) to access plots. Follow the driving directions in the site information packets to the pre-determined parking locations.
- 2) Hike to the plot following the route specified on the site information packet. Use the GPS to access all plots, using a compass and maps as needed. For step-by-step GPS use, refer to the MOJN general SOP *Using Garmin 76CSx GPS Devices* (Lehman 2017)
- 3) Once the GPS unit registers “zero” distance to the waypoint or otherwise indicates the point has been reached. At this point, be very wary of introducing sampling bias (remember that

randomness is a key element of statistical power). It is crucial that navigators ignore the vegetation and rely on the GPS unit in order to eliminate selection bias.

- 4) Once at the point, gently toss a pin flag over your shoulder. Where it lands is the point. Stick the pin flag in the ground.
- 5) At this point, the crew can find a spot to put backpacks and prepare to survey. To reduce trampling, ensure that the Field Crew doesn't lounge within the plot.
 - a. Exceptions: If it is not clear that all four plots of the north-south transect will fit in the stand, assess the stand before installing rebar. Hike around the stand to its furthest extents to determine if the transect can fit. If needed, pull out the meter tape 75 m. If the 75 m north-south oriented transect won't be contained in the stand, refer to the offsetting procedures below.
- 6) Once the Field Crew feels confident the transect will fit in the stand, establish a monument. Drive the 1.5 ft rebar into the ground (using a mallet) and place a pre-stamped aluminum cap on the rebar. This marks the center of the plot.
 - a. Exceptions: If the rebar will not sink into the ground, if the slope is talus, or if a plot lands on a large boulder, create a small cairn to denote the plot. If the rebar cannot be sunk in the ground, take a photo of the location; ensure that the plot marker is in the photo and attempt to include other major features if possible (e.g. a very large tree, a ridge in the background, features that look as though they will stick around for at least a few years). Make it easy on future crews by documenting plots that cannot be monumented with rebar.
- 7) Once the first plot has been established, install the next three plots along the transect. The transect, unless offset procedures are required, is oriented north-south. Using a compass set the bearing to 0 degrees and measure out 25 meters in precisely that direction.
 - a. One field crewmember must stand at plot center, while another pulls out the meter tape. The third field person should help direct the orientation and direct the meter tap if it snags.
- 8) Once the next plot has been established, record the plot location using a high accuracy GPS. After the location has been recorded, have a second observer double check the location data to ensure there are no errors.
- 9) Continue steps 6 to 8 until all four plots are established.

Procedures for Locating Established Transects

- 1) Field Crews will use pre-prepared site information packets (see SOP 1) to aid in driving directions to parking locations, as well as hiking navigation to stands.
- 2) Ensure that you are navigating to the correct point, according to the Stand, Transect and Plot ID and have all plot establishment supplies packed before heading to the plot.
- 3) Following the site information packets, navigate to the plot using a GPS to navigate to waypoints (go through the steps outlined in the MOJN general SOP *Using Garmin 76CSx GPS Devices*; Lehman 2017).
- 4) Once the GPS location is within 15 m, look for the rebar with the aluminum MOJN cap, or a cairn if the slope is talus. It may be buried under debris. For particularly hard to find rebar markers, previous crews may have taken photos to assist future crews in relocating the plot; check the photos from previous years if necessary.

Collecting General Transect Data

Data that describes the area where the transect is located is collected in both establishment years and in revisit years. Record the data listed below every year that data are collected.

- 1) At Plot #1, collect the transect characteristics information on the datasheet including the stand number (site #), aspect, slope, elevation, NAD (should be NAD83) on the field sheet if this is a new site.
 - a. Record aspect by holding the compass in front of you and then face towards the down-slope in the direction that water would drain if falling on the ground. The aspect is the azimuth in which the red compass arrow is pointing when you hold the compass in front of you and face down slope.
 - b. Record slope using a clinometer or a laser range finder. This information is only recorded in the first plot in each aspen stand.
- 2) Stand height is recorded at each plot (not just plot 1). To record stand height, use the laser range finder to record the tallest tree in the plot.

Procedures for Offsetting Transects

Aspen monitoring in PARA has a slightly different approach than monitoring at GRBA. Since the stands in PARA are small (500 m² to 45,000 m²) and less dense than that of GRBA, each stand has 0-2 transects (refer to Appendix C). To establish a transect at the PARA stands, crews should navigate to the random pre-determined point (refer to Appendix C). In the field, if that point does not fall in the stand, or if the transect will not fit entirely in the stand based on where the random point is located, the point must be "offset". To offset the point, crews move to the closest suitable location (up to 200 m from the original location) in any direction so that the point is located within the stand of interest, and the entire 100 m transect will be included in the aspen stand. If the observer cannot move the point less than 200 m and be able to locate the entire transect in the stand, then they can "bend". To bend the transect, the crew establishes an "L" shaped transect, instead of one that is a straight line. When bending the transect occurs, the crew must detail precisely which plots are located perpendicular to the rest of the transect.

Standard Operating Procedure (SOP) 4: Measuring Vegetation along Transects

Version 1.0

Revision History

Version #	Date of Revision	Revised By	Changes

This SOP describes how to measure the vegetation in plots. Primarily, this describes how to count the stem density of aspen and conifers within the plots. Instructions for data entry and repeatability are also provided.

Procedures

- 1) Follow SOP 3 to establish the transect. At Plot #1, begin collecting the vegetation data. This requires a data recorder and one or two observers.
- 2) Thread the end loop of the logger's tape over the red and white striped survey pin and anchor the pin in the center of the first plot near the yellow MOJN cap (Figure 33). One crew-member extends the tape at least 4 m away from the plot center in any direction. Note the starting point in the circular plot so trees are not counted twice.
- 3) Count the number of aspen and conifer stems within pre-determined size classes that are rooted within, or have 50% or more of the stem basal area at the soil level within, the 4-m radius plot (Table 4.1). Conifer plants shorter than 15 cm above ground are not counted. Dead stems that are lying on the ground are not counted. Dead stems that are leaning or otherwise partially standing are counted if they are rooted, or if they comprise 50% or more of the stem basal area at the soil level, in the plot.

Table 4.1. Important size classes of aspen and conifers.

Class	Description
Class I	Suckers or seedlings $\leq$ 46 cm (1.5 ft) tall. Conifer seedlings shorter than 15 cm (6 inches) are not counted due to uncertainty in survival
Class II	Suckers or seedlings $\leq$ 46 - 152 cm (1.5-5 ft) tall
Class III	Greater than 152 cm (5 ft) and up to 2.5 cm (1 inch) in dbh (diameter at breast height)
Class IV	Greater than 2.5 cm (1 inch) in dbh and shorter than 75% of the stand height
Class V	Greater than 2.5 cm (1 inch) in dbh and taller than 75% of the stand height
Class VI	Dead stems $\geq$ 2.5 cm (1 inch) in dbh

- 4) The recorder enters stem count data into the field sheet during or immediately after completion of the count, and before proceeding on to other measurement activities. Refer to SOP 2 for instructions on clear communication between the data recorder and other crewmembers.
- 5) Check data after measuring each plot, including stand, transect, and plot ID of each plot, before moving on to the next plot.
- 6) Once the total aspen and conifer stem counts are complete and entered into the field sheet, use the GPS unit to locate the plot center for the next plot along the transect 25 m away from the previous plot center in the azimuth identified for that particular stand and transect. Preliminary locations for the first plot in each transect generated by the GRTS draw process are listed for GRBA in Appendix 1. The sample locations within the 8 selected stands for PARA are in Appendix 2.
- 7) Repeat vegetation measurements as outlined in steps 2-5 until all plots in the transect are measured and recorded in the field data sheet or tablet, if used.
- 8) When all transects in the stand are completed, go to the location from which the distance photo of the stand is taken. If this is a new stand, move to a location where you have a good view of the entire stand and take a digital photograph. Record the XY coordinates from where the distance photo was taken on the field data sheet. Record the azimuth of the photo, i.e. the compass direction the camera was facing while the photo was taken. It is helpful to bring a hard copy of the distance photos from previous years to the field to help line up the camera and zoom to capture the same extent as in previous year's photos. These photos should be available in previous years' annual reports.
- 9) Quantifying the precision and repeatability of transect measurements is important for long-term assessment of data quality. Make duplicate counts of aspen and conifer periodically during sampling in order to provide estimates of precision, reproducibility, and measurement error.
 - a. Specifically, each field crew must independently assess relative percent difference (RPD) on 10% of the transects. Transects chosen for RPD estimation will include some from the early, middle, and late periods of the sampling period. Crew leaders should determine which transects to conduct an RPD measurement on according to general pace and workflow, as well as transect suitability. Transects where some aspen size classes are completely absent are not suitable for RPD. Duplicate values will be recorded in the field sheet, mark the plots RPD.

Standard Operating Procedure (SOP) 5: Data Management

Version 1.0

Revision History

Version #	Date of Revision	Revised By	Changes
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This SOP describes the data management procedures used for the data collected during aspen monitoring. The database model is described in detail, including definitions of all input and computed data fields. Procedures for data certification, data archiving, QA/QC, and handling of sensitive information are provided. A list of the yearly aspen monitoring data management tasks is included, including timing for execution of various data management steps.

Data Collection

Collecting and managing data

Data collected in the field will be recorded on paper datasheets until an electronic data collecting system is deemed practical. To minimize potential ambiguity of field sheets, MOJN has established handwriting best practices that are summarized in Table 5.1.

Before leaving a stand, the Crew Lead is responsible for ensuring that all field sheets have been filled out completely and that the information on each form is logical and legible. Upon returning from each field trip, datasheets will be filed in the incoming data file cabinet. After data have been entered into the database, the field sheets will be scanned to 300 dpi or greater PDF files. When retroactive changes are made to paper datasheets, they must be re-scanned. The Protocol Lead is responsible for safekeeping and organization of the datasheets until data entry and verification procedures have been completed, at which point the datasheets are stored, and eventually archived, by the Network Data Manager.

Table 5.1. Handwriting best practices.

Description	Correct Method
Use a line through the 7	7
Use a line through the 0 (zero)	0
Single line through mistakes Never erase Never scribble out	~~Brito~~ BRTO
Never use "ditto" marks	Line with arrow through the column or row where data is repeated
Clear distinction between P and D	P D
Date format	mm/dd/yyyy
Time format	24 hour, hh:mm (e.g. 13:00)
Fill in every field	use a line through it or N/A (not applicable)
Decimal points	Points should be distinct and unmistakable for commas or dashes
Park or Park Code is always four alpha characters	DEVA, GRBA, JOTR, LAKE, MANZ, MOJA, PARA

Importing and managing photographs

To import photographs from a MOJN camera memory card, insert the card into a USB card reader and plug the reader into a computer that has access to the MOJN shared drive (M:\). Open Windows Explorer and navigate to the memory card. Run the script titled TransferPhotos.bat and follow the prompts. For devices without a memory card (e.g. phone camera) or memory cards without the TransferPhotos.bat script, consult the Data Management team.

All incoming photos must be stored in M:\MONITORING_FieldPhotoOriginals_DoNotModify. The photos in this folder are organized by memory card ID and date and should never be renamed or edited. Aspen monitoring photos should be copied into M:\MONITORING\Aspen\Data\Images and organized by park, at which point they may be renamed according to the following convention:

StandID_YYYYMMDD_description

Where *StandID* is the unique stand ID code. This code includes the four-letter park code, a letter indicating the protocol ("A" for aspen), and either a 3-digit number indicating the GRTS number of the stand (GRBA stands) or a 3-letter code indicating the stand name (PARA stands).

The *description* should adhere to the following standard, where ##### is a four-digit number corresponding to the last four digits of the original photo filename:

Repeat Photos

REPEAT_####

Stand Rejection Photos

REJECT_####

Project File Storage Conventions

All of the files associated with the development and implementation of this protocol will be stored on the MOJN server under the folder \Monitoring\Aspen.

The Aspen folder will contain at a minimum the following folders:

- **Analyses** (Contains R scripts and results)
- **Data**
 - **Database** (Contains the database front-end, current backend, and backups of previous database versions)
 - **FieldData** (Contains a scan of all field data sheets grouped in folders by park and field season.)
 - **Images** (Contains all photographs taken at a site grouped in folders by park and field season.)
- **Implementation**
 - **FieldDataForms** (Contains blank field data sheets and lookup code “cheat sheets”)
 - **GIS_Basedata** (Contains spatial data for navigation and simple map making)
 - **SitePackets** (Contains a Word file for each spring including navigation waypoints and a map with the suggested access route)
- **ProjectFiles**
 - **Permits** (Contains copies of permits for conducting field work)
 - **Protocol** (Contains folders for the published protocol narrative and SOPs, draft revisions of the narrative and SOPs, and files documenting the protocol development process)
 - **SampleDesign** (Contains files specific to the GRTS draw)
- **Reports** (Contains data and trends reports)

Other parts of this SOP will contain additional information on required file naming procedures that are specific to this protocol. Where file naming procedures are not defined, it should be assumed the MOJN general SOP “MOJN File Naming Conventions” is applicable.

Database Design

The MOJN database is a local copy of the Microsoft Access database used by UCBN for their aspen monitoring data. The database structure conforms to the standards of version 3.2 of the Natural Resource Database Template (NRDT), and 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 aspen data tables). While UCBN uses an integrated data dictionary database file (holding various lookup tables shared across all UCBN protocols) and an integrated species database file (holding UCBN species data, from the NPSpecies database, also shared across all UCBN protocols), MOJN will store these tables directly in the Aspen back-end database. UCBN-specific components of the database such as lookup tables may be updated with information relevant to MOJN. The database will track the quality control and quality assurance process (data processing level) that has been applied to each site visit. A data model for the aspen monitoring database shows the relationships among the core data tables, lookup tables, and cross reference tables.

Data Dictionary

The following data dictionary provides a table description for every table contained in the database back-end file and, for each table, provides each field name, the field type, the field size, and the field description (Tables 5.3-5.19).

Table 5.3. (tbl_Sites) Table stores descriptive data for sites. Sites are aspen stands in which sampling transects occur. Linked 1:Many to tbl_Transects, and linked to descriptive Site tables.

Field Name	Field Type	Size	Field Description
Site_ID	ReplicationID	16	Primary key, uniquely identifying each tbl_Sites record
GIS_Location_ID	ReplicationID	16	Link to GIS feature, if applicable
Site_Name	Text	50	Unique name for a site (constructed from UnitCode and SiteNumber)
Site_Number	Long Integer	4	Site number (sequential for aspen stands within a Park)
Site_Desc	Text	255	Description for a site, if applicable
Unit_Code	Text	12	Park unit code (Park or Park sub-unit code)
Site_Notes	Text	255	General notes on the site, if applicable

Table 5.4. (tbl_Site_Details) Table stores topographic data about sites (aspen stands), and includes the date and location (sampling plot) of data collection. Linked Many:1 to tbl_Sites.

Field Name	Field Type	Size	Field Description
SiteDetails_ID	ReplicationID	16	Primary key, uniquely identifying each tbl_Site_Details record
Site_ID	ReplicationID	16	Link to tbl_Sites (foreign key)
Aspect_Deg	Long Integer	4	Aspect (in degrees). Typically measured at first plot of first transect, at first Site visit only.
Slope_Perc	Long Integer	4	Slope (as percent). Typically measured at first plot of first transect, at first Site visit only.
Elevation_m	Long Integer	4	Elevation (in meters). Typically measured at first plot of first transect, at first Site visit only.
Measure_Date	Date/Time	10	Date of Site (aspen stand) measurements
Measure_Loc	Text	150	Location of Site measurements (default is first plot [1_1] of first transect)

Table 5.5. (tbl_Site_Height) Table stores canopy height data for sites (aspen stands), and includes the date and location (sampling plot) of data collection. Linked Many:1 to tbl_Sites.

Field Name	Field Type	Size	Field Description
SiteHeight_ID	ReplicationID	16	Primary key, uniquely identifying each tbl_Site_Height record
Site_ID	ReplicationID	16	Link to tbl_Sites (foreign key)
Height_m	Long Integer	4	Height of stand canopy (meters). Typically measured at first plot of first transect; measured at each Site visit.
Height_Plot	Text	50	Plot at which Height was measured. (Default = Plot 1_1 for Site)
Height_Date	Date/Time	10	Date on which Height was measured

Table 5.6. (tbl_Site_Notes) Table stores notes on sites (aspen stands), and includes a date field. Linked Many:1 to tbl_Sites.

Field Name	Field Type	Size	Field Description
SiteNotes_ID	ReplicationID	16	Primary key, uniquely identifying each tbl_Site_Notes record
Site_ID	ReplicationID	16	Link to tbl_Sites (foreign key)
Site_Notes	Text	255	Notes on general conditions/observations for Site (aspen stand)
Site_Note_Date	Date/Time	10	Date on which Site Notes recorded

Table 5.7. (tbl_Site_StandImg) Table stores photo image data for sites (aspen stands), and includes image file details, coordinates of point from which image taken, and a date field. Linked Many:1 to tbl_Sites.

Field Name	Field Type	Size	Field Description
SiteImg_ID	ReplicationID	16	Primary key, uniquely identifying each tbl_Site_StandImg record
Site_ID	ReplicationID	16	Link to tbl_Sites (foreign key)
St_Img_Number	Text	50	Stand Photo Number, if applicable
St_Img_File_Name	Text	255	Name of Stand Photo file. Park_Stand_Date (where Date in yyyyymmdd format)
St_Img_File_Path	Text	255	File location Path of Stand Photo file
St_Img_Bear_deg	Long Integer	4	Bearing (in degrees) on which Stand Photo taken
X_Coord_ImgLoc	Double	8	X coordinate of location from which Stand Image taken
Y_Coord_ImgLoc	Double	8	Y coordinate of location from which Stand Image taken
Coord_Units_ImgLoc	Text	10	Coordinate distance units (e.g., meters)
Coord_Sys_ImgLoc	Text	50	Coordinate system
GPS_Unit	Text	80	GPS unit used to collect Stand Image Location coordinates
Datum	Text	50	Datum of mapping ellipsoid
UTM_Zone	Text	50	UTM Zone
Est_H_Error_m	Single	8	Estimated horizontal accuracy in meters
St_Img_Date	Date/Time	10	Date on which Stand Photo taken
St_Img_Notes	Text	255	Notes regarding Stand Photo, if applicable

Table 5.8. (tbl_Transects) Table stores descriptive data for transects. Transects occur within sites (aspen stands), and include plots where tree data is collected. Linked 1:Many to tbl_Locations, and Many:1 to tbl_Sites.

Field Name	Field Type	Size	Field Description
Transect_ID	ReplicationID	16	Primary key, uniquely identifying each tbl_Transects record
Site_ID	ReplicationID	16	Link to tbl_Sites (foreign key)
Tran_Number	Long Integer	4	Transect Number (sequential for given Site)
Tran_Name	Text	50	Transect Name (constructed from SiteName [tbl_Sites] and TranNumber)
Tran_Bear_deg	Long Integer	4	Bearing (in degrees) along which Transect is established
Transect_Notes	Text	255	Notes on Transect, if applicable

Table 5.9. (tbl_Locations) Table stores sampling Location data. Locations are Plots along Transects within Sites (aspen stands). Tree data is collected at Locations. Linked 1:Many to tbl_Events, and Many:1 to tbl_Transects.

Field Name	Field Type	Size	Field Description
Location_ID	ReplicationID	16	Primary key, uniquely identifying each tbl_Locations record
Site_ID	ReplicationID	16	Link to tbl_Sites (foreign key)
GIS_Location_ID	ReplicationID	16	Link to GIS feature, if applicable
Meta_MID	ReplicationID	16	Link to Metadata record
X_Coord	Double	8	X coordinate of Plot
Y_Coord	Double	8	Y coordinate of Plot
Coord_Units	Text	10	Coordinate distance units (e.g., meters)
Coord_System	Text	50	Coordinate system
UTM_Zone	Text	50	UTM Zone
Datum	Text	50	Datum of mapping ellipsoid
Est_H_Error_m	Single	8	Estimated horizontal accuracy in meters
Accuracy_Notes	Text	255	Positional accuracy notes, if applicable
GPS_Unit	Text	80	GPS unit used to collect Location coordinates, if applicable
Loc_Name	Text	80	Name of the location (constructed from TransectName [tbl_Transects] and LocNumber)
Loc_Number	Long Integer	4	Location (Plot) number
Updated_Date	Date/Time	10	Date of entry or last change
Loc_Notes	Text	255	General notes on the location, if applicable

Table 5.10. (tbl_Events) Table stores sampling event data. Linked Many:1 to tbl_Locations, and linked to all field data tables (plot trees and ground cover data).

Field Name	Field Type	Size	Field Description
Event_ID	ReplicationID	16	Primary key, uniquely identifying each tbl_Events record
Location_ID	ReplicationID	16	Link to tbl_Locations (foreign key)
ProtoVer_ID	Text	10	Link to tlu_Protocol_Ver (indicates the Protocol version in use at time of Event)
Start_Date	Date/Time	10	Date of sampling Event
Start_Time	Date/Time	6	Start time (24 hour format) of sampling Event
End_Time	Date/Time	6	End time (24 hour format) of sampling Event
Event_Notes	Text	255	Event notes (Plot-specific notes recorded during Event)
PlotType	Text	50	Type of Plot (default = circular)
PlotSize_m	Long Integer	4	Plot Size (meters) - default is 4m.
RepeatSamp	Yes/No	4	Does this Event represent a Repeat Sample?

Table 5.11. (xref_Event_Contacts) Cross-reference table between tbl_Events and tlu_Contacts (stored in UCBN_Data_Dictionary backend file), allowing one or more contact persons to be associated with a given sampling Event.

Field Name	Field Type	Size	Field Description
Event_ID	ReplicationID	16	Link to tbl_Events
Contact_ID	ReplicationID	16	Link to tlu_Contacts
Contact_Role	Text	50	The contact's role in collection of field data

Table 5.12. (tbl_Events_PlotTrees) Table stores plot tree data. Uses species codes from UCBN_NPSpp_Module linked back-end file, and tree size class codes from tlu_Tree_Class. Linked Many:1 to tbl_Events.

Field Name	Field Type	Size	Field Description
Trees_ID	ReplicationID	16	Primary key, uniquely identifying each tbl_Events_PlotTrees record
Event_ID	ReplicationID	16	Link to tbl_Events (foreign key)
SppCode	Text	50	Tree species code
Tree_Class_Code	Text	50	Size class of tree (from tlu_TreeClass)
Count	Long Integer	4	Percent Cover class for bare ground within plot (from tlu_CoverClass pick-list)

Table 5.13. (tbl_Events_GrCover) Table stores ground cover data. Uses species codes from UCBN_NPSpp_Module linked back-end file. Linked Many:1 to tbl_Events.

Field Name	Field Type	Size	Field Description
GrCover_ID	ReplicationID	16	Primary key, uniquely identifying each tbl_Events_GrCover record
Event_ID	ReplicationID	16	Link to tbl_Events (foreign key)
SppCode	Text	50	Species code
Veg_Cover_Perc	Long Integer	4	Percent Cover of ground cover species (estimated to nearest 1%)

Table 5.14. (tlu_Tree_Class) Lookup table storing tree size class codes and definitions of the size class codes.

Field Name	Field Type	Size	Field Description
TreeClass_ID	ReplicationID	16	Primary key, uniquely identifying each tlu_Tree_Class record
Tree_Class_Code	Text	15	Code used for Tree Class
Tree_Class_Descript	Text	255	Description of Tree Class

Table 5.15. (tlu_Proto_VSign) Lookup table of vital sign and protocol. Linked 1:Many to tlu_Protocol_Ver.

Field Name	Field Type	Size	Field Description
Prototcol_Parent	Text	10	Primary key. Four letter code to identify each vital sign protocol.
Vital_SignI_Name	Text	150	Full Name of associated Vital Sign

Table 5.16. (tlu_Protocol_Ver) Lookup table of protocol versions, linked to tbl_Events in order to associate a protocol version with each individual sampling event.

Field Name	Field Type	Size	Field Description
Protocol_Ver_ID	Text	10	Primary key. Four letter Protocol Parent code plus version (e.g., ASPN_2_3, etc.).
Prototcol_Parent	Text	10	Link to tlu_Proto_VSign (foreign key).
Description	Memo	NA	Description of this Protocol Version

Table 5.17. (tlu_ProtoVer_PlotDetails) Lookup table storing details on plot size for a given protocol version. Linked 1:1 to tlu_Protocol_Ver.

Field Name	Field Type	Size	Field Description
Proto_Plot_ID	ReplicationID	16	Primary key, uniquely identifying each tlu_ProtoVer_PlotDetails record
Prototcol_Ver_ID	Text	10	Link to tlu_Protocol_Ver (foreign key). Four letter Protocol Parent code plus version (e.g., ASPN_2_3, etc.).
Plot_Type	Text	50	Type of sampling plot, if applicable (e.g., Circular, Rectangular, etc.)
Plot_Diameter	Text	50	Diameter of circular plot, if applicable (include units)
Plot_Length	Text	50	Length of plot, if applicable (include units)
Plot_Width	Text	50	Width of plot, if applicable (include units)
Plot_Notes	Memo	NA	Notes about plot, if applicable

Table 5.18. (tbl_DB_Meta) Database description and links to I&M metadata tools.

Field Name	Field Type	Size	Field Description
DB_Meta_ID	ReplicationID	16	Local primary key
Db_Desc	Memo	NA	Description of database purpose
Meta_MID	ReplicationID	16	Link to Metadata record
Meta_File_Name	Text	255	Filename of Metadata record

Table 5.19. (tbl_DB_Revisions) Database revision history data.

Field Name	Field Type	Size	Field Description
Revision_ID	Text	50	Database revision (version) number or code
Revision_Contact_ID	ReplicationID	16	Link to tlu_Contacts
DB_Meta_ID	ReplicationID	16	Link to tbl_DB_Meta
Revision_Date	Date/Time	8	Database revision date
Revision_Reason	Memo	NA	Reason for the database revision
Revision_Desc	Memo	NA	Revision description

Data Entry, Verification, and Validation

Data Entry

Data from paper data sheets will be entered into the MOJN Aspen database as soon after data collection as possible through an MS Access frontend. Ideally, this will be conducted throughout the field season. Otherwise, it should occur immediately following the field season. Data entry should be completed by someone who participated in data collection or is familiar with the project and data. The primary goal of data entry is to transfer the data from paper into the database with 100% accuracy. The database will be backed up regularly to maximize the ability to recover should irreversible errors or problems occur during the data entry session.

When the person entering the data finds a correctable error or omission on the field data sheet, this correction should be entered in the database and recorded on the field data sheet along with the correction date and the initials of the person who made the correction.

Data entry should be viewed as an important step in the overall QA/QC process, and care should be taken to review data while the observers are in the field.

Data verification

The aspen database application will incorporate quality assurance/quality control (QA/QC) strategies to ensure data quality. The database design and the allowable value ranges assigned to individual fields within the data tables help to minimize the potential for data entry errors and/or the transcription of erroneously recorded data.

After the initial data entry process for a stand is completed, all of the records will be reviewed for consistency with hard-copy datasheets. This task should be completed by someone other than the person who completed the original data entry. The completion of data entry, data verification and other QA processes will be tracked in the database. Any outstanding discrepancies between the database and the field sheets should be clearly documented in the appropriate comments field in the database.

The Data Manager will supervise the verification of the geospatial component of the field data each season by completing a proximity analysis of any newly collected coordinates against the known stand and photo point coordinates.

When data verification is complete, the dataset is considered to have reached the “provisional” data processing level. The data processing levels referred to in this document are more fully described in *Certification Guidelines for Inventory and Monitoring Data Products* (NPS 2016).

Data validation

The Protocol Lead and Data Management Team collaboratively validate a given season’s dataset (i.e., ensure that the data make sense). Some validation methods have been incorporated into the database as queries. Other, more specific, validation routines are developed in collaboration with the Protocol Lead and incorporated into the database as appropriate. Data Management Team will work closely with the Protocol Lead to provide any needed database queries, reports, graphs, or export file formats to assist with the overall validation.

Metadata

Once the data have undergone QC procedures, the Data Manager and Protocol Lead will complete the necessary accompanying metadata. Metadata are defined as structured information about the content, quality, condition, and other characteristics of a given dataset. Additionally, metadata provide the means to catalog and search among datasets, thus making them available to a broad range of potential data users.

The Protocol Lead and Data Manager will work collaboratively to fill out the MOJN Metadata Interview form. Any records that did not meet the documented quality standards in the validation

process must be clearly identified in the metadata, which will be an FGDC and NPS compliant metadata record in XML format.

When data has undergone all QC procedures and metadata are complete, the dataset is considered to have reached the “accepted” data processing level and upon approval of the full Quality Assurance Plan for this protocol the data will be considered “certified”.

Data Distribution

Prior to publication of any reports or data, MOJN staff will work with a staff member from each park represented in the dataset to complete a data sensitivity assessment form. The results of this assessment will dictate the appropriate audience for the data: Park only, NPS only, or public. Redacted datasets and reports may be created when it is deemed that sensitive information should be obscured for one or more of these audiences. The sensitivity or “protected status” of species and location data will be tracked in the database following the guidance in the IMD document *Minimum Standards for Network Projects* (Frakes 2017).

As part of the reporting cycle, summary reports and derived data products will be made available on the IRMA website Data Store (<http://irma.nps.gov/DataStore/>).

Data Maintenance and Archiving

Secure data archiving is essential for protecting data files from loss or corruption. Once the master project dataset and metadata are considered final for a field season, the Data Manager will place a copy of the dataset and the metadata record into the appropriate folder within the archive directory on the Network server. These archived files will be stored in read-only format. Any subsequent changes made to this database must be documented in an edit log and in the metadata. In addition to the database copy in its native format, all tables will be archived in a comma-delimited ASCII format that is platform-independent.

Additional digital files to be archived include all digital photos associated with that field season, and any digital files associated with data analysis products and project reporting.

Hard-copy materials (e.g., datasheets, field notebooks) are currently stored in the Network office but will eventually be moved to an NPS-approved repository for permanent storage.

Any editing of archived data must be documented in the edit log and accompanied by an explanation that includes pre-and post-edit data descriptions. Datasheets can be reconciled to the database through the use of the edit log.

Prior to any major changes of a dataset, a copy is stored with the appropriate version number to allow for tracking changes over time. Each additional version will be assigned a sequentially higher number. Frequent users of the data are notified of the updates and provided with a copy of the most recent version.

Revising the Protocol

This SOP explains how to make and track changes to the protocol narrative and related SOPs. Following these guidelines ensures that data collection and processing procedures are documented and retained for use and interpretation of historical data sets. Project staff should refer to this SOP when any changes to an approved protocol document are necessary. The procedures in this SOP are based on the *NCPN Protocol Versioning Guidance Document* (NCPN-NPS 2009).

Modifications must be reviewed for clarity and technical soundness. Small changes or additions to existing methods will be reviewed in-house by MOJN staff. An outside review is required for substantive changes in methods. Regional and national staff of the NPS and experts outside of the NPS with familiarity in vegetation monitoring and data analysis will be used to review major changes.

Record all changes to a protocol document (protocol narrative or SOP) in the document's revision history log, even minor edits like fixing typos or formatting changes. It is not necessary to record the specific edits made, rather just the fact that typos were fixed or formatting changes were made. For minor edits, record the same document version number in the revision history log. For actual protocol changes (e.g., changes in methods, equipment), assign a new version number in the revision history log. Depending on the significance of the changes, it may be okay to combine multiple changes in the same entry in the revision history log. 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, and the reason for the changes along with the new version number (if applicable).

Schedule of Data Management Tasks

Table 5.20. The yearly aspen monitoring data management task list. This table identifies tasks by project stage, indicates who is responsible for the task, and establishes the timing for its execution.

Project Stage	Task Description	Responsibility	Timing
Preparation	Notify Data Manager of needs (field maps, GPS support, training)	Protocol Lead	ASAP, before Feb 1
	Ensure that project workspace is ready for use and GPS download software is loaded	Data Manager	by May 1
	Prepare and print field maps and data sheets	Protocol Lead /Data Manager	by May 1
	Update and load data dictionary, background maps, and target coordinates into GPS units	Protocol Lead/Data Manager	by May 1
	Provide database/GPS training as needed	Data Manager/Protocol Lead/Field Lead	May
	Train field crew in plant identification and field sampling protocols	Protocol Lead and/or Field Lead	May
	Examination and certification of field observer qualifications, enter training results into database	Protocol Lead and/or Field Lead	May
Data acquisition	Collect field observations and position data during field trips	Technicians/Volunteers	May-Jul
Data entry & processing	Review data sheets after each day	Field Lead	daily
	Enter data into working copy of the database	Technicians	after each tour
	Verification of accurate transcription as data are entered	Technicians	after each tour
	Periodic review of database entries for completeness and accuracy	Field Lead	As needed
	Upload processed and verified data to archive master database copy	Data Manager and/or Technician	August
Product development	Complete field season report	Protocol Lead / Field Lead	Jul-Aug
Product delivery	Send field season report to Data Manager	Protocol Lead / Field Lead	by Sep 1
Quality review	Quality review and data validation using database tools	Protocol Lead/Data Manager	Jul-Oct
	Prepare coordinate summaries and/or GIS layers and data sets as needed for spatial data review and reports	Data Manager	by Sep 15
Metadata	Identify any sensitive information contained in the data set	Protocol Lead and Park Resource Manager	Aug-Oct
	Update project metadata records	Protocol Lead	Aug-Sept

Standard Operating Procedure (SOP) 6: Data Summary, Analysis, and Reporting

Version 1.0

Revision History

Version #	Date of Revision	Revised By	Changes
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This SOP describes the stand level power analysis that was conducted to estimate the number of plots necessary to establish within aspen stands in GRBA, to detect a change in stem density of by 25% with 90% confidence and 80% power. This PIP bases its statistical power needs off the original work done by UCBN staff. A park-level power analysis was also performed, describing the power to detect a 25% increase and decline in stem density over 5 years. Note that because PARA is small and has few aspen stands, a formal power analysis for that park was not conducted; few choices exist for a small sample size that could be informed by a power analysis.

Computational code in the statistical software SAS is included. The power analyses are followed by descriptions of status analysis and trend analysis.

Analytical Procedures

The statistical methods outlined below are described for implementation in the statistical analysis software SAS. SAS code is provided for each analysis step.

Aspen stem density is sampled in six size classes described below (Table 6.1).

Table 6.1. Classes of aspen stem density.

Class	Description
Class I	Suckers or seedlings ≤ 46 cm (1.5 ft) tall. Conifer seedlings shorter than 15 cm (6 inches) are not counted due to uncertainty in survival
Class II	Suckers or seedlings ≤ 46 - 152 cm (1.5-5 ft) tall
Class III	Greater than 152 cm (5 ft) and up to 2.5 cm (1 inch) in dbh (diameter at breast height)
Class IV	Greater than 2.5 cm (1 inch) in dbh and shorter than 75% of the stand height
Class V	Greater than 2.5 cm (1 inch) in dbh and taller than 75% of the stand height
Class VI	Dead stems ≥ 2.5 cm (1 inch) in dbh

Aspen total stem density by size class can be calculated by plot, transect, or stand by adding all individual aspen stems within the sampled area and then divided with the total sampled area (plot,

sum of sampled area along transect, or sum of sampled area within stand). The statistical analysis will be conducted to detect change and estimate trend within four combinations of size classes as follows: Suckers (Class I+II), Regeneration (Class III+IV), Mature Trees (Class V), and Dead Stems (Class VI).

Power Analysis

Within Stand Power Analysis: For the within stand power analysis the sampling unit, n , is the circular 4-m radius plot. The objective for this power analysis was to estimate the number of plots necessary within stands to detect a change of 25% between two sampling periods (5 years) with a 10% acceptable false-change error and $> 80\%$ power. We recognize that there is a high variability in stand size within the parks and therefore performed this power analysis based on pilot data where the sampled stands were relatively large (2-3 ha) in size. Following Elzinga et al (2001) we computed the required sample size for detecting a difference in the true mean in permanent sampling units as follows:

$$n = s^2 (Z_a + Z_b)^2 / (\text{mcd})^2$$

where:

n = sample size, number of plots within a stand

s = sample standard deviation

Z_a = Z-coefficient for a Type I

error Z_b = Z-coefficient for a Type II error

mcd = minimum detectable change in stem count since the initial sampling in year 1.

$$s = (s_1) / (2 (1 - \text{corr}_{\text{diff}}))$$

s_1 = sampling standard deviation among sampling units at the first time period

$\text{corr}_{\text{diff}}$ = Correlation coefficient between sampling unit values in the first and second time period. This value is currently not known and adjustments may be advisable in the future.

The standard deviation in stem count of aspen regeneration (Class III+IV) between 4-5 m radius sub-plot samples within aspen stands have previously been assessed by Strand (2007) in the Owyhee Mountains, and in the pilot studies of 2005 and 2006. Strand (2007) found that the average standard deviation in stem count of the medium size class (2-10 m high) was 646 stems/ha based on 5-7 plots in 26 stands. The pilot study of 2005 sampled 13 stands with an average standard deviation of 602 stems/ha in the medium size class (regeneration). The five stands sampled in the pilot study of 2006 show a variable standard deviation (see Aspen Protocol Narrative from Strand et al. 2009). The average standard deviation for these intensively sampled stands is 795 stems/ha. In general, the standard deviation of Class III+IV is of the same magnitude as the mean for each stand.

Based on these previous studies in relatively large stands (2 - 3 ha) we computed the number of samples required for an adequate statistical test at different levels of confidence and power. We based the statistical calculation on methods described in Elzinga et al. (2001) described above. We estimated the number of samples for both temporary (Figure 35) and permanent (Figure 36) plots. In

both cases we estimated the number of samples for a 25% minimum change detection using 600 stems/ha as the standard deviation between plots. In the case of permanent sampling units we estimated the correlation between time periods to 0.8. This value is currently not known and may be adjusted in the future as more data becomes available. This analysis reveals that 14 plots are necessary in the case of permanent sampling units while 70 plots would be required for temporary sampling units ($\alpha = 0.1$, power = 0.8; Figure 6.2).

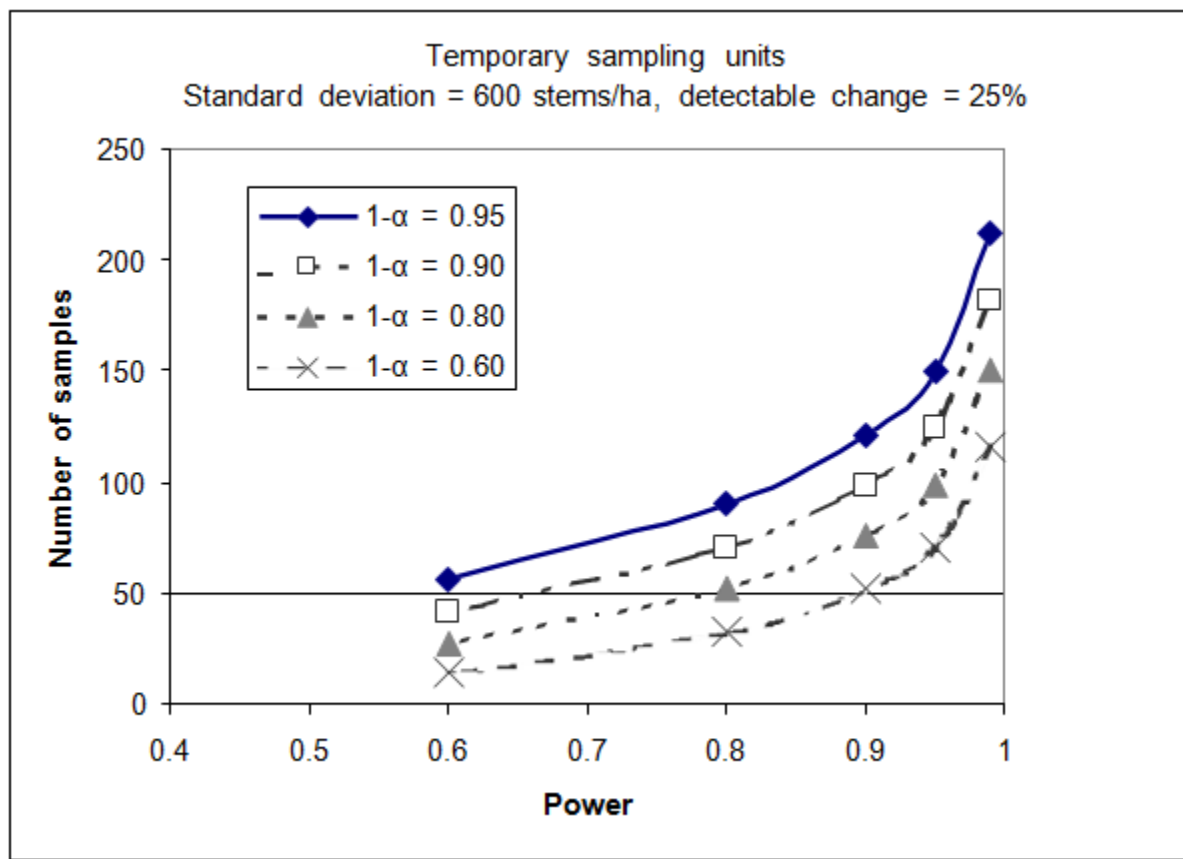


Figure 6.2. Sample size versus power for temporary plots

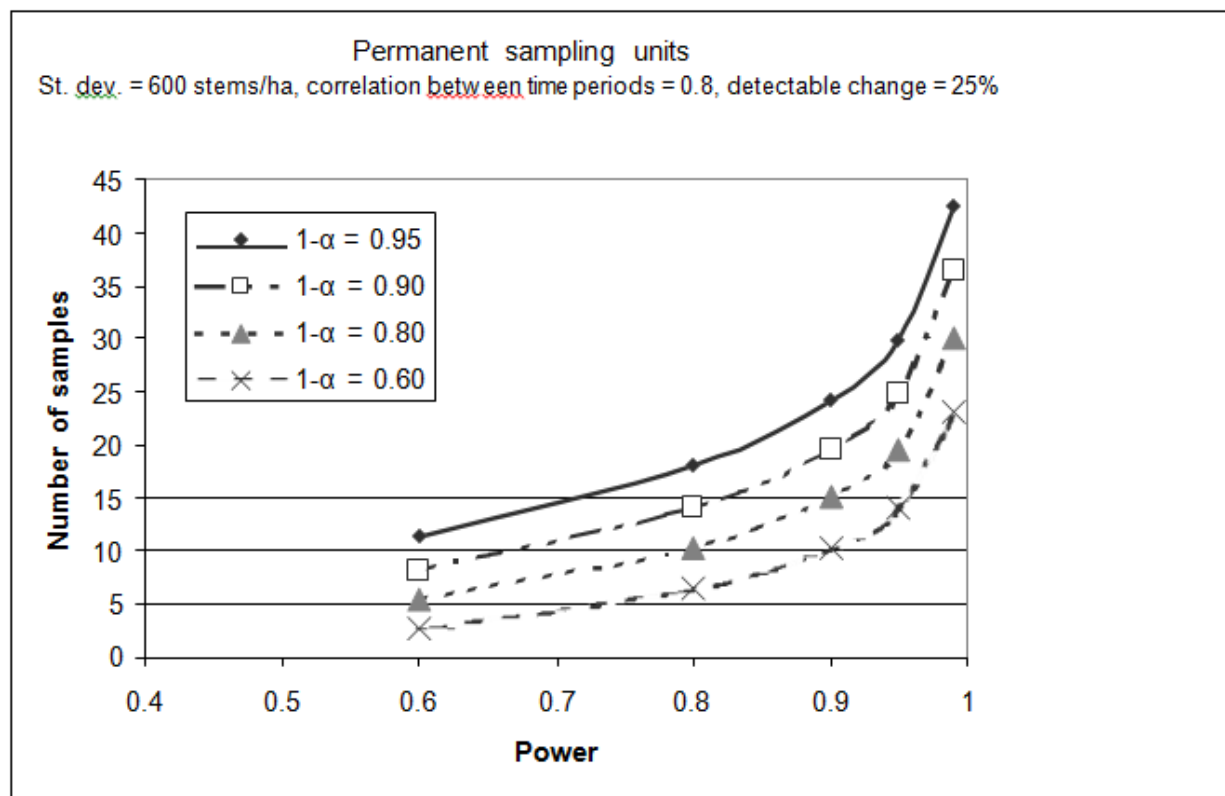


Figure 6.3 Sample size versus power for permanent plots

The results from this power analysis guided us to select permanent sampling locations to maximize the statistical power for a given alpha level while minimizing the sampling effort. In stands of the size 2-3 ha 14-15 plots are required to determine a change in mean of 25% with a false-change error of 0.1 and a power of 0.8. In the case of temporary plots, number of plots required for the same false-change error level and power is 60-70, which is practically unreasonable. Given that the recommended distance between plot centers is 25 m to avoid statistical dependence between plots, this large number of 4-m plots could not physically fit within a 2-3 ha aspen stand.

Park Level Power Analysis: The power analysis at the park level was performed using pilot data collected by UCBN in 2010. They used the statistical software package SAS using proc GLMPOWER to calculate the power to detect a 25 percent increase and decline over 5 years. We assume a revisit design (found in the Aspen Protocol Narrative, Strand et al. 2018); sampling during years 2007, 2010, and 2015. Thus, for an assumed decline/increase of 25% over 5 years the net change of 25% should be reached during year 2012. We assume a linear change on the log-scale, which corresponds to a multiplicative change on the original scale. For example, if we assume a -0.25 change over 5 years, this means a 25% decline on the original scale over 5 years. Or an annual change on the original scale of

$$(1 + (-0.25))^{1/4} = 0.93 \quad (1)$$

which is a 7% yearly decrease.

The following mixed model was derived based on Piepho and Ogutu (2002) for a similar aspen monitoring protocol

$$\ln(y_{ijk}) = \mu + w_j\beta + b_j + \alpha_i + w_j t_i + g_{k(i)} + c_{ij} + e_{ijk} \quad (2)$$

where $i = 1, \dots, m_a$; $j = 1, \dots, m_b$, and $k = 1, \dots, m_i$ i indexes the stand, j indexes the year of sampling, and k indexes the transects within a stand.

m_a = the number of stands in a sample;

m_b = the number of years in a sample;

m_i = the number of transects within stand i ;

w_j = is a constant representing the j th year (covariate);

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

α_i = the fixed intercept of the i th stand;

b_j = random effect of the j th year = 0 if no panel structure used (true for Aspen for one park);

t_i = random slope of i th stand, iid as $N(0, \sigma_t^2)$;

$g_{k(i)}$ = random effect of transect within stand, iid as $N(0, \sigma_g^2)$;

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

e_{ijk} = unexplained error, iid as $N(0, \sigma_e^2)$.

This model simplifies for the power analysis because we have no estimate of variability over time given only one year of data. Therefore, σ_t^2 , σ_c^2 , and σ_e^2 are all equal to zero. Also, we assume no panel structure for aspen such that $b_j = 0$. The model in equation 2 simplifies to the following:

$$\ln(y_{ijk}) = \mu + w_j\beta + \alpha_i + g_{k(i)} \quad (3)$$

This model assumes each stand has a unique intercept or fixed effect $\mu + \alpha_i$ and a common linear trend in time β . The error term is simply the variability of transects within stands ($g_{k(i)}$).

The power was calculated using proc GLMPower in SAS for $\alpha = 0.10$ and three years of data: 2007, 2010, and 2015. The stand effects were estimated using the data collected in CRMO during the field season 2007. The linear contrast coefficients for the time effect are estimated using proc iml in SAS.

```
proc glmpower data=noerror2; class Stand Year Transect; model LogY = Stand Year;
contrast 'linear' Year -.641533 -.116642 .7581754 ; /*2007, 2010, 2015*/ power
alpha=.10
stddev = .4 /*THIS ESTIMATE IS FROM THE SAS CODE AspenNested020308*/ Ntotal = 90
```

power = .; run;

Table 6.4. Power analysis results for the regeneration and mature tree classes based on sampling in 22 aspen stands in CRMO in the field season 2007.

Percent Change	Regeneration Class Power	Mature Tree Class Power
-25%	1	1
+25%	1	0.994
-10%	0.816	0.627
+10%	0.745	0.555

These results clearly exceed the original goal of achieving a power of 0.8 and a change in 25%.

NOTE: The power may be slightly over-estimated because we are unable to estimate the variance components for time based on the pilot dataset. These calculations can be updated after the second year of surveying to determine a more accurate power to detect a given change with $\alpha = 0.10$.

Status Analysis

The design for each of the two parks is a three-stage cluster sample. The primary sampling unit (PSU) is a stand. We are proposing to census the stands ($n=N$) in PARA, in GRBA (where aspen forest comprises ~29% of the park) we are sampling the population, not conducting a census of all stands. The secondary sampling unit (SSU) is a transect. There are m_i transects per stand out of M_i possible. We are proposing to sample so that $m_i/m_i = A_i/A$ where m is the sum of the m_i 's, A_i is the area of the stand and A is the total area of all stands. That is, we are proposing to allocate transects to stands in proportion to the area of the stand. The tertiary sampling unit (TSU) is a plot. We are proposing 4 plots per transect 25 m apart—this makes the transect 75 m long.

The **design based** estimator of stems/ha is

$$\hat{\mu} = \frac{N}{n * m} \sum_{i=1}^n M_i y_i = \sum_{i=1}^N \sum_{j=1}^{M_i} \sum_{k=1}^4 \frac{y_{ijk}}{4m}$$

The variance of $\hat{\mu}$ is estimated as

$$s_{\hat{\mu}}^2 = \Phi + \frac{1}{N} \sum_{i=1}^N \left(\frac{A_i}{A} \right)^2 \left(1 - \frac{m_i}{M_i} \right) \left(\frac{s_i^2}{m_i} \right) + \sum_{ij} k_{ij} \frac{s_{ij}^2}{4}$$

where s_i^2 is the transect-to-transect variance, k_{ij} is a constant that goes to 0 as the number of plots per transect goes to the total possible, and s_{ij}^2 is the plot-to-plot variance. Note that for PARA, the first term is zero because we are doing a census of stands and the finite population correction factor at that

level goes to zero. In GRBA, since we will be estimating N, not conducting a census, the first term is non-zero.

The **model based** estimator is the estimate of μ in a nested ANOVA. This is simply the mean of all the plot densities. In this case, the design and model based estimators are the same. The variance of the estimator is found from a nested ANOVA. This same ANOVA provides estimates of the transect-to-transect and plot-to-plot variances needed above.

Status results will be summarized after each year of data collection. Standard summary statistics will include measures of central tendency ($\hat{\mu}$), and standard deviation ($\hat{\sigma}$) for stem density, expressed as stems per hectare, within size classes for aspen and conifer species summarized by transect and by aspen stand. Graphical representation of data in the form of charts and maps is also important in exploratory data analysis, particularly during the early stages of an analytical exercise. Graphical presentation can aid in communicating results and can trigger the generation of new, or the refinement of existing, hypotheses about pattern and process. As the monitoring project continues and data from sequential time periods become available the power analysis will be revisited and refined to optimize the data collection and analysis efforts.

Trend Analysis

Trend analyses will begin after three plot revisits (15 years) and will be conducted every five years thereafter according to the panel design as described in the preceding revisit design section. The null hypothesis (H_0) that there is no difference in stem count within individual parks will be tested with a repeated measures nested analysis of variance for the suckers (class I+II), regeneration (class III+IV), mature stems (class V), and dead stems. Initially the trend analysis will be performed on data from only two points in time, however as more data becomes available (i.e. after three sampling periods) the trend analysis will be conducted using a linear regression design to evaluate trajectories. All analyses will be performed in the statistical analysis software SAS and SAS codes are provided for each analysis step. The example dataset in this section illustrates three years of sampling. The data for 2007 was collected in CRMO while the data from 2010 and 2015 were simulated for the purpose of developing these analysis techniques.

The following mixed model was derived based on Piepho and Ogutu (2002)

$$\ln(y_{ijk}) = \mu + w_j\beta + b_j + \alpha_i + w_j t_i + g_{k(i)} + c_{ij} + e_{ijk} \quad (1)$$

where $i = 1, \dots, m_a$; $j = 1, \dots, m_b$, and $k = 1, \dots, m_i$, i indexes the stand, j indexes the year of sampling, and k indexes the transects within a stand. Let:

- m_a = the number of stands in a sample;
- m_b = the number of years in a sample;
- m_i = the number of transects within stand i ;
- w_j is a constant representing the j th year (covariate);
- μ and β = fixed intercept and slope of the linear time trend;
- α_i = the fixed intercept of the i th stand;
- b_j = random effect of the j th year = 0 if no panel structure used (true for Aspen for one

park);

t_i = random slope of i th stand, iid as $N(0, \sigma_t^2)$;

$g_{k(i)}$ = random effect of transect within stand, iid as $N(0, \sigma_g^2)$;

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

e_{ijk} = unexplained error, iid as $N(0, \sigma_e^2)$.

Because we are interested in measuring net trend over time as a percent change, the response must be logged so that exponential change may be estimated. As indicated in the model above, the natural log of the response is being modeled, i.e. $\ln(y_{ijk})$. Therefore, inference is actually made on median trend rather than mean trend.

To test for a linear trend in the medians we are interested in testing the null hypothesis of $\beta=0$ (no trend) versus the alternative hypothesis of $\beta \neq 0$ (annual trend). As defined above, β is the coefficient of the Year variable (referred to as WYear in the SAS code) and represents annual trend of the outcome on the natural log scale.

Annual trend on the logged scale is estimated by $\hat{\beta}$ the coefficient of the Year variable. For example for three sampling years (2007, 2010, 2015), if the estimate of annual trend of Aspen Mature (stems/ha) on the logged scale is 0.01492 (SE=0.2221) and the t-value is 0.07. The degrees of freedom for the t -statistic are 21.3, based on the Satterthwaite approximation recommended by Van Leeuwen et al. (1996). Based on this t -statistic we would conclude there is no evidence to indicate there is a linear trend in stems/ha within the Mature age class for Aspen (p-value = 0.9471).

Annual trend on the original scale is estimated by $\exp(\hat{\beta})$. If we are interested in interpreting the percent change in the median of the original scale we need to back-transform the confidence interval end points. Confidence intervals for the annual percent change, $\exp(\hat{\beta}) - 1$, are found by applying the exponential function to the endpoints of the confidence interval for $\hat{\beta}$ and subtracting 1. In other words, if the $(1-\alpha)100\%$ -confidence interval for $\hat{\beta}$ is (a,b), then the $(1-\alpha)100\%$ -confidence interval for the percent annual change in the median is $(\exp(a)-1, \exp(b)-1)$. For example, if the annual trend on the natural log scale is estimated as 0.0149 with a 95%- confidence interval of (-0.4467, 0.4765). We would state for the original scale: We are 95% confident the annual percent change in the median mature aspen stems/ha will be between -36% to +61% (-0.36, 0.61 95%-confidence interval).

Inference on the net population change is similarly calculated as $\exp(m\hat{\beta}) - 1$, where m is the total number of years over which the net trend is estimated. The corresponding $(1-\alpha)100\%$ - confidence interval is computed as $(\exp(ma)-1, \exp(mb)-1)$, where a and b are defined as above. Therefore, for a net trend over 8 years with an estimated annual trend on the natural log scale of 0.0149 with a 95%-confidence interval of (-0.4467, 0.4765), the estimate of net trend of the median mature aspen stems/ha will be $\exp(8*0.01492)-1 = 0.1268$ with a 95%-confidence interval of (-0.9719, 44.2408).

Analysis Code in the SAS Software

The following is an example dataset illustrating three years of sampling. The data for 2007 was collected in CRMO while the data from 2010 and 2015 were simulated for the purpose of developing these analysis techniques.

```

/* I generated this data using LeighAnnStarcevich code for
SimPopnChange assuming all variances were 1.

sas.data.25decline<-
SimPopnChange(N=length(stands),w=0:8,StartYear=2007,change=-.25,
mu=6.1644,ai=standeffectsMATURE,sig2t=1, sig2g=1, sig2c=1, sig2e=1)
*/

data testinc25;
input Year WYear Stand Transect Y LogY;
datalines;
2007 0 5 1 201.1636959 5.304118984
2007 0 7 1 57.09648082 4.044742483
2007 0 9 1 6793.563995 8.823730972
2007 0 9 2 1617.298976 7.388512738
2007 0 10 1 72119.97721 11.18608636
2007 0 11 1 676.0103914 6.516208448
2007 0 12 1 7897.053671 8.974245016
2007 0 13 1 6.50084667 1.871932425
2007 0 14 1 66.36413267 4.19515674
2007 0 14 2 51.07462601 3.933287818
2007 0 14 3 21.18101642 3.053105329
2007 0 16 1 9186.304864 9.125469052
2007 0 17 1 355.1516938 5.872545005
2007 0 18 1 82.8603952 4.417157206
2007 0 20 1 661.1526246 6.493984713
2007 0 21 1 24.82665632 3.211917927
2007 0 23 1 12539.70846 9.436655565
2007 0 23 2 3095.30201 8.03764076
2007 0 24 1 621.3277164 6.431858666
2007 0 26 1 2059.699745 7.630315496
2007 0 26 2 399.7675114 5.990883157
2007 0 26 3 2449.702518 7.803721875
2007 0 27 1 3274.744571 8.093995151
2007 0 29 1 4879.837901 8.492867281
2007 0 30 1 974.4905994 6.881914872
2007 0 32 1 88.37015676 4.481534319
2007 0 32 2 32.79801584 3.490368021
2007 0 33 1 1425.091274 7.261991142
2007 0 34 1 14099.10578 9.553866654
2007 0 34 2 2205.129837 7.698541669
2010 3 5 1 236.6710642 5.466671262
2010 3 7 1 5.962374625 1.785468829
2010 3 9 1 232.7838737 5.450110442
2010 3 9 2 660.4997977 6.492996818
2010 3 10 1 1619.443357 7.389837762
2010 3 11 1 96.93174816 4.574007104
2010 3 12 1 163.1156693 5.094459577
2010 3 13 1 0.003572558 -5.634473427
2010 3 14 1 559.2019114 6.326510609
2010 3 14 2 199.0303325 5.293457238
2010 3 14 3 9.744039898 2.276655806
2010 3 16 1 30482.13749 10.32489613
2010 3 17 1 387.8916037 5.960725929

```

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2010	3	18	1	1439.12931	7.271793564
2010	3	20	1	23.20378416	3.144315376
2010	3	21	1	0.710730003	-0.341462665
2010	3	23	1	2110223.16	14.56230426
2010	3	23	2	251234.6326	12.43414257
2010	3	24	1	0.049947203	-2.996788781
2010	3	26	1	1003.30956	6.911059374
2010	3	26	2	303.3993144	5.715049807
2010	3	26	3	302.5529547	5.712256319
2010	3	27	1	28394.85327	10.25396318
2010	3	29	1	594.664492	6.387997367
2010	3	30	1	15455.98363	9.645751497
2010	3	32	1	15177336.08	16.53531383
2010	3	32	2	568119.1803	13.2500865
2010	3	33	1	39.93039373	3.687137782
2010	3	34	1	1130.896954	7.030766361
2010	3	34	2	59.95507178	4.093595478
2015	8	5	1	11.76199858	2.464873875
2015	8	7	1	0.002832557	-5.866575285
2015	8	9	1	22.9614842	3.133818212
2015	8	9	2	94.72589083	4.550987361
2015	8	10	1	579.4236145	6.362033841
2015	8	11	1	649.4178539	6.476076352
2015	8	12	1	3.795630734	1.333850598
2015	8	13	1	3.46E-06	-12.57404527
2015	8	14	1	1.790321455	0.582395188
2015	8	14	2	1.809985255	0.593318699
2015	8	14	3	0.213484843	-1.544189441
2015	8	16	1	8716985.524	15.98078404
2015	8	17	1	7.342279764	1.993649389
2015	8	18	1	20657.43692	9.935830675
2015	8	20	1	0.937712315	-0.064312078
2015	8	21	1	0.002691925	-5.91749891
2015	8	23	1	6.32199E+11	27.17246992
2015	8	23	2	15610795644	23.47122854
2015	8	24	1	7.94E-08	-16.34859493
2015	8	26	1	1.565621448	0.448282836
2015	8	26	2	5.853046117	1.766962229
2015	8	26	3	58.14069032	4.062865769
2015	8	27	1	22101.47024	10.00339941
2015	8	29	1	33270.77192	10.41243457
2015	8	30	1	7683.780194	8.946866918
2015	8	32	1	1.18792E+14	32.40839731
2015	8	32	2	2.87628E+13	30.99010489
2015	8	33	1	170.9336501	5.14127547
2015	8	34	1	5.025858099	1.614596205
2015	8	34	2	0.19352947	-1.642325479

Reporting

A summary report will be produced each year a panel is sampled, with a more detailed report produced every five years. The annual report will include the following:

- List project personnel and their roles.
- List of the stands that were sampled during the current year
- Provide a summary history of mean and standard deviation within size classes and species within the stands sampled during each year of the study, broken down by stand and park.

- Provide status and trend (after 2010) estimates of aspen regeneration, mature and dead stem density for each stand and park.
- Report the density of conifers within the stands.
- Provide a summary of the digital photographs taken during the field season.
- Evaluate data quality and identify any data quality concerns and/or deviations from protocols that affect data quality and interpretability.
- Evaluate and identify suggested or required changes to the protocol.

In order to reduce the reporting burden on MOJN staff, the annual summary will be developed for internal Network distribution only. However, a 1-2 page resource brief will be prepared for public consumption and provided to park interpretive staff for distribution to interested visitors. An NPS template for producing maps with ESRI ArcGIS or ArcView software is available at <http://imgis.nps.gov/templates.html>.

A more in-depth analysis and report will be produced every five years. In addition to the above, the five-year report should also provide density estimates during the previous time periods, assess changes in spatial patterns of the aspen density estimates, and identify any possible changes in conifer density within the stands and parks. The report will also evaluate operational aspects of the monitoring program, such as whether population boundaries need to be adjusted or the sampling period remains appropriate (the optimal sampling season could conceivably change over time in response to climate change).

Annual reports and trend analysis reports will use the NPS Natural Resource Publications template, a pre-formatted Microsoft Word template document based on current NPS formatting standards. Annual reports will use the Natural Resource Report template, and trend analysis and other peer-reviewed technical reports will use the Natural Resource Technical Report template. These templates, guidelines for their use, and documentation of the NPS publication standards are available at the following address: <http://www.nature.nps.gov/publications/NRPM/index.cfm>.

Schedule for Aspen Monitoring Project Deliverables**Table 6.5.** Schedule for aspen monitoring project deliverables.

Deliverable Product	Primary Responsibility	Target Date	Destination(s)
Field season report	Protocol Lead	September 1 of the same year	MOJN Digital Library ¹
Raw data files	Field Lead	September 15 of the same year	MOJN Digital Library ¹
Photographs (select, quality images for long-term storage)	Protocol Lead	November 30 of the same year	MOJN Digital Library ¹
Certified working database and geospatial data with draft metadata	Protocol Lead with Data Manager assistance	delivered by November 30 of the same year, not posted to public sites until June of the second year	master project database and GIS data sets, copy to MOJN Digital Library ¹ , and NR-GIS Metadata and Data Store ²
Data certification report	Protocol Lead	November 30 of the same year	MOJN Digital Library ¹
Full metadata (parsed XML)	Data Manager	March 15 of the following year	NR-GIS Metadata and Data Store ² , MOJN Digital Library ¹
Annual report	Protocol Lead	April 30 of the following year	MOJN Digital Library ¹ , printout to local park collections
5-year analysis report	Protocol Lead	Every 5 years by April 30	MOJN Digital Library ¹ , printout to local park collections
Other publications	NPS Lead, Protocol Lead, Data Manager	as completed	MOJN Digital Library ¹ , printout to local park collections
Other records	NPS Lead and Protocol Lead	review for retention every January	retain according to NPS Director's Order #19 ³

¹ The MOJN Digital Library is a hierarchical digital filing system stored on the MOJN file server. Network users have read-only access to these files, except where information sensitivity may preclude general access.

² NR-GIS Metadata and [Data Store](#) is a clearinghouse for natural resource data and metadata. Only non-sensitive information is posted to NR-GIS Metadata and Data Store. Refer to the protocol section on sensitive information for details.

³ NPS Director's Order 19 provides a schedule indicating the amount of time that the various kinds of records should be retained ([available online](#)).

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Appendix A. Summary of GRBA GRTS Draw

Table A.1. GRTS draw results for GRBA Aspen panels. Each panel, Conifer/Aspen and Aspen, includes 20 samples each. Additional samples are included in case they need to be used (e.g. if locations are rejected in the field, or if in the future the monitoring effort is expanded).

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GRTS #	Plot Code	Stratum	Panel	UTM 11N X (m)	UTM 11N Y (m)
001	GRBAA001	Conifer / Aspen	Sample	737031	4302159
002	GRBAA002	Conifer / Aspen	Sample	736713	4313168
003	GRBAA003	Conifer / Aspen	Sample	737363	4319432
004	GRBAA004	Conifer / Aspen	Sample	732418	4322028
005	GRBAA005	Conifer / Aspen	Sample	740943	4302838
006	GRBAA006	Conifer / Aspen	Sample	736606	4315827
007	GRBAA007	Conifer / Aspen	Sample	735911	4321165
008	GRBAA008	Conifer / Aspen	Sample	732931	4321700
009	GRBAA009	Conifer / Aspen	Sample	742116	4316333
010	GRBAA010	Conifer / Aspen	Sample	738049	4316887
011	GRBAA011	Conifer / Aspen	Sample	734738	4322078
012	GRBAA012	Conifer / Aspen	Sample	732893	4325379
013	GRBAA013	Conifer / Aspen	Sample	736243	4312670
014	GRBAA014	Conifer / Aspen	Sample	738100	4317256
015	GRBAA015	Conifer / Aspen	Sample	735218	4324495
016	GRBAA016	Conifer / Aspen	Sample	733175	4324449
017	GRBAA017	Conifer / Aspen	Sample	729831	4318501
018	GRBAA018	Conifer / Aspen	Sample	736761	4316419
019	GRBAA019	Conifer / Aspen	Sample	735563	4321013
020	GRBAA020	Conifer / Aspen	Sample	730216	4320219
021	GRBAA021	Conifer / Aspen	OverSample	737036	4312316
022	GRBAA022	Conifer / Aspen	OverSample	737882	4312606
023	GRBAA023	Conifer / Aspen	OverSample	734218	4322771
024	GRBAA024	Conifer / Aspen	OverSample	732652	4324168
025	GRBAA025	Conifer / Aspen	OverSample	740574	4303395
026	GRBAA026	Conifer / Aspen	OverSample	735812	4317144
027	GRBAA027	Conifer / Aspen	OverSample	737076	4320788
028	GRBAA028	Conifer / Aspen	OverSample	733205	4322400
029	GRBAA029	Conifer / Aspen	OverSample	736565	4314749
030	GRBAA030	Conifer / Aspen	OverSample	740441	4315989
031	GRBAA031	Conifer / Aspen	OverSample	734442	4322010
032	GRBAA032	Conifer / Aspen	OverSample	732492	4325260
033	GRBAA033	Conifer / Aspen	OverSample	737998	4311308
034	GRBAA034	Conifer / Aspen	OverSample	734745	4316744
035	GRBAA035	Conifer / Aspen	OverSample	737216	4320230
036	GRBAA036	Conifer / Aspen	OverSample	731298	4324802
037	GRBAA037	Conifer / Aspen	OverSample	736626	4312807
038	GRBAA038	Conifer / Aspen	OverSample	734321	4326138
039	GRBAA039	Conifer / Aspen	OverSample	736120	4324254
040	GRBAA040	Conifer / Aspen	OverSample	733173	4322610
041	GRBAA041	Aspen	Sample	738147	4300781
042	GRBAA042	Aspen	Sample	738136	4311502
043	GRBAA043	Aspen	Sample	737460	4315821
044	GRBAA044	Aspen	Sample	732207	4322193

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045	GRBAA045	Aspen	Sample	736666	4302748
046	GRBAA046	Aspen	Sample	737558	4313305
047	GRBAA047	Aspen	Sample	732537	4324945
048	GRBAA048	Aspen	Sample	734779	4322903
049	GRBAA049	Aspen	Sample	737478	4311196
050	GRBAA050	Aspen	Sample	737050	4313902
051	GRBAA051	Aspen	Sample	730768	4320008
052	GRBAA052	Aspen	Sample	733672	4322512
053	GRBAA053	Aspen	Sample	736860	4317680
054	GRBAA054	Aspen	Sample	736376	4312450
055	GRBAA055	Aspen	Sample	731300	4321755
056	GRBAA056	Aspen	Sample	734761	4321465
057	GRBAA057	Aspen	Sample	730028	4316749
058	GRBAA058	Aspen	Sample	736339	4313682
059	GRBAA059	Aspen	Sample	733524	4323151
060	GRBAA060	Aspen	Sample	735324	4322609
061	GRBAA061	Aspen	OverSample	736464	4315170
062	GRBAA062	Aspen	OverSample	736202	4312045
063	GRBAA063	Aspen	OverSample	731437	4320643
064	GRBAA064	Aspen	OverSample	734301	4322033
065	GRBAA065	Aspen	OverSample	735599	4303686
066	GRBAA066	Aspen	OverSample	738362	4313315
067	GRBAA067	Aspen	OverSample	739393	4316456
068	GRBAA068	Aspen	OverSample	732236	4327238
069	GRBAA069	Aspen	OverSample	735269	4316863
070	GRBAA070	Aspen	OverSample	736554	4313654
071	GRBAA071	Aspen	OverSample	730616	4319223
072	GRBAA072	Aspen	OverSample	734698	4324795
073	GRBAA073	Aspen	OverSample	736485	4304097
074	GRBAA074	Aspen	OverSample	735698	4313552
075	GRBAA075	Aspen	OverSample	733168	4322783
076	GRBAA076	Aspen	OverSample	733991	4322984
077	GRBAA077	Aspen	OverSample	736197	4315307
078	GRBAA078	Aspen	OverSample	737674	4316154
079	GRBAA079	Aspen	OverSample	733543	4322152
080	GRBAA080	Aspen	OverSample	733968	4321741

Appendix B. Example Field Data Sheet

STAND C1RO 14						ASPEN Field Data Form							
Visit Date	Aspect (Deg)	Slope (%)	Elev (m)	Stand Height (m)	Measure Loc (Plot)	Stand Image #	Img Bearing (Deg)	X_Coord	Y_Coord	Img			
Site Notes		Plot Type Circular		Plot Diam (m) 4 m		Datum		UTM_Zone					
Site record created by G.Dicus, from E.Strand C1RO Site list.													
Number of Transects		3		Number of Plots		12							
Tran_PLOT Number		1_1	1_2	1_3	1_4	2_1	2_2	2_3	2_4	3_1	3_2	3_3	3_4
UTM_East_Coord		273775	273775	273775	273775	273726	273726	273726	273726	273766	273766	273766	273766
UTM_North_Coord		4664393	4664418	4664443	4664468	4664308	4664333	4664358	4664383	4664259	4664284	4664309	4664334
Datum		NAD83	NAD83	NAD83	NAD83	NAD83	NAD83	NAD83	NAD83	NAD83	NAD83	NAD83	NAD83
UTM_Zone		12N	12N	12N	12N	12N	12N	12N	12N	12N	12N	12N	12N
Transect Bearing (from DB, if entered)		0	0	0	0	0	0	0	0	0	0	0	0
TreeSp1	Class1												
	Class2												
	Class3												
	Class4												
	Class5												
TreeSp2	Dead												
	Class1												
	Class2												
	Class3												
	Class4												
TreeSp3	Class5												
	Dead												
	Class1												
	Class2												
	Class3												
TreeSp4	Class4												
	Class5												
	Dead												
	Class1												
	Class2												
TreeSp5	Class3												
	Class4												
	Class5												
	Dead												
	Class1												
GroundSp1	PerCvr1												
	PerCvr2												
GroundSp2	PerCvr3												
	PerCvr4												
GroundSp3	PerCvr5												
	PerCvr6												
GroundSp4													
GroundSp5													
GroundSp6													

Tree SizeClass Codes : Class 1 = Suckers or seedlings < 46 cm (1.5 ft) tall. Conifer seedlings < 15 cm (6 in) are NOT counted.
 Class 2 = Suckers or seedlings 46 - 152 cm (1.5 - 5 ft) tall.
 Class 3 = Trees > 152 cm (5 ft) tall and <= 2.5 cm (1 in) dbh (diameter at breast height).
 Class 4 = Trees > 2.5 cm (1 in) dbh and shorter than 75% of the stand height.
 Class 5 = Trees > 2.5 cm (1 in) dbh and taller than 75% of the stand height.
 Dead = Standing dead trees.

Appendix C. PARA Stand Overview

Table C.1. Site code, size and number of transects of PARA Aspen stands

Site Code	Description	Area (sq meters)	Num of Transects
PARAACOY	Trumbull - Coyote Springs Stand	4163	1
PARAATR1	Trumbull - Mature Tree Stand	546	1
PARAATR2	Trumbull - Main Stand	11437	1
PARAATR3	Trumbull - Lower Paired Stand	4004	1
PARAATR4	Trumbull - Upper Paired Stand	1185	1
PARAAEXC	Logan - Exclosure Stand	38632	2
PARAALOG	Logan - Trailhead Stand	4411	1
PARAABAS	Basalt Escarpment Stand	88855	0*

*The Basalt Escarpment Stand is very sparsely populated and young, and not suitable for monitoring using transects. However, this site is interesting since it is on a rugged basalt escarpment and is large. Therefore this stand will be monitored using photopoints.

Table C.2. Site code and randomly selected transect start points for PARA Aspen stands

Site Code	Draw Order	UTM X 11N	UTM Y 11N	UTM X 12N	UTM Y 12N
PARAACOY	1	846685	4037060	308683	4032223
PARAATR1	1	845673	4036780	307657	4032008
PARAATR2	1	846219	4036660	308194	4031858
PARAATR3	1	846951	4036460	308912	4031615
PARAATR4	1	846822	4036350	308776	4031507
PARAAEXC	1	841699	4030120	303281	4025613
PARAAEXC	2	841554	4030040	303132	4025544
PARAAEXC	3	841820	4030230	303408	4025713
PARAALOG	1	840450	4030910	302085	4026482
PARAABAS	1	844856	4031730	306528	4027021
PARAABAS	2	844971	4031690	306641	4026976
PARAABAS	3	844796	4031660	306465	4026961

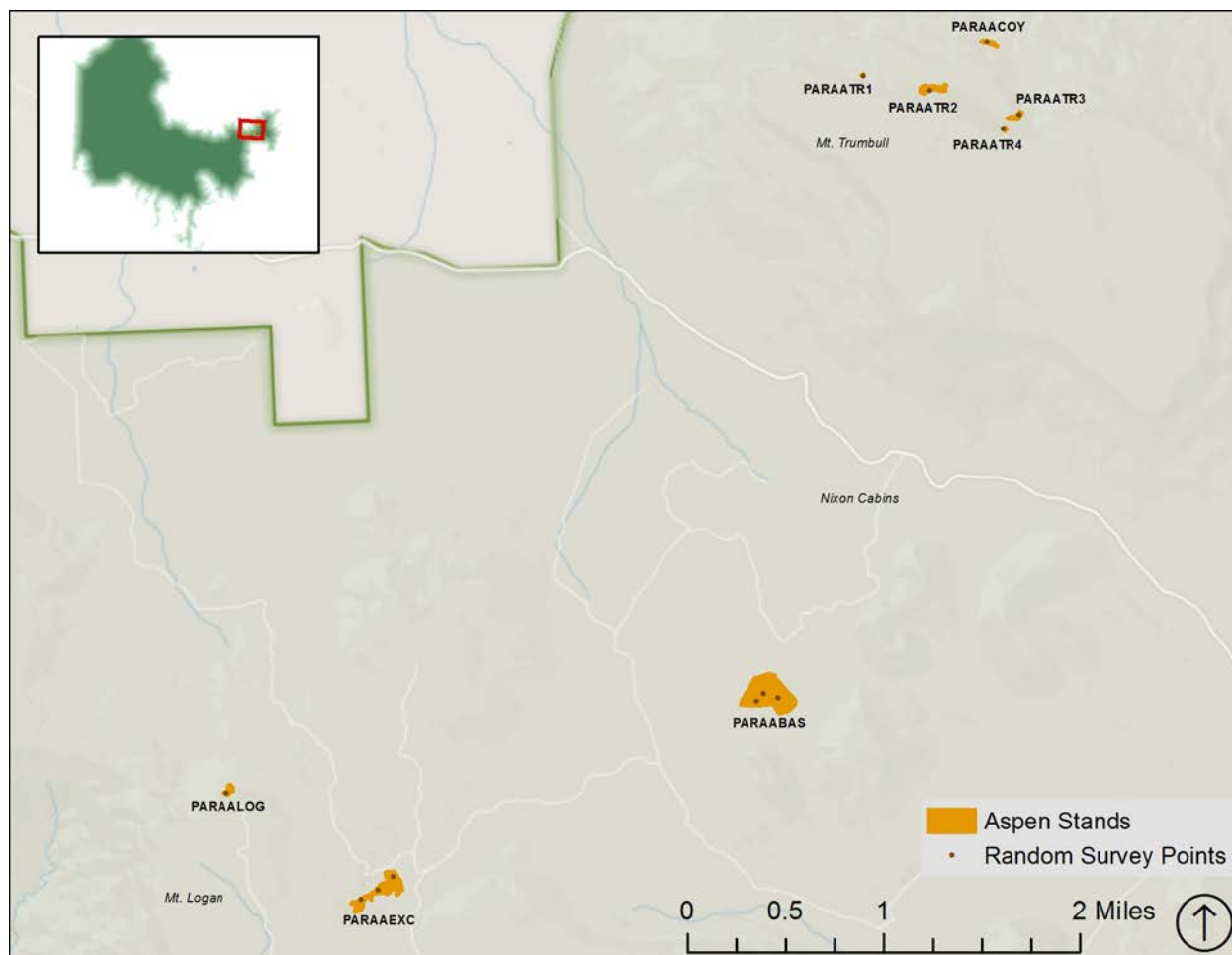


Figure C.1. Aspen Monitoring Sites at PARA

Appendix D. GRBA Stand Overview Maps

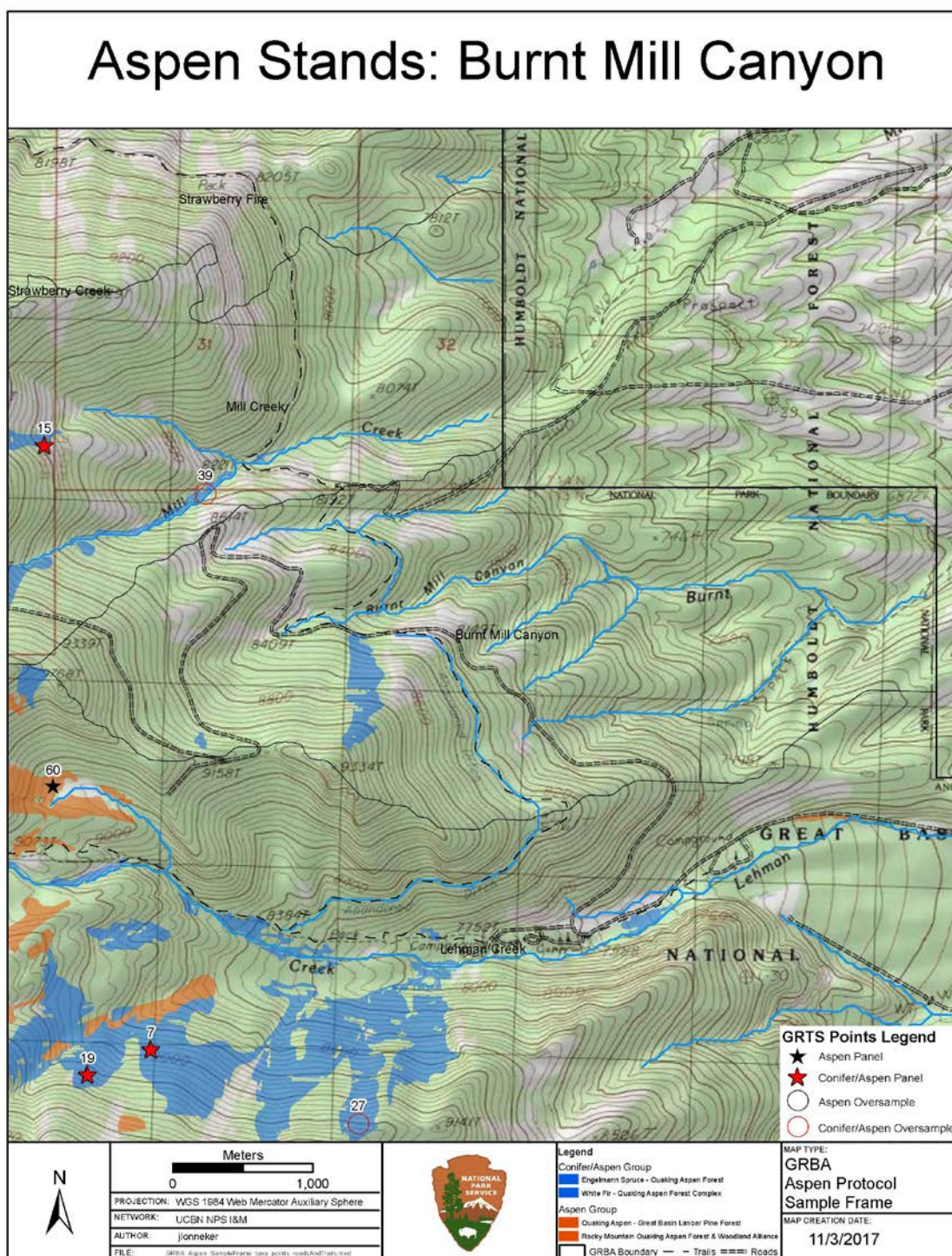


Figure D.1. Aspen Monitoring Sites at GRBA – Burnt Mill Canyon

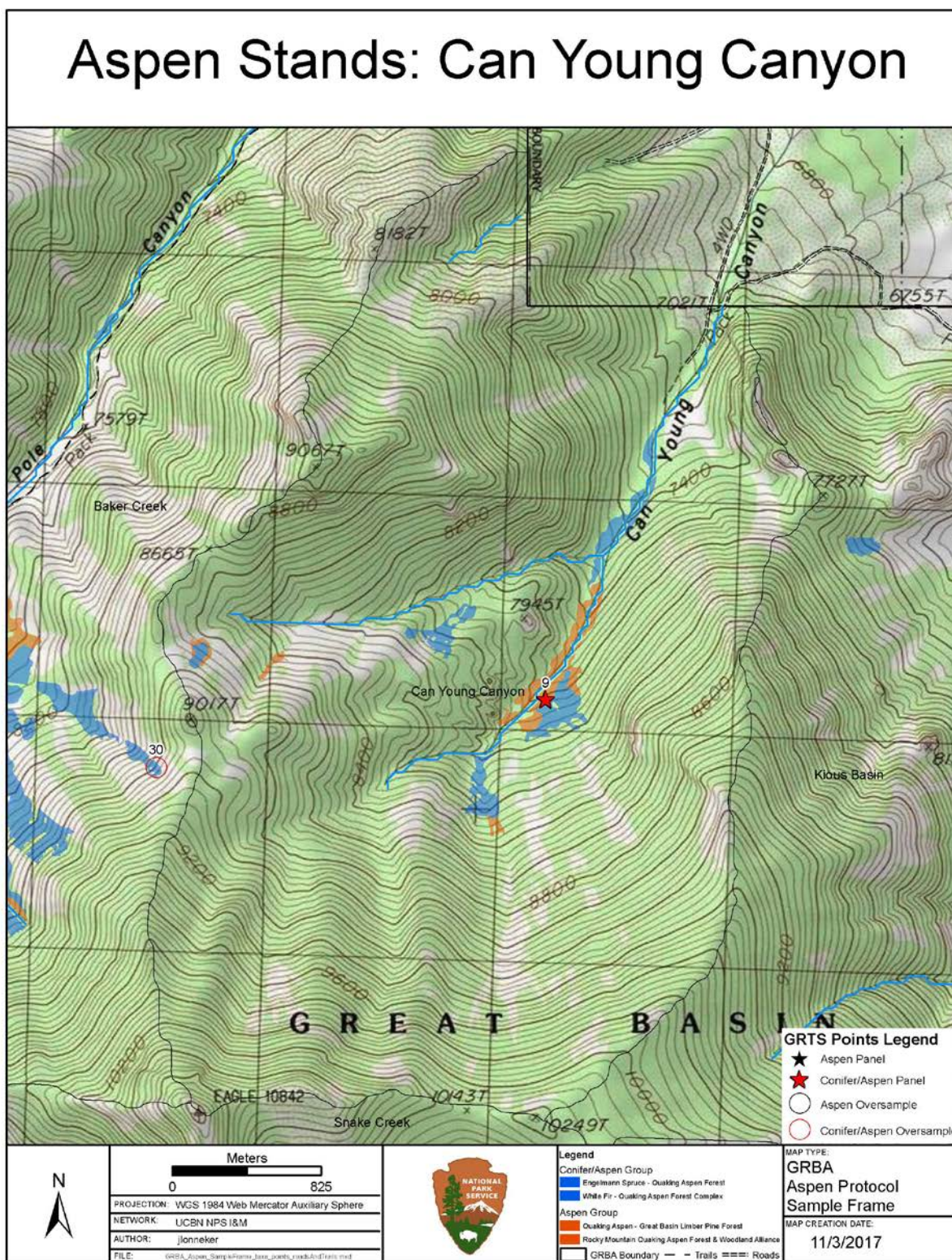


Figure D.2. Aspen Monitoring Sites at GRBA – Can Young Canyon



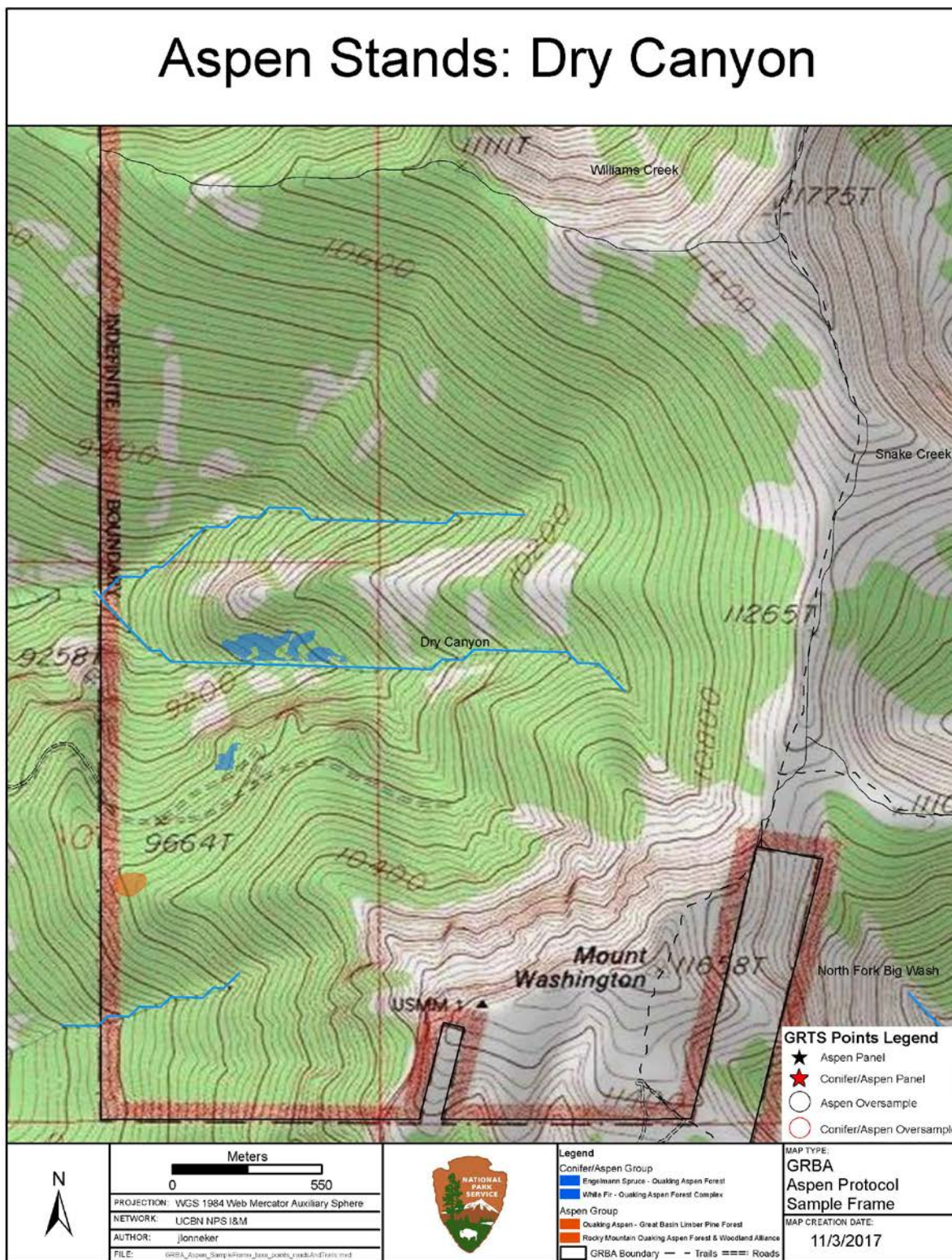


Figure D.4. Aspen Monitoring Sites at GRBA – Dry Canyon

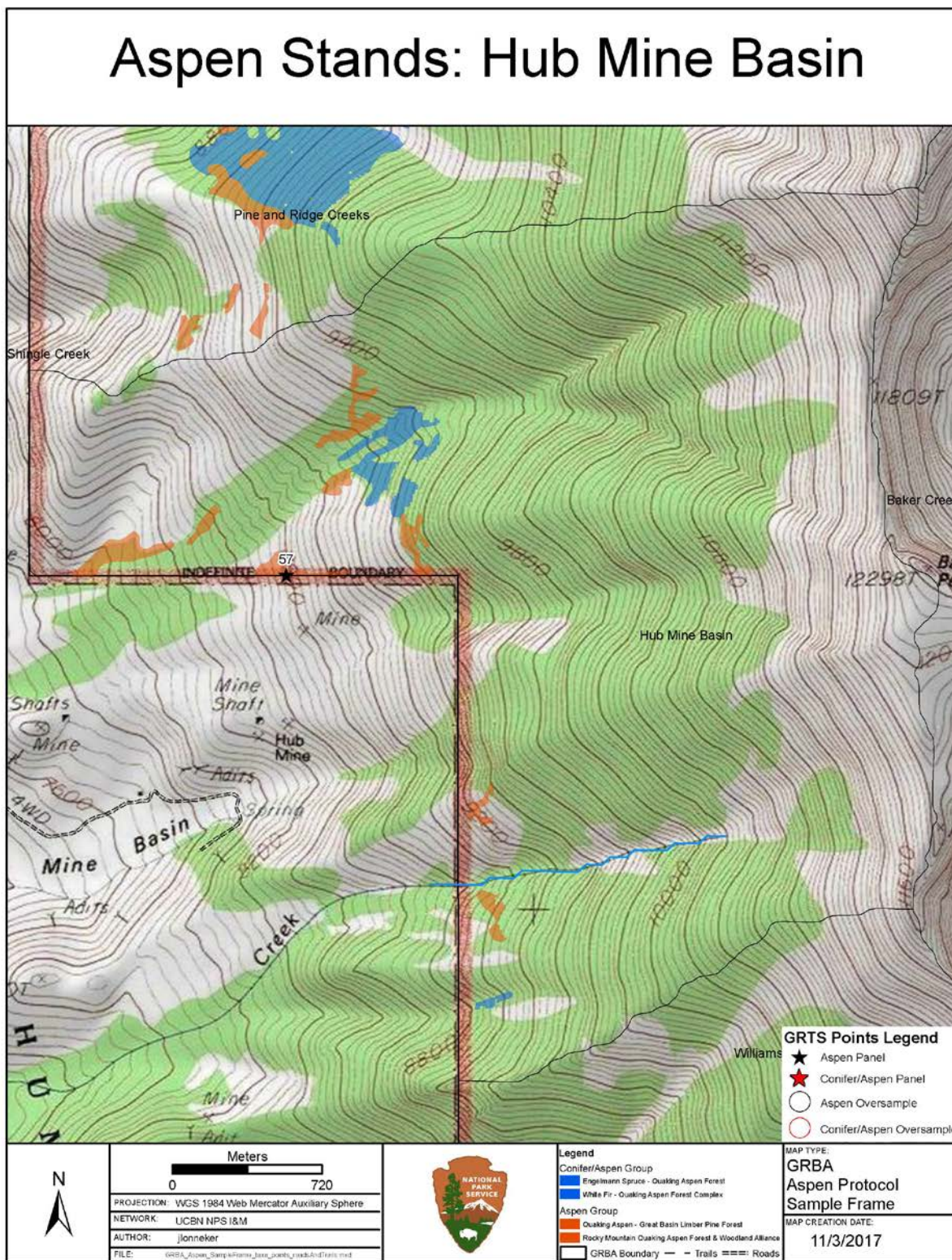


Figure D.5. Aspen Monitoring Sites at GRBA – Hub Mine Basin

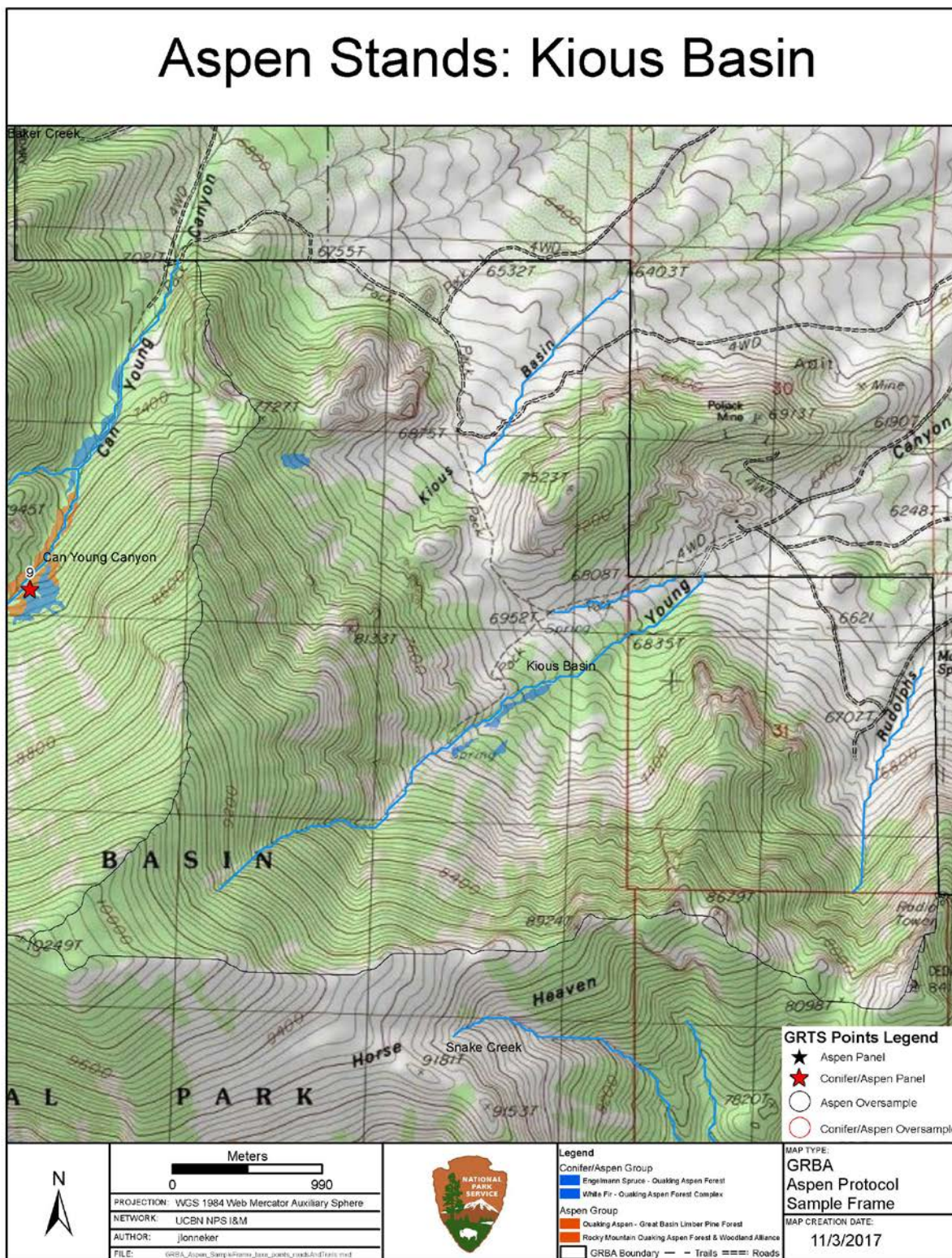


Figure D.6. Aspen Monitoring Sites at GRBA – Kious Basin

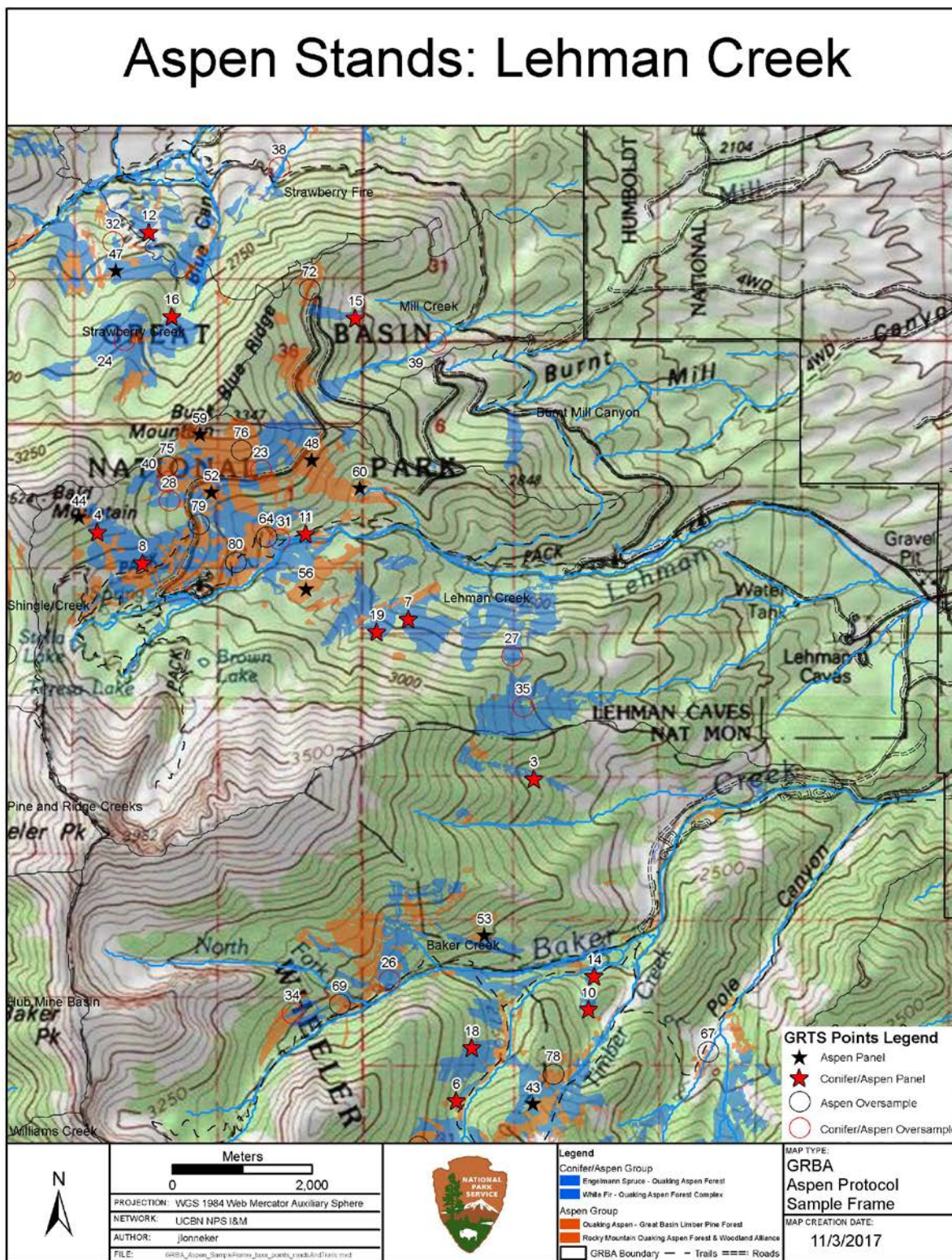


Figure D.7. Aspen Monitoring Sites at GRBA – Lehman Creek

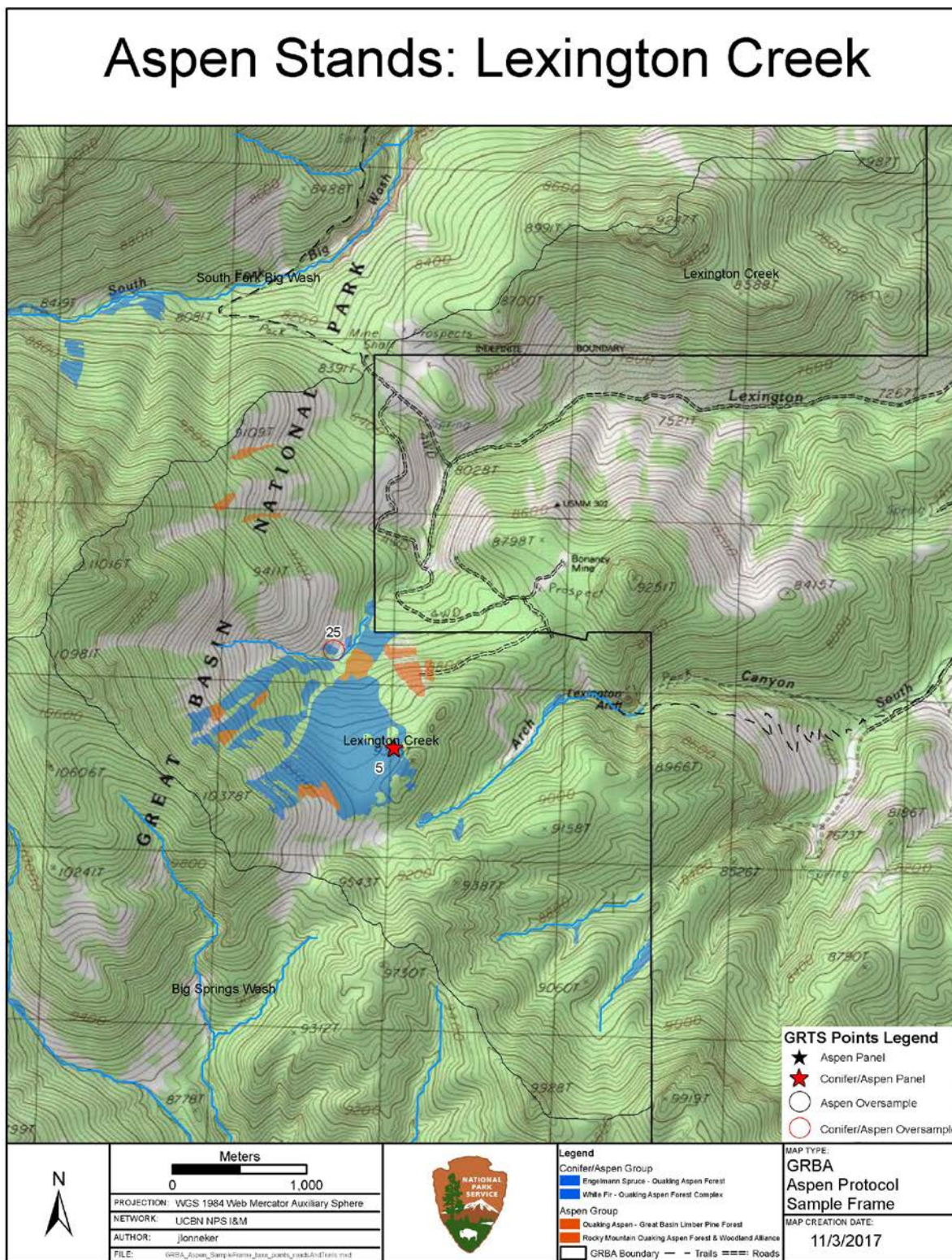


Figure D.8. Aspen Monitoring Sites at GRBA – Lexington Creek

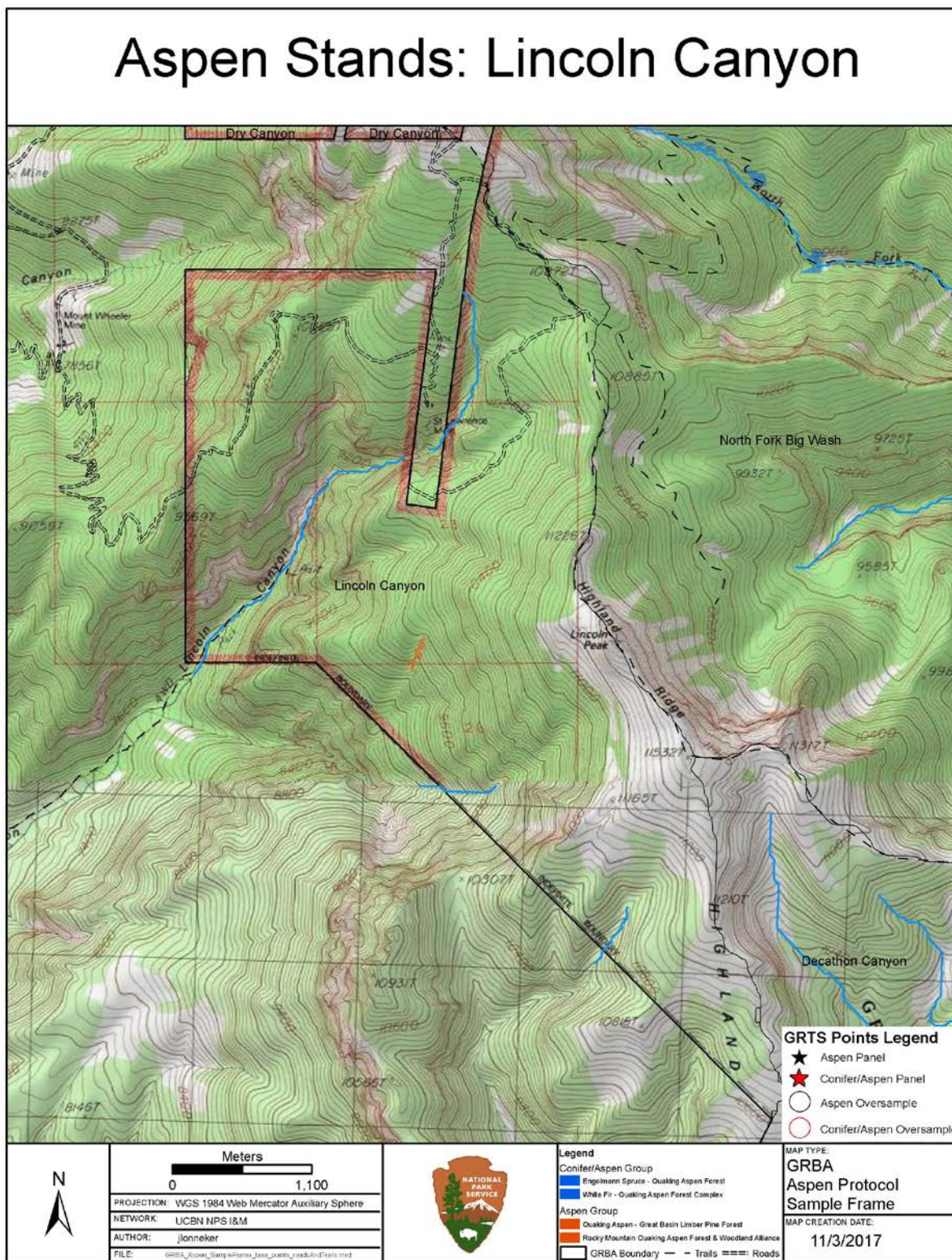


Figure D.9. Aspen Monitoring Sites at GRBA – Lincoln Canyon

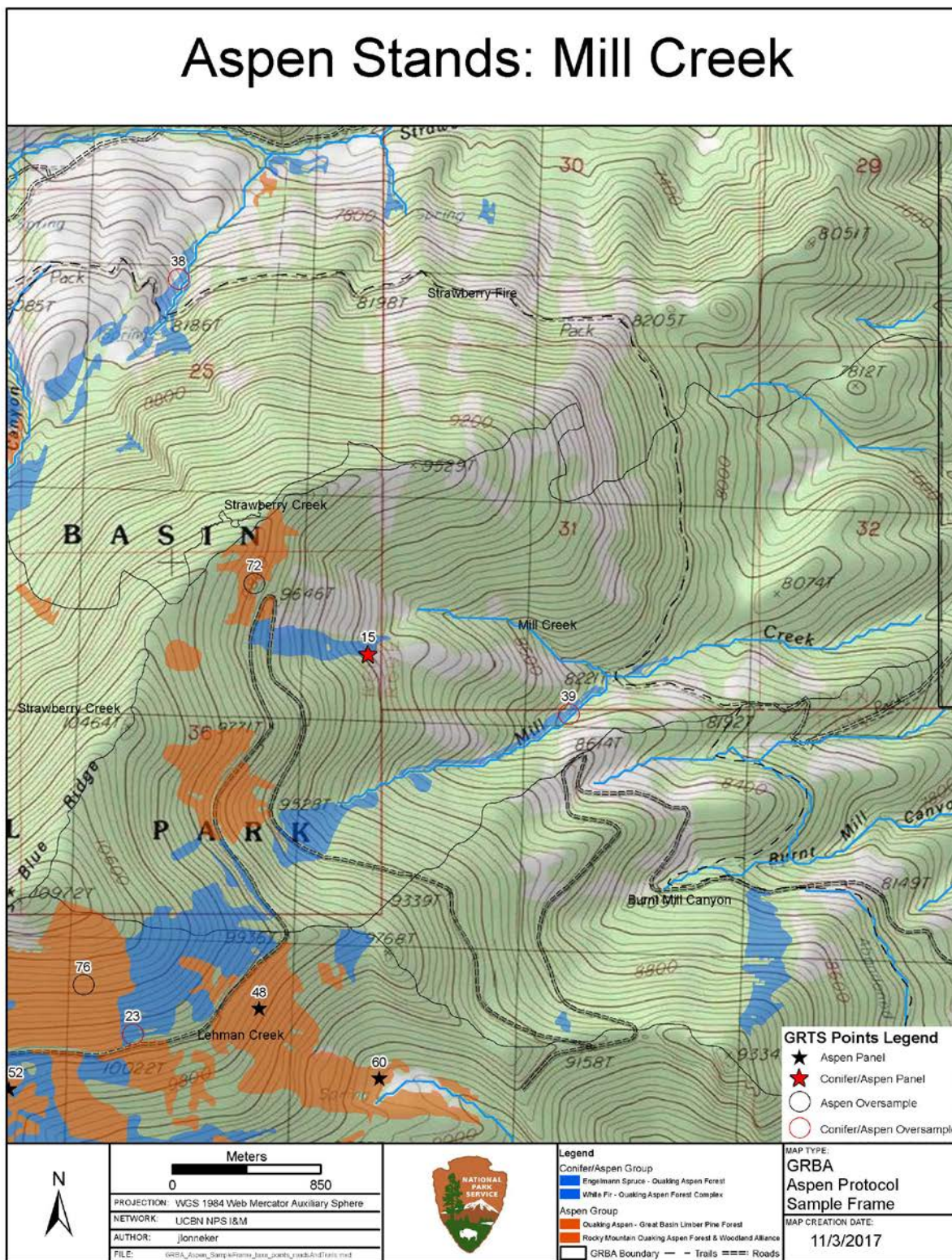


Figure D.10. Aspen Monitoring Sites at GRBA – Mill Creek

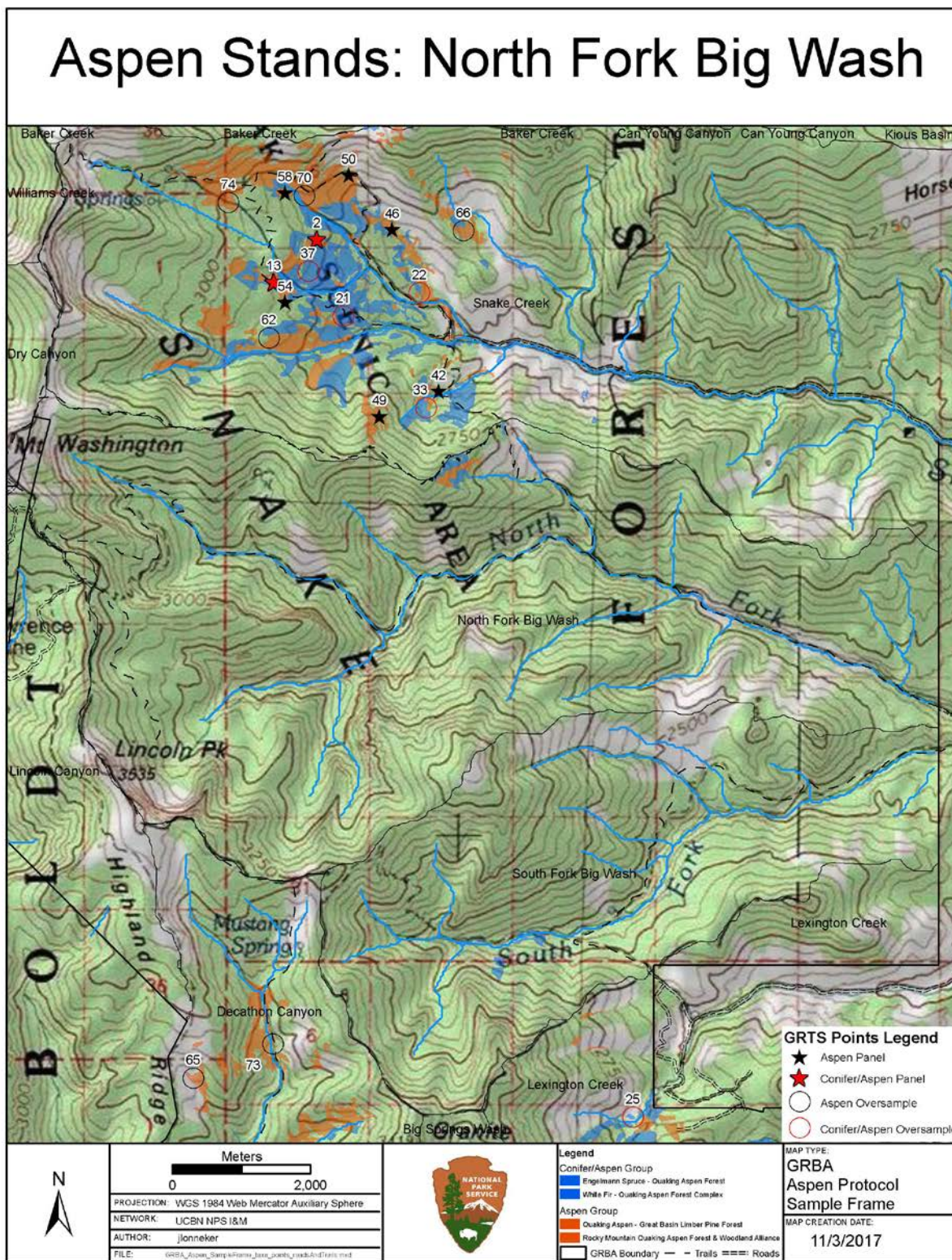


Figure D.11. Aspen Monitoring Sites at GRBA – North Big Fork Wash

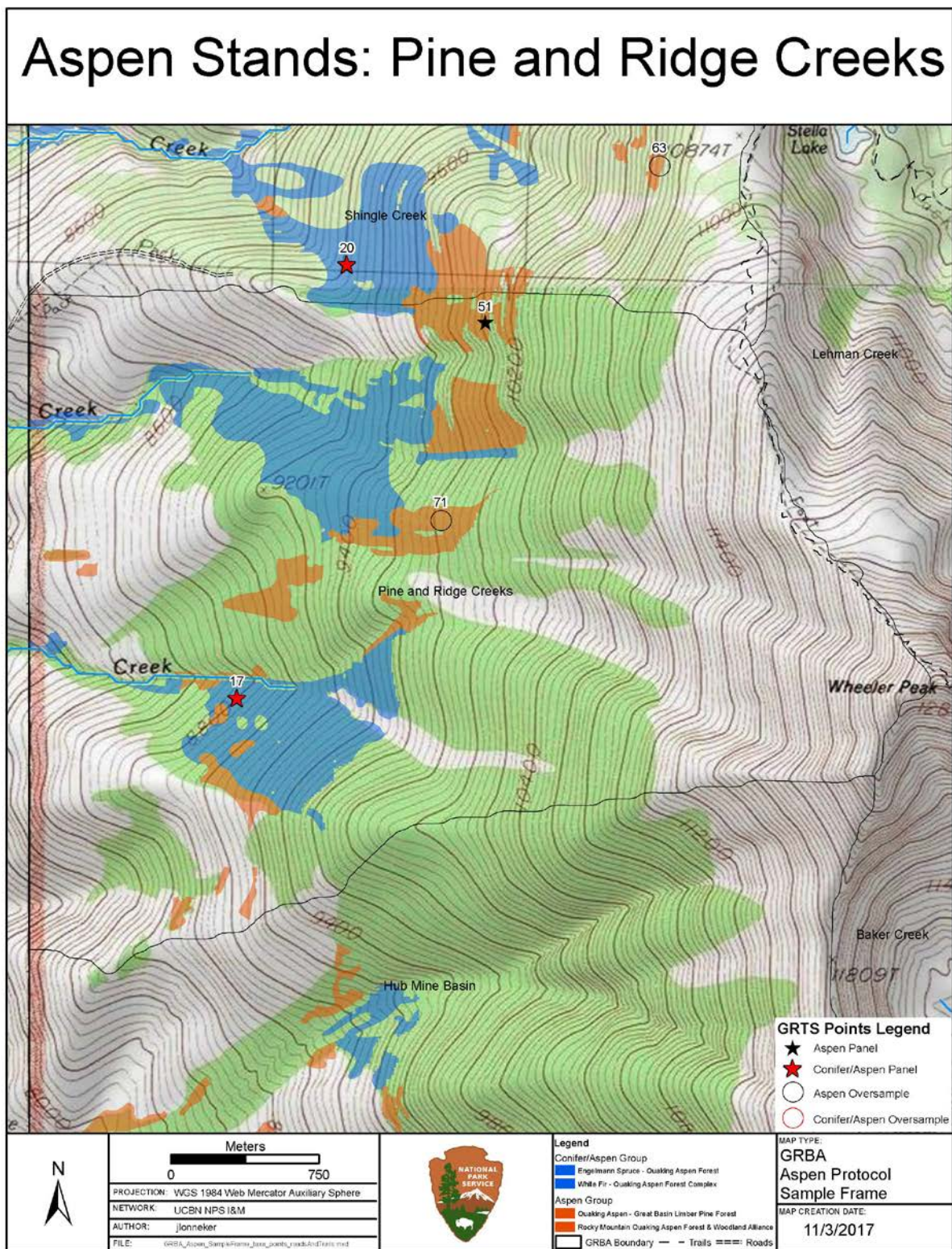


Figure D.12. Aspen Monitoring Sites at GRBA – Pine and Ridge Creeks

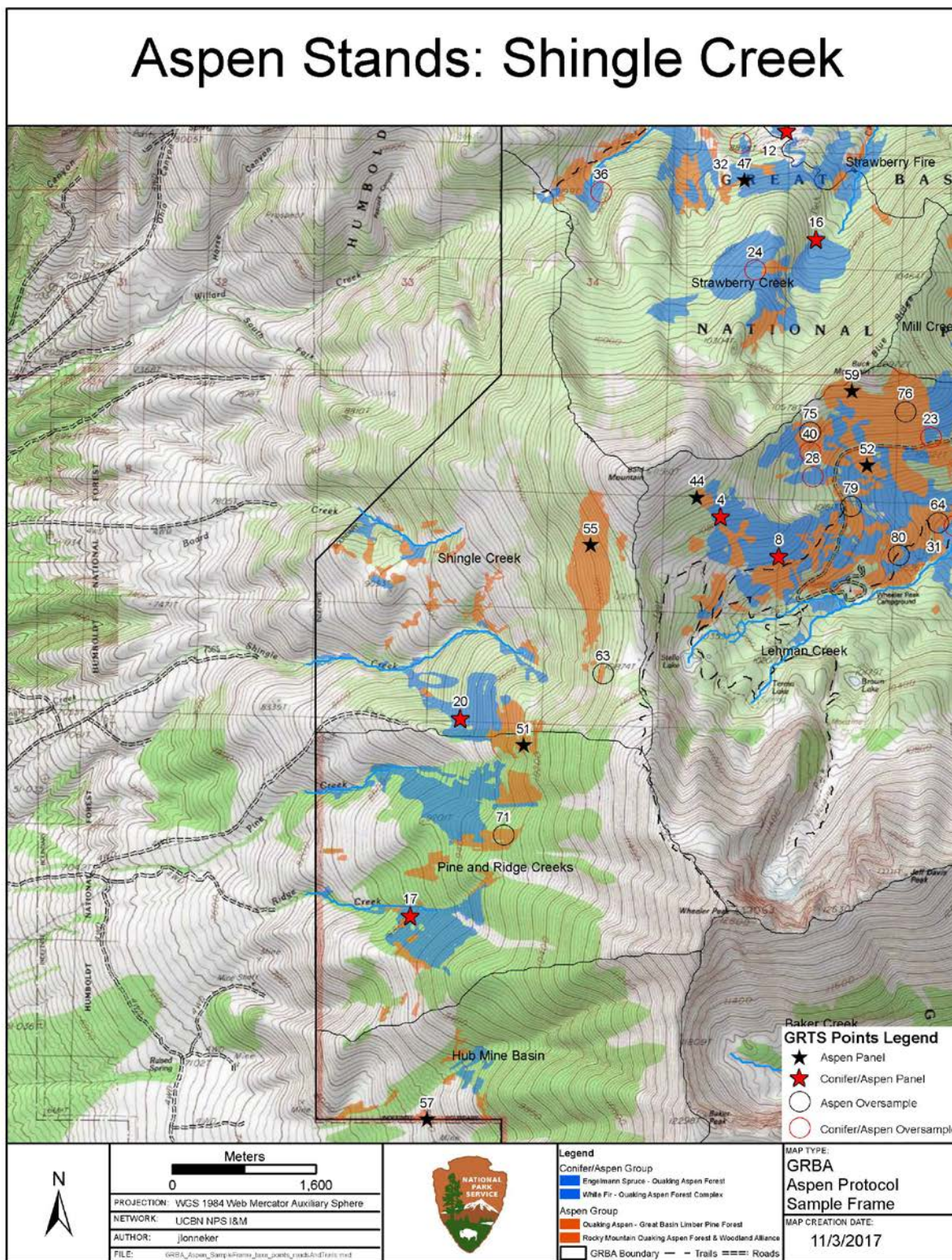


Figure D.13. Aspen Monitoring Sites at GRBA – Shingle Creek

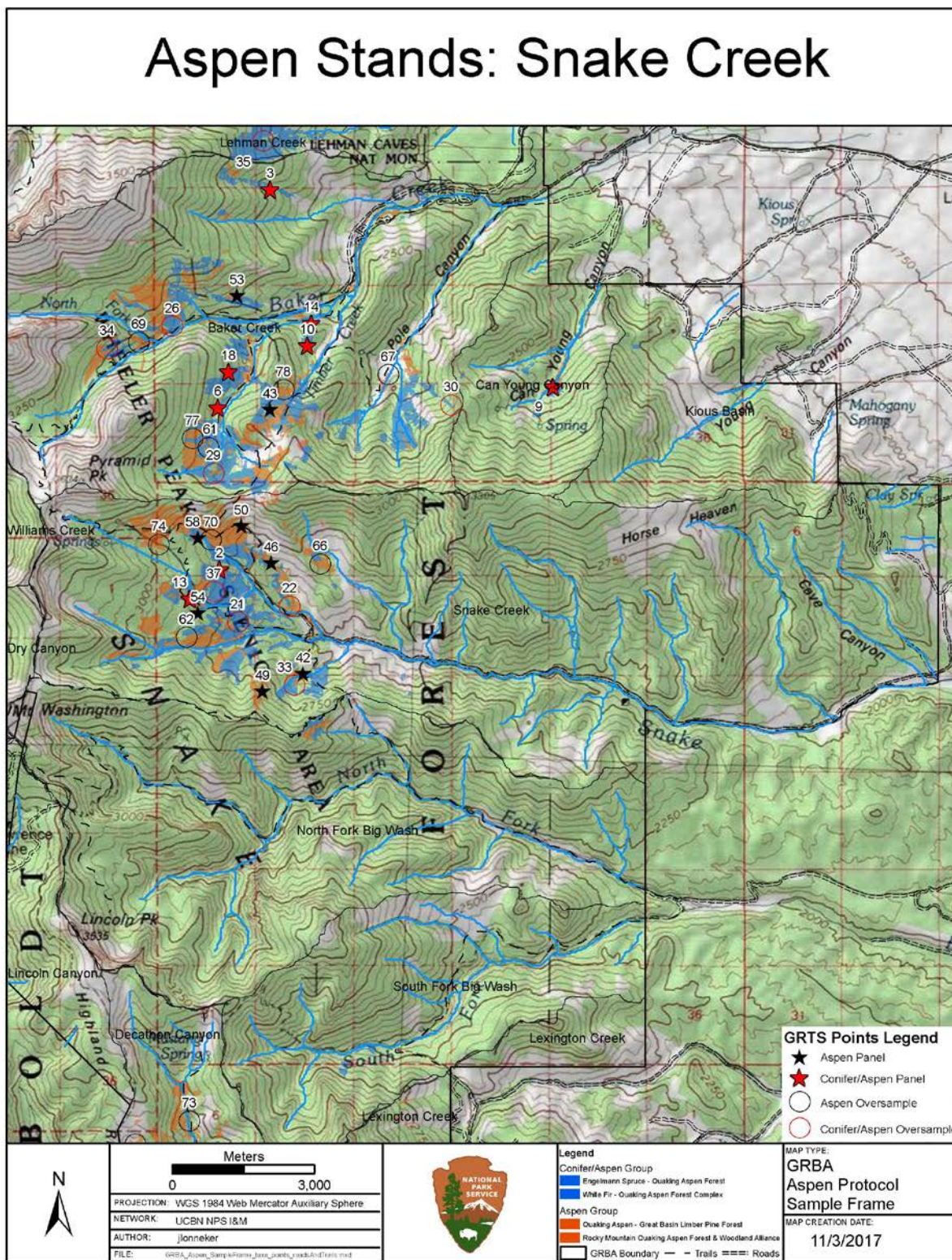


Figure D.14. Aspen Monitoring Sites at GRBA – Snake Creek

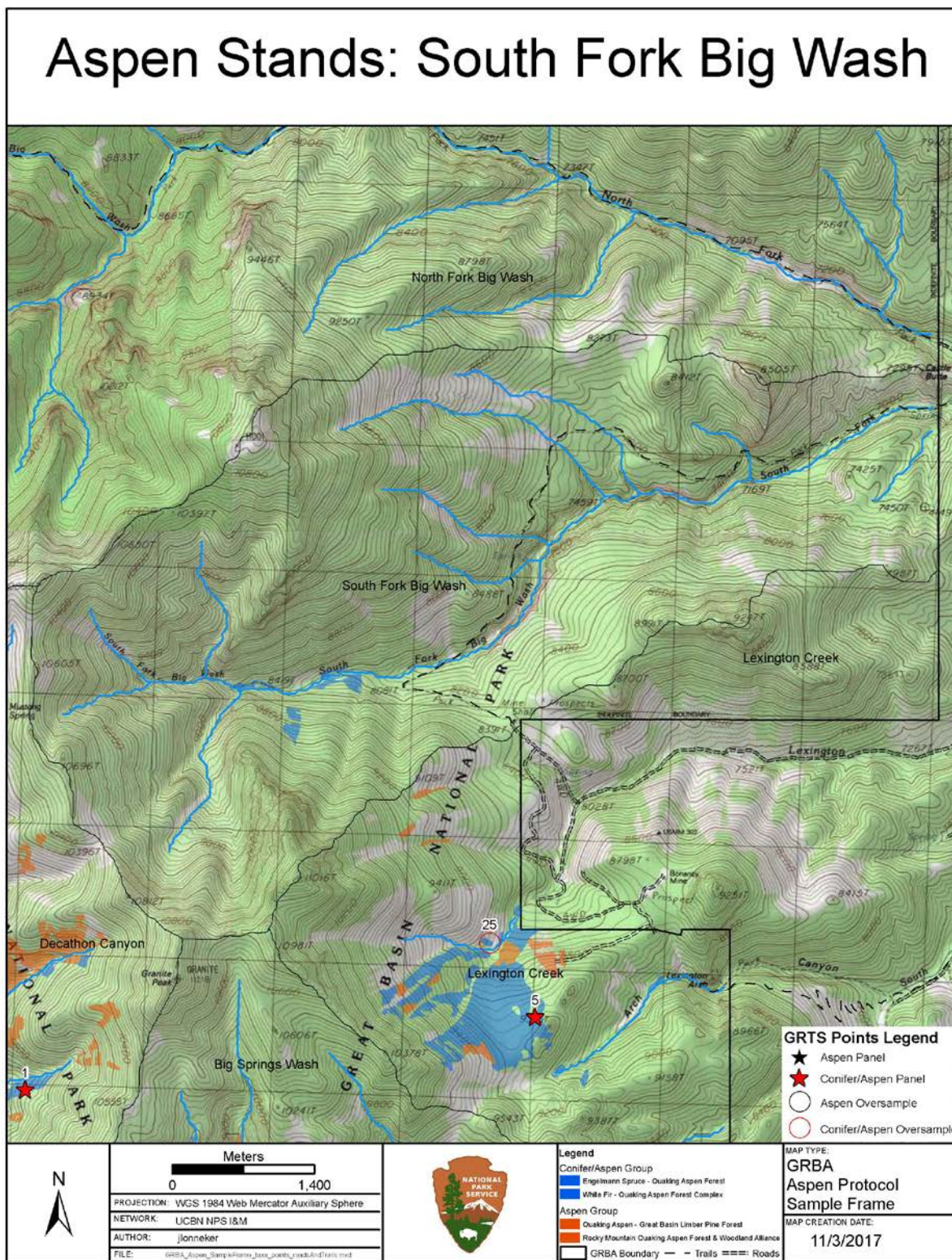


Figure D.15. Aspen Monitoring Sites at GRBA – South Fork Big Wash

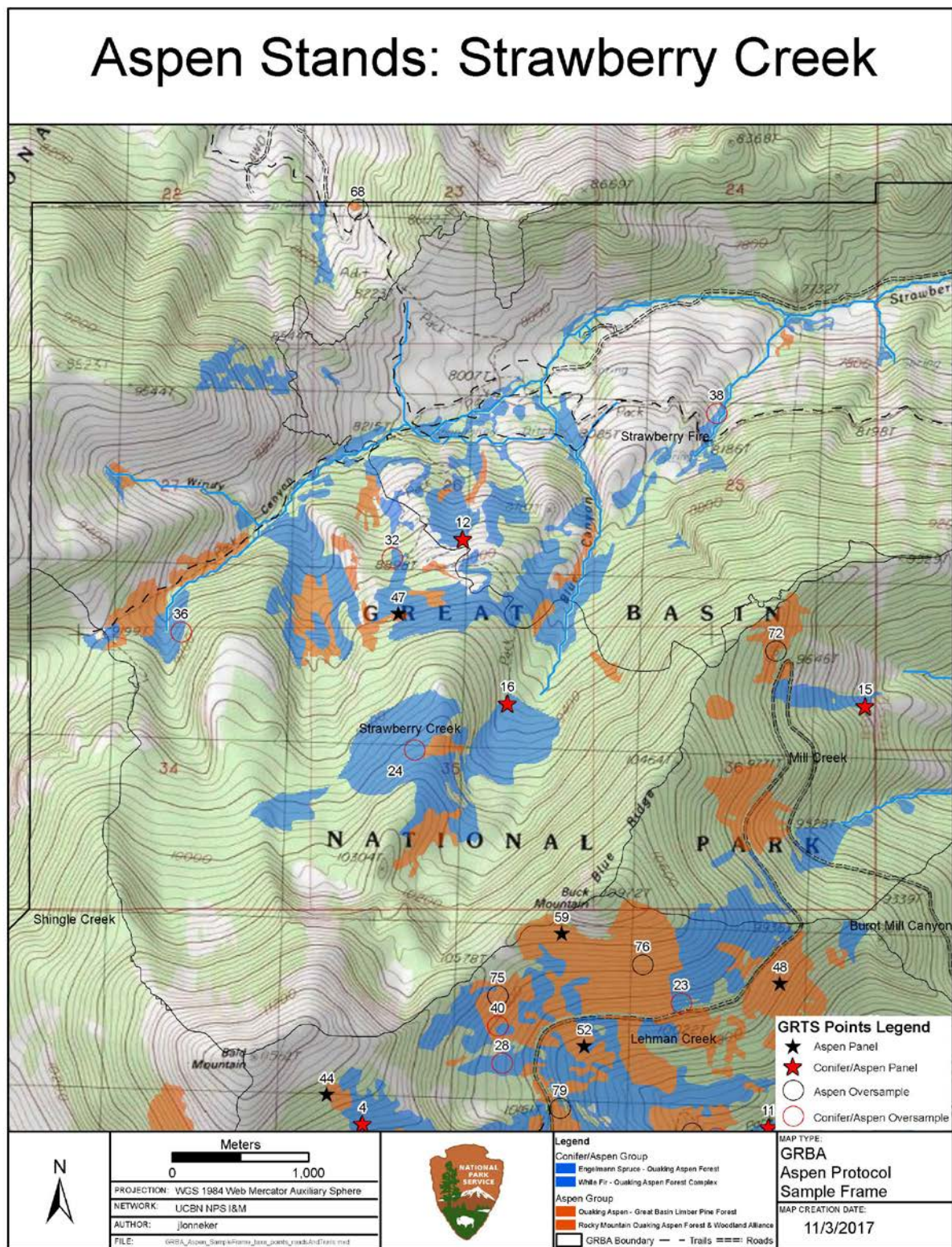


Figure D.16. Aspen Monitoring Sites at GRBA – Strawberry Creek

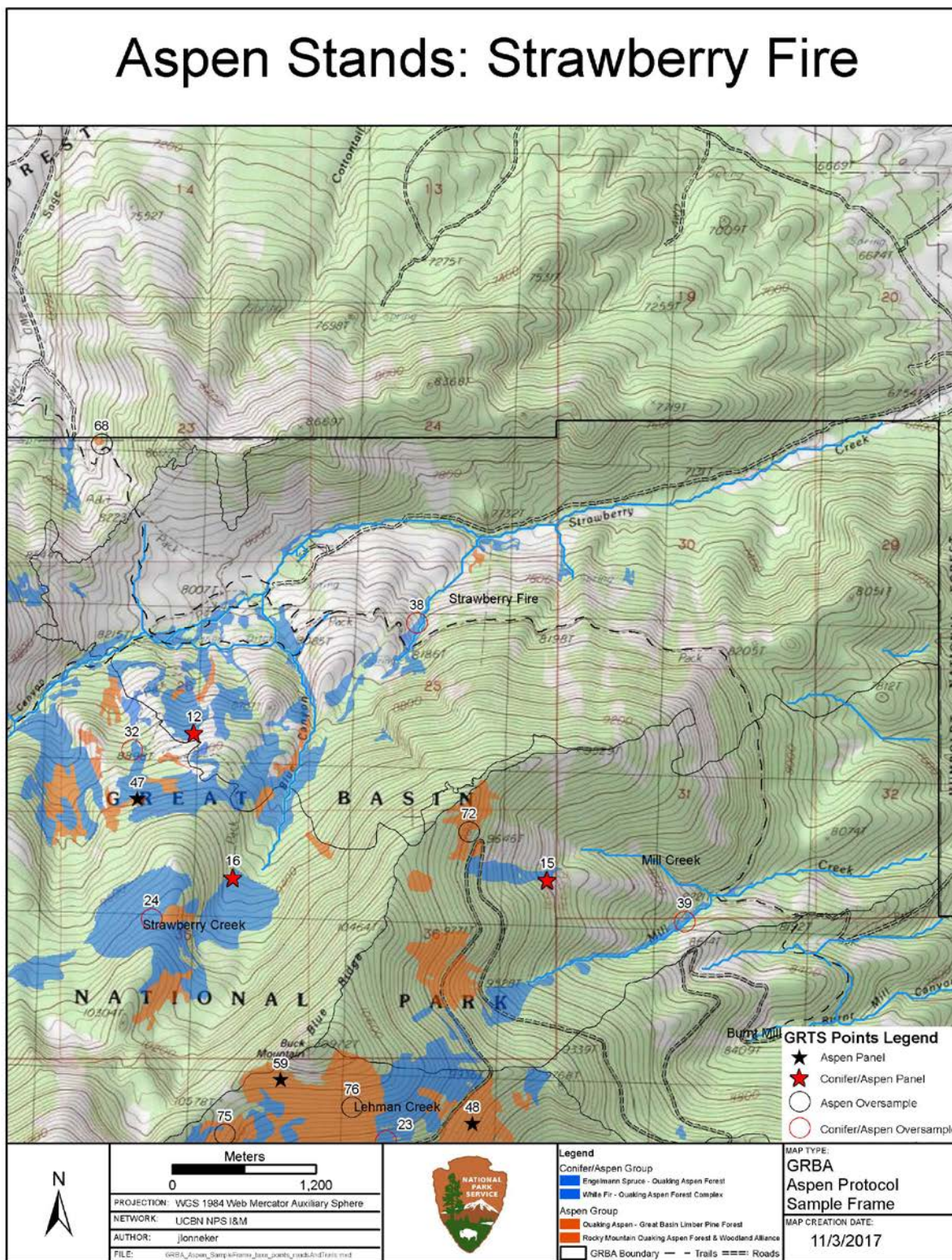


Figure D.17. Aspen Monitoring Sites at GRBA – Strawberry Fire

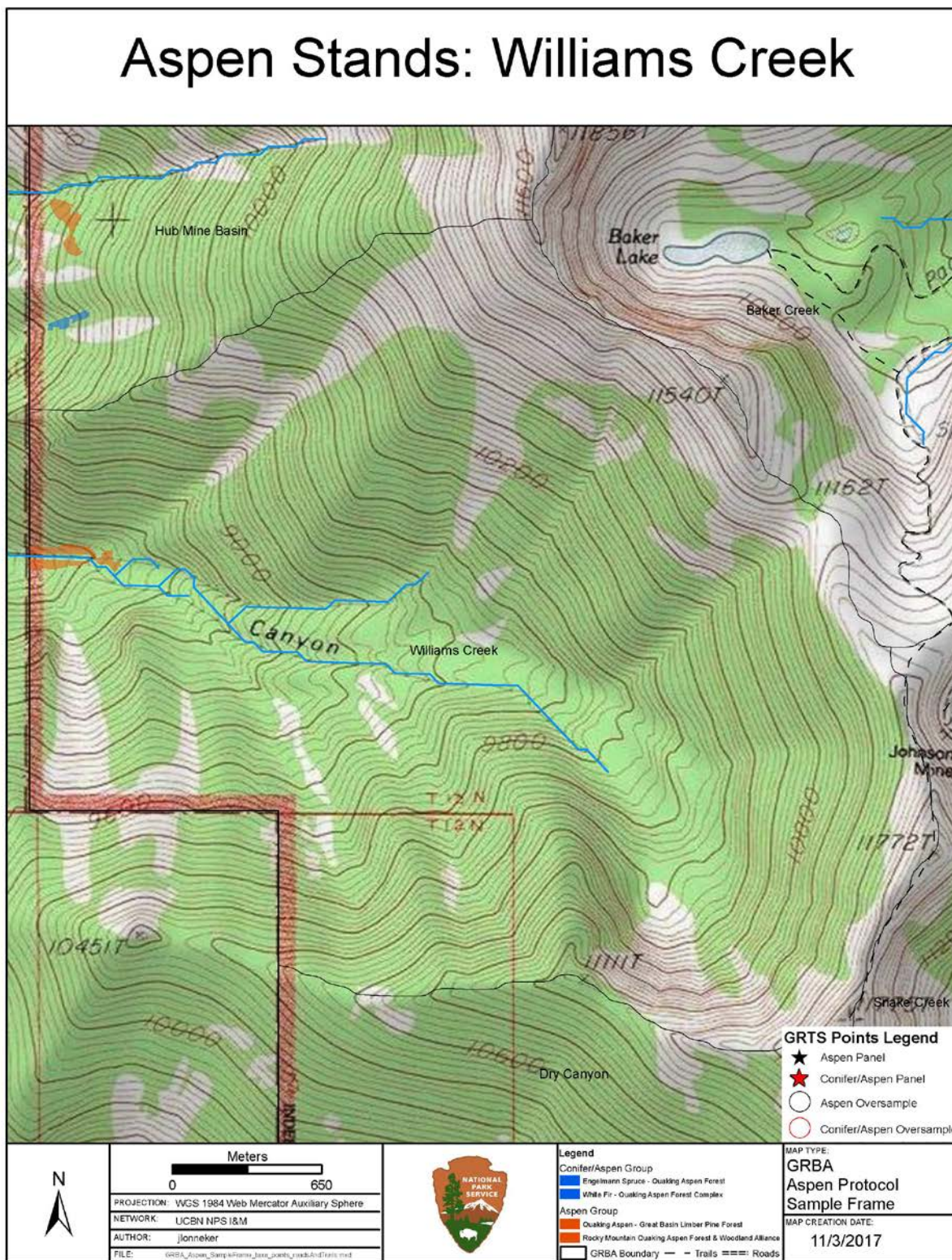


Figure D.18. Aspen Monitoring Sites at GRBA – Williams Creek

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