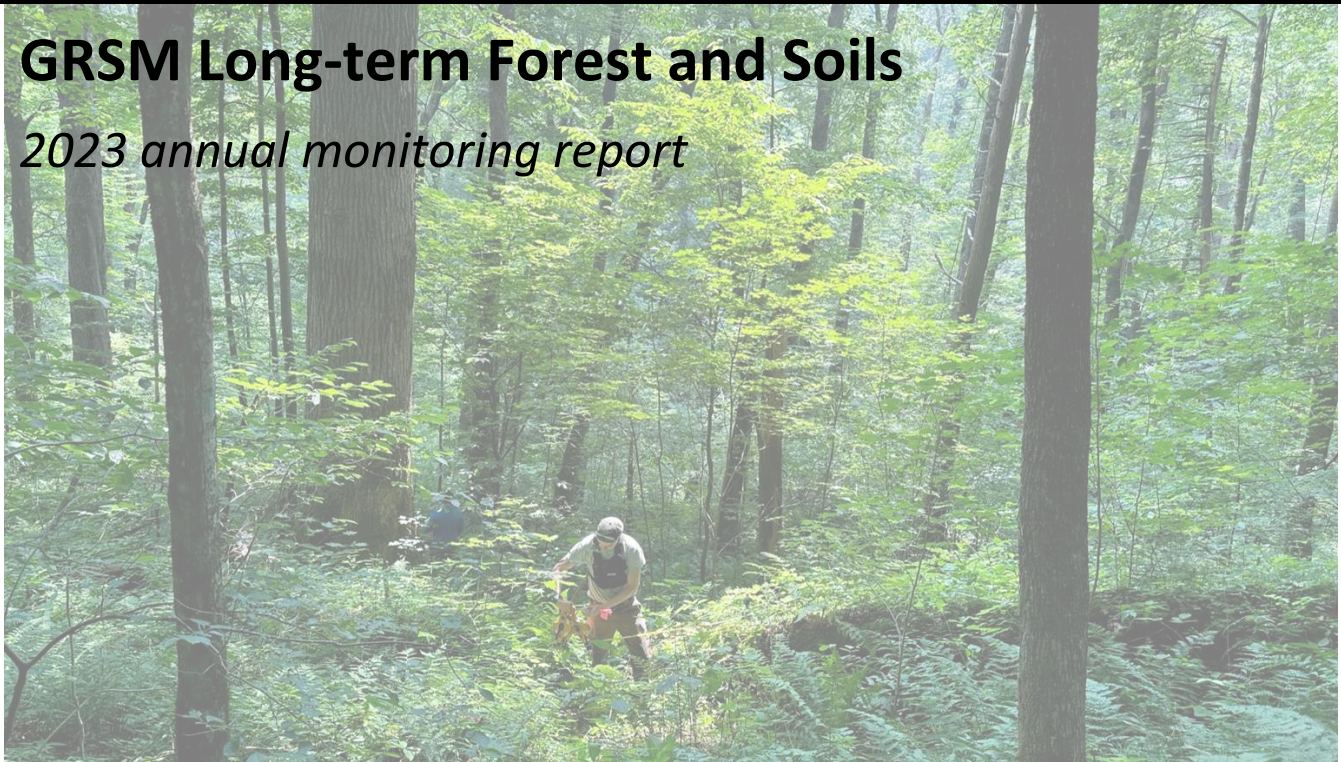




# GRSM Long-term Forest and Soils

## *2023 annual monitoring report*



**Cover photo:** Vegetation monitoring crew members run a forestry tape through a cove forest to establish a plot.

## Forest & Soils Monitoring Introduction

---

Great Smoky Mountains National Park (GRSM) is world-renown for its biological diversity, including over 1700 species of vascular plants. This flora is arranged across gradients of elevation, aspect, land-use history and topography forming over 100 unique vegetation communities that repeat across the landscape. Such diversity in communities makes it challenging to monitor status and trends in ecosystem health, which is the primary purpose of the Vital Signs Monitoring Program. This program monitors six 'vital signs' (acid deposition, water quality, soil quality, climate changes, aquatic communities, and vegetation communities) within GRSM to ascertain overall condition and trend of our natural resources. To monitor vegetation communities and soil quality, GRSM developed a network of 160 vegetation plots spread across all elevations in six major watersheds of the park. This plot network is designed for forested landscapes so other vegetation community types (e.g. grassy balds) and associated soils are not monitored under this protocol (heretofore "Forest Monitoring Protocol"). At each plot, information is collected on living and standing dead tree species, size, and health; tree regeneration in the understory and seedling layer; shrub diversity and density; overall plant diversity and abundance of herbaceous species; abundance of down deadwood, and soil physical and chemical properties. Each plot is classified into a vegetation community type which is then categorized as one of eight major forest types in the park: Oak-Hickory, Pine-Oak, High Elevation Hardwood, Cove Hardwood, High Elevation Spruce-Fir, Early Successional, Hemlock, and Montane Alluvial. This resource brief will review each of the major forest types to help explain how our long-term monitoring can help us learn about the health of each system, as well as providing administrative and logistical records for the field season.

### ***Changes for 2023 field season***

The 2023 field season did not see any major changes in data collection methodologies. However, a few small updates were made and should be discussed here. First, additional soil samples were collected in 12 plots for a pilot Soil QA program. These samples

were sent to a soil lab at the University of Tennessee for analysis, and results will be compared to the standard samples sent to Waypoint Analytical, Inc., which once again received data for all 32 soil samples.

Additionally, a small change in 2023 was the reduction in the list of potential damage codes for overstory trees. Previous QA data had shown that these codes were not used consistently, and this trend was reported across other monitoring networks. A simplified code list was produced, and these codes will no longer be used for standard statistical analysis. Instead, they are used to better describe the condition of the tree in the field to help with future monitoring efforts (e.g., a tree would be listed as either a “twin” or having a “fork” top depending on where the split of the tree was interpreted as occurring – an important distinction for measuring tree diameter).

## Administrative Reporting

---

### ***Crew Members***

Long-term Forest and Soil Monitoring staff for 2023 (Photo 1) consisted of:

Troy Evans, Vegetation Ecologist

Jonathan Cox, Biological Science Technician

Kacey Russo, Biological Science Technician (Seasonal)

Kaylin Fleenor, SECC Intern

Lev Smolianski, SECC Intern

Assistance was given from other I&M staff, including permanent and seasonal employees, and other SECC interns. Particularly, Tom Remaley, Joshua Albritton, Emily Descepedes, Alex Dowd, and Angel Chaffin provided a lot of help with plot completion.



**Photo 1:** I&M vegetation monitoring crew members pause for a photo. Left to Right: Jonathan Cox, Kaylin Fleenor, Lev Smolianski, Kacey Russo, Angel Chaffin, Alex Dowd (photo by Troy Evans).

### Overnight trips

Crews spent 6 nights out in travel status for plot work. This number of nights out is lower than usual, due to decisions to move several plots to long daytrips instead of overnights. Overnights consisted of 2 nights in Deep Creek Campground, 2 nights in Hazel Creek at BCCS #83 Bone Valley, 1 night at Purchase Knob Science Center, and 1 night at Laurel Gap Shelter on Balsam Mountain Trail.

### Completed and Rejected Plots

All 32 plots in this cycle were visited for the 2023 field season (Figure 1). Soil samples were collected from all locations, but vegetation data were collected from all except VSG334. This plot location in the Shutts Prong area of Porters Creek is particularly difficult to work in, and it was deemed that vegetation sampling would be too dangerous and would cause too much damage to vegetation if completed this year. VSG334 is a lower-slope site with significant hemlock loss and deadwood, and is situated on a steep boulderfield with a dense layer of dog hobble (*Leucothoe fontanesiana*) covering the site. This combination of factors make leg entrapments or significant falls very likely, and running accurate field lines almost impossible. Site conditions will be reviewed next cycle and a decision made about whether to keep or replace the plot in future cycles.

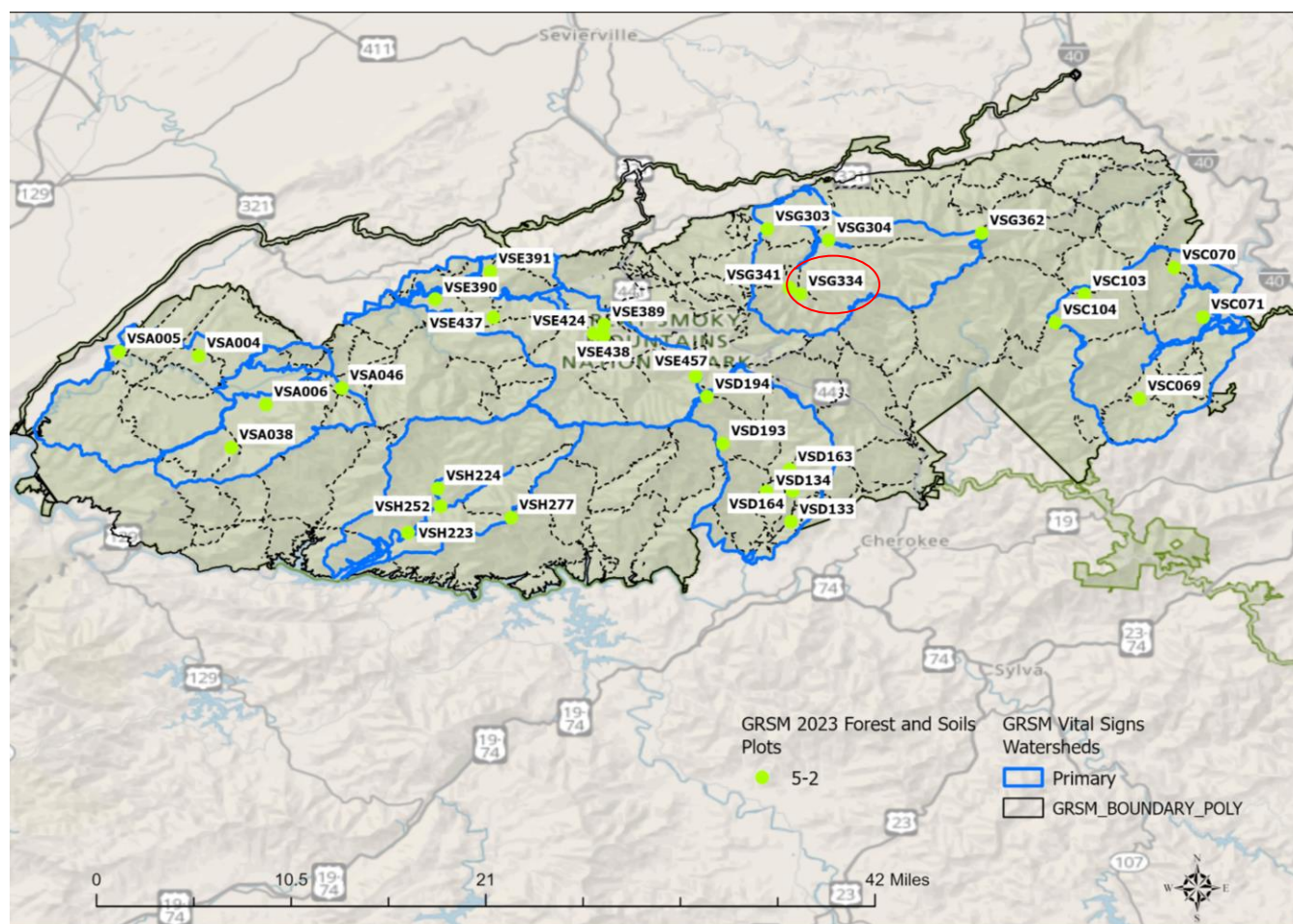


**Figure 1:** A map showing the 32 completed plot locations for the 2023 field season. Specific information for each plot can be found in Appendix B. VSG334 (circled) only had soil data collected.

## Lessons Learned and Notes for Re-reading Plots

---

### **Safety Lessons Learned**

There were no major lost-time incidents in 2023 among field staff. Near misses and safety considerations were standard for field work. Specific thoughts are listed below:

**Field-treatment of Insect Stings** 2023 was a particularly bad year for ground-nesting and aerial stinging insects, especially yellow jackets. Nests were encountered almost daily, and crew members received stings multiple times a week. While stings are more often a nuisance than a life threat, the risk of anaphylaxis and the potential for secondary injuries while escaping from insects can pose real risks. No crew members in 2023 had a history of elevated reactions to stings, and no elevated reactions occurred in the field. However, diphenhydramine was taken by crew members on several occasions to treat post-sting symptoms, such as swelling and headaches. While this treatment is appropriate in those circumstances, it is worth noting that individual tolerances to diphenhydramine vary, with some individuals becoming extremely drowsy or ataxic afterwards. These effects from antihistamines should be considered in the overall picture of field safety before taking in the field. Particularly, any crew member that takes Diphenhydramine or other antihistamines that may cause drowsiness should not operate a vehicle for a reasonable period afterwards. Also, the added risk of drowsiness or a loss of balance should be weighed against the potential for an adverse allergic reaction to the stinging before a crew member takes antihistamines. Additionally, good field communication and planning is needed for environmental threats such as stinging insects or venomous snakes (Photo 2). Any occurrences in or near the plot shall be communicated to all crew members, and the location be visible marked with a pin flag or something similar for awareness (in 2023, we used a blue pin flag for any hazards in the plot).



**Photo 2:** One of several timber rattlesnakes (*Crotalus horridus*) seen throughout the field season. Crews began marking in-plot hazards, such as venomous snakes, with blue flagging to note a hazard is present.

**Upstream Travel for Plot Access** 2023 field work included 3 plots that required long-distance upstream movement to reach. Two of these were in the Greenbrier area, and one in the Little River area. Each stream was unique and had unique challenges that varied with gradient and stream order. In all cases, helmets should be required PPE for stream travel, though were not used for two of these plots. No near misses occurred, but this added piece of PPE will help mitigate some of the risk involved with moving

up drainages that are often filled with *Rhododendron* on both banks, forcing crews to stay in stream channels. When possible, visit plots before the field season to find best approach routes and note any specific hazards that may exist along the way.

### **Thoughts for re-reading plots in this cycle**

This section covers notes on re-visiting specific plots, to be used as reference during future revisits.

**VSA005** This plot is on a spur ridge off of Happy Valley Ridge, upslope of BCCS #1. This location burned in 2016, and subsequent regeneration makes it difficult to approach slope from directly downslope. The best approach to come up ridge to the east of the plot as high as possible, then cross the ravine traveling west to the plot location.

**VSA038** This location is relatively easy to access off of Gregory Ridge Trail, but the plot itself is very steep and has extremely high coverage of greenbrier. It is a difficult site to work in, and so crew selection should be considered for visiting this location.

**VSA046** This plot is on Allnight Ridge to the east of Anthony Creek trail. It has a long off-trail approach that is all relatively steeply uphill. The spur ridgeline that extends due west of the plot is difficult to traverse due to pine beetle kill, and the ravines are difficult due to downed hemlock and very dense rhododendron. The best approach in 2023 was to cross Anthony Creek at the toe of the western spur ridge, then ascend that ridge staying off to the south edge of it for the duration of the approach. Multiple stinging insect nests encountered on approach and in the plot.

**VSC071** This plot is on a low ridge over Cataloochee Creek Road in the vicinity of the group campsite. Approach in 2023 largely matched the 2017 approach. This is a long section of steep off trail with intermittent *Rhododendron*, *Kalmia*, and downed hemlocks along the way. In 2023, best approach was up one of the low ridges instead of staying in the ravine, but conditions may change by next cycle. Notably, in both 2017 and 2023, a rattlesnake was located in Module 2 of the plot.

**VSC103 & VSC104** These two Cataloochee plots are in the vicinity of Laurel Gap shelter, and in 2023 were completed as a single overnight trip. VSC103 was completed on the first day, after hiking to Laurel Gap shelter and dropping overnight gear. VSC104 was then completed on the hike out.

**VSD133** This plot is on a low, steep spur ridge off of Indian Creek in the Deep Creek area. It can be approached several ways, either by starting up the ravine to the south of the spur ridge, then gaining the ridge when feasible, or by starting west or north of the spur ridge and gaining it as soon as possible. Indian creek can be challenging to cross without wet-wading through it, so best approach may be dependent on the best place to cross the stream. The narrow ridgeline at the plot is slippery, and resource damage is possible on a wet day, so plan for a dry day if possible. Multiple stinging insect nests in and around plot.

**VSD134** This plot is along McCracken Branch on Deep Creek Trail. Best approach still follows the 2017 tracklog, approaching plot up the steep spur ridge to the west of the plot, then cutting side slope through several ravines to the plot location. Moving up McCracken Branch does not look like a feasible option.

**VSE390** This plot sits on a low ridge between Little River Road and Lumber Ridge Trail. In 2017, the plot was approached downslope from Lumber Ridge, though this access required a long on trail hike then significant elevation loss and re-gain to exit. In 2023, we approached the plot by hiking up White Oak Flats Branch from Little River Road. This hike in is a little over a mile off trail and follows a moderately-established manway. Moving up the manway is slow-going, and high water would make this approach very difficult. However, White Oak Flats approach is probably still preferable to Lumber Ridge.

**VSE424 & VSH224** Both of these plot locations are relatively easy to access, but both are in nearly continuous rhododendron on very steep toe slopes. Running plot lines and collecting data are difficult, crew selection should be considered for both of these locations. In addition, VSH224 involves multiple crossing of Bone Valley Creek and should be attempted at lower water levels. A UTV could be used to access the plot via Bone Valley Trail, but then 1 additional off-trail crossing is still required to reach the plot.

**VSG303** Best access to this plot largely follows the 2017 tracklogs, approach the downslope cemetery then continue upstream ~180 meters before starting upslope. This drainage is young successional with largely open understory, though it is very steep. Once on contour with the plot, cut back NE across two ravines to plot location.

**VSG334** This plot up the Shutts Prong drainage of Porters Creek is the one that was skipped for vegetation data in 2023. As described above, the plot is on a low, steep slope with continuous boulder field coverage and dog hobble on top of that. Many downed hemlocks add to the difficulty of mobility in the plot. Even collecting soil was difficult due to the boulder coverage and

lack of A-horizon over much of the plot. Reassess this plot next cycle and determine if it should stay in the network or be permanently removed. Approach involves upstream travel in Shutts for around 400 meters, which is not too difficult in low water conditions.

**VSG341** This plot sites about 1000 meters up Lowes Creek from the Porters Creek intersection. Best approach as of 2023 was to hike Porters Creek Trail to Fern Branch Falls, then follow Fern Branch down to Porters Creek, and find a safe place to cross to access Lowes Creek. Once in the Lowes Creek drainage, vegetation really keeps you in the drainage for most of the hike, with water levels at times around waist deep, though normal around knee deep. Once about 200 meters from the plot, it is possible to move to the west slope of the creek and hike through the woods to the plot locations. The rhododendron ends below here and overland travel is not difficult. In future years with forest succession, approaching the plot overland again via gaining elevation in Canon Creek drainage then bumping over the ridge is a possibility. IN 2017 it was extremely difficult due to thickets of greenbrier and downed hemlocks. Best to scout pre-season.

**VSG362** This plot is in the saddle between Old Mt. Black and Mount Guyot, and falls about 60 meters off of the Appalachian Trail. In 2023, the decision was made to complete this plot has a long day-trip instead of an overnight. This was feasible, but required an extremely fit crew and an early start. Any other plots in the Mt. Guyot area that are further in than VSG362 will likely still require an overnight stay to complete.

### ***Observational totals for 2023***

The 2023 field season included collecting data on 2134 trees of 46 different taxa, recording 1498 plant species records from 281 different taxa, averaging 48 per plot. Soil samples were collected from all plots, and double-collected from 12 plots for QA. Additionally, 4,525 shrubs were identified and measured, and 12,253 seedlings were identified and counted.

## **Results of QA and Data Validation**

---

### ***Field Quality Assurance (QA)***

Quality Assurance (QA) is a broad data concept that involves confirmation that data collected are accurate and complete. Field QA (referred to as just QA in this section) is a subset of this concept that involves double-collection of data in the field by independent observers, which is then compared to ascertain observer error. Observer error values are compared to the pre-determined Data Quality Standards (DQS, internal link [here](#)) to confirm that standards are being met. If/when error falls outside of DQS thresholds, corrective actions are taken to reduce error – generally either continued crew trainings or proposed protocol changes. For forest vegetation data, field QA is completed throughout the season by choosing two plots to re-measure QA data for each datasheet. The QA collection is performed on the same day as regular data collection by a separate crew. Soil data QA is completed by sampling enough soil to run two lab analyses, which are then compared to obtain observational error.

In 2023, vegetation QA results were overall positive, but several metrics show room for improvement. A brief overview is below, and the QA report (internal link [here](#)) is available for more information. Soil QA have not been completed at this time, and so will be reportedly separately when analyses are received.

### **Tree DBH and Canopy Position Measurements**

Tree diameter can be a struggle to match exactly in the field, and the current standard is for 2 observers to be within 0.5 cm of each other. In 2023, values fell outside of the 0.5cm threshold 12.5% of the time (10 out of 80 trees). This is a significant improve over 2021 values. After two years of specific training and QA data collection, we have determined that the 0.5 cm standard is too rigorous to realistically achieve in the field, especially with the large number of trees within GRSM that are over 50cm in diameter. Starting in 2024, the standard will move to 1 cm between two independent observers. Crews will strive to still meet the 0.5cm threshold, but up to 1 cm disparity will be allowed within the standard.

Tree canopy position is a categorical metrics that classifies live trees as either Dominant, Co-dominant, Intermediate, or Suppressed. DQS for canopy position is that two observers will agree on a class 90% of the time, and neither of the QA plots met

this threshold (18% and 43% disparity). All values were within 1 class of each other, and most confusion was between suppressed and intermediate trees. To address this in 2024, crews will ‘calibrate’ on canopy position periodically throughout the field season, beyond their initial training. Percent error values for all measured tree metrics are shown in Table 1 for both QA plots.

**Table 1:** Percent error values for various tree metrics in QA plots. Percent error values represented the percentage of cases where the delta values between independent observers fall outside of the established Data Quality Standards

| LOC_NAME | Tree Species ID | DBH | Canopy position | Tree Vigor |
|----------|-----------------|-----|-----------------|------------|
| VSE389   | 3%              | 19% | 43%             | 3%         |
| VSE391   | 4%              | 8%  | 18%             | 2%         |

Deadwood Measurements

Deadwood abundance is measured along two 50 meter transects and tallied into decay and diameter classes. Data Quality Standards are that total abundance of deadwood should be within 10% between observers, as well as the tally within any decay X diameter class should be within 10%. While independent observers do a good job with overall deadwood counts, QA data show issues with attributing deadwood into the same decay class and diameter class. Starting in 2024, the number of decay classes will be reduced from 6 to 3 so that data can be more reproducible, and more precise measuring tools will be tested for assigning diameter classes before the season begins.

Woody stems (shrubs/saplings) densities

Woody stem counts per species and overall were occasionally outside of data quality standards in 2023. While this is partially due to an extremely dense regeneration plot being selected as a QA in 2023, it is apparent that more crew training is needed to meet standards in 2024. More effort will be focused on crew training for woody stem techniques, and occasional “check up” trainings will be instituted throughout the field season. If QA results do not improve in 2024, then other corrective actions may need to be taken.

**Data Validation**

Data validation occurs after all data collection is complete and the database has been verified, meaning that the data has been confirmed as matching the field datasheets. Validation is the process of confirming that recorded values are within expect ranges and make sense ecologically and mathematically (e.g. smaller stature trees such as dogwoods were not recorded with very large diameters). While data validation has occurred for every year of plotwork before data were certified, in 2021 data validation steps were expanded to look at not only data collected in 2021 but also the change in data values between cycles. Data validation steps continue in 2023 that look at within-year, and between-cycle values. A full report for Data Validation is available for more information (internal link [here](#)).

In 2023, most validation checks were as expected. One herbaceous species of plant should have been given a cover class and was not, and several trees showed abnormally large growth between cycles that likely signified a mismeasurement in one of the cycles. Furthermore, two trees were recorded as standing dead in 2017, but given a living vigor code in 2023. These anomalies are out of over 2,000 measured trees and represent a fraction of a percent of all data collected. Problematic trees will be flagged in the database, so they can be removed from analyses if deemed necessary.

## Data/Anecdotal Observations

Interesting trends in collected data, as well as anecdotal observations, are included in this section. Anecdotal observations include anything noticed by field crews, either within or without of general plot work, that is useful to note. Not all forest changes can be picked up by standard plot metrics, so this section will include data-supported and un-supported notes. It is worth noting here that annual reports are based on a subset of the entire plot network, so any data-based observations are tentative and subject to analyses after plot cycles are completed.

### **Overstory Death of Northern Red Oak in Elkmont area**

In the previous two annual reports, northern red oak (*Quercus rubra*) death was noted anecdotally in the upper Hazel Creek area, near Jenkins Ridge. In 2023, further loss of northern red oak was observed in the Elkmont area. These were overstory trees, especially in and near plot VSE389. Trees appear to have died in the last 1-3 years, and no trees appeared to be in further decline in the area (trees were either dead or generally healthy). Further recent-dead oaks were reported along Little River Gorge Rd. by hazard tree contractors within the last year, so there is more evidence of mature northern red oak death. Most likely, this was caused by an environmental event (drought etc), as no biological agents have been observed and no oaks in decline have been noted.

### ***Rhododendron maximum* is increasing cover**

While this has not been explicitly looked at in the data yet, based on repeat plot photos rosebay rhododendron (*Rhododendron maximum*) has increased coverage over many plot locations. Existing shrubs are growing quickly, and new shrubs are recruiting from the seedling layer. This may correlate with existence of canopy gaps post-hemlock, or just may be an overall trend range-wide. Data need to be analyzed for a more detailed look. Expanding rhododendron could have implications for future tree recruitment and overall plant diversity.

### **Snag (standing dead tree) density is decreasing**

Based on data from the first two years of the second plot cycle, the amount of standing dead snags in GRSM forests are decreasing. Snag densities are down 20% across the board, with live tree mortality not keeping up with the rate of snag-fall that is occurring. Snags/hectare were around 135 in the first cycle and are currently at 108. On the ground, this change is evident with the increased number of logs, branches, and tree tops found within plots and the forest at large.

This density change appears to largely be driven by coniferous tree species that have been impacted by various forest pests in the last 40-50 years, including Fraser fir (*Abies fraseri*) impacted by BWA, eastern hemlock (*Tsuga canadensis*) impacted by HWA and various pines (*Pinus* spp) impacted by southern pine beetle outbreaks (SPB). Further notes on these forests pest can be found in Appendix A under the vegetation types descriptions. All of these conifer species can remain standing as snags for decades after dying, but eventual decay to the point of falling over. Peak snag densities of Fraser fir and pines affected with the late 1990's outbreak of SPB probably occurred before the beginning of this protocol, but what snags remained are finally coming down. Peak hemlock snag density probably occurred around the beginning of this protocol, and is still actively elevated as hemlock continue to die from HWA (~20% of living hemlock died between first and second cycle of plots). The table below shows snag abundance from first and second cycles of plots for various species groups, showing their contribution to the overall decline. It is worth noting here that "Other/Unk Conifer" includes many dead Fraser fir that could not be separated from dead spruce so were lumped together, and that "Unknown Tree" refers to trees that were generally already dead and often bark-less during a plot's first cycle, so were never able to be identified to a genus. These would include conifers as well as deciduous trees. Most of the loss in snag density here is attributed to hemlock, Other/Unk Conifers, and Unknown trees. Deciduous trees that have been identified at least to the genus level have actually slightly increased in snag density (i.e. deciduous trees mortality is at a slightly higher level than snag-fall).

**Table 1:** Change in standing snags density (#/ha) from first cycle plots to second. Several conifer species are individually highlighted, and other species lumped into groups.

| Spp_Group         | First | Second | Percent Delta |
|-------------------|-------|--------|---------------|
| Fraser Fir        | 3.40  | 3.43   | 0.87 %        |
| Hemlock           | 60.16 | 41.37  | -45.42 %      |
| Other Deciduous   | 28.06 | 29.93  | 6.25 %        |
| Other/Unk Conifer | 18.66 | 17.16  | -8.74 %       |

| Spp_Group    | First | Second | Percent Delta |
|--------------|-------|--------|---------------|
| Unknown Tree | 25.56 | 14.93  | -71.2 %       |

### ***One year of repeat-measures soil data is now available***

The soil quality data cycle lagged behind vegetation data by one year, as protocols were still being developed and refined in 2016. That means that 2023 is the first year that repeat measures are available for soil data, with the original collection in 2017. All standard metrics were analyzed by the same lab, though the lab lost a portion of data (Aluminum, Total Carbon, Total Nitrogen) for a subset of six plots in 2023.

It is worth noting that Field QA has not been completed for soil data yet, and so change values should be considered preliminary. Plot-level change values are reported for pH, Sulphur ppm, and cation exchange capacity (CEC) in Appendix B of this report. Overall, it appears that pH is increasing (becoming more basic) at most locations, Sulphur (ppm) is decreasing across most locations (a potential sign of Sulphur desorption), and that CEC is variable and site-specific. Not enough data are available to create means for watersheds or elevation bands yet, hopefully after another season of data collection. During this off-season, change values will be added to the internally-hosted Soils Web App (currently in Beta, [here](#)).

## **Community Condition Rankings**

Forest and soils data are combined and analyzed at the community level, and each community given a condition ranking. Condition rankings include the *status* and *trend* of ecological health of the community, as well as the *confidence* we have in the ranking levels. Status notes the current condition of the community, with the values of Good, Caution and Poor. Trend notes the expected direction of change of the community condition, with values of Improving, Stable, or Declining. Confidence in the rankings is based on the amount of data in support of the status and trend, and has values of Low, Medium, and High.

Condition rankings are based on the full body of knowledge we have for each community, inclusive of previous internal work, external research, expert opinion, and data from our current monitoring effort. As new data emerges, condition rankings will be updated to reflect our current understanding of ecosystem health. If rankings change annually, this section will include a table of updated values.

No forest community rankings were changed after the 2021 field season. However, 2021 marked the beginning of the second cycle of monitoring and so as repeat data are gathered, changes to condition rankings may occur.

### ***Forested community types***

Forest and soils monitoring plots are grouped into eight forested community types: spruce/fir, high elevation hardwood, cove hardwood, hemlock, oak/hickory, pine/oak, montane alluvial, and early successional. Grouping occurs based on the National Vegetation Classification System (NVCS) association type assigned as part of data collection, and is based on dominant and diagnostic tree species, understory species, and environmental factors. Currently, there are two forested communities with a status of good (cove hardwood and early successional), three that have a status of caution (high elevation hardwood, oak/hickory, and pine/oak) and three that have a status of poor (spruce/fir, hemlock and montane alluvial). Information about each community, including rankings, a description, and plot monitoring data can be found in Appendix A of this report.



**Figure 4.** The vegetation monitoring crew descends Lowes Creek drainage after completing a monitoring plot.

## For more information

---

Contact: Troy Evans, Vegetation Ecologist

[Troy\\_Evans@nps.gov](mailto:Troy_Evans@nps.gov), office phone 865-430-4742

## Appendix A. Forest Community Descriptions and Condition Rankings

Community descriptions, condition rankings, and associated plot data for each of the eight forested community types monitored within GRSM are given below.

### Spruce/Fir Forests



#### Condition Ranking



Poor & Improving  
(Medium Confidence)

Spruce-fir forests occupy the highest elevations of GRSM, occurring in truly boreal habitats above 5000 ft. These forests are evergreen dominant with Fraser fir (*Abies fraseri*) and red spruce (*Picea rubens*) being the most common species, though occasional hardwoods such as yellow birch (*Betula alleghaniensis*) and American beech (*Fagus grandifolia*) can be present. These stands generally have low species richness but include unique species such as southern Appalachian endemics and disjunct relic populations of more common northern species. Spruce-fir forests have been greatly altered by the introduction of balsam woolly adelgid (*Adelges picea*), an invasive insect that eliminated most mature fir trees in GRSM during the mid-20th century. Young Fraser firs have since recruited back into the mid-story of many stands but their fate into the future is still unknown. Current trends have been for low balsam woolly adelgid infestation numbers and good cone crops for Fraser fir. Other stressors in spruce-fir include soil acidification, air quality issues, and climate changes. These impacts have led to the current rating of spruce-fir as Poor and Improving (medium confidence). Important monitoring metrics include fir recruitment and mortality, overall tree vigor and mortality rates, and population dynamics of rare plant species with ranges limited to the highest elevations.

#### Plot Data Summary

The below table summarizes changes between cycles for spruce-fir plots that have more than one cycle of data. This data is preliminary as it is only based on 2 of 5 years of repeat data. Current trends based on these 7 plots include a decrease in standing snag densities as discussed above, and a tree recruitment rate that is over double current mortality rates, leading to an overall increase in live tree density and basal area. These numbers reflect a stand that is continuing to recover, shows high tree health, and shows the presence of both spruce and fir in all growth classes.

**Table 1:** An overview of repeat measures for Spruce/Fir Plots

| Metric                                    | First_Cycle_Data                                                                                                                                            | Second_Cycle_Data                                                                                                                                           | Delta |
|-------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| Community Type                            | Spruce/Fir Forests                                                                                                                                          | Spruce/Fir Forests                                                                                                                                          |       |
| # Plots                                   | 7                                                                                                                                                           | 7                                                                                                                                                           |       |
| live tree basal area (m <sup>2</sup> /ha) | 42.9                                                                                                                                                        | 45.99                                                                                                                                                       | 7%    |
| live tree density (#/ha)                  | 815.95                                                                                                                                                      | 857.33                                                                                                                                                      | 5%    |
| snag density (#/ha)                       | 237.17                                                                                                                                                      | 197.24                                                                                                                                                      | -17%  |
| tree mortality rate (#/ha/yr)             |                                                                                                                                                             | 7.26                                                                                                                                                        |       |
| tree recruitment rate (#/ha/yr)           |                                                                                                                                                             | 15.68                                                                                                                                                       |       |
| tree vigor                                | 3                                                                                                                                                           | 3                                                                                                                                                           | 0     |
| Most abundant canopy species              | <i>Picea rubens</i> ,<br><i>Betula alleghaniensis</i> ,<br><i>Sorbus americana</i> ,<br><i>Abies fraseri</i> ,<br><i>Prunus serotina</i> v. <i>serotina</i> | <i>Picea rubens</i> ,<br><i>Betula alleghaniensis</i> ,<br><i>Abies fraseri</i> ,<br><i>Sorbus americana</i> ,<br><i>Prunus serotina</i> v. <i>serotina</i> |       |
| Most abundant midstory species            | <i>Picea rubens</i> ,<br><i>Betula alleghaniensis</i> ,<br><i>Abies fraseri</i> ,<br><i>Acer spicatum</i> ,<br><i>Acer pensylvanicum</i>                    | <i>Picea rubens</i> ,<br><i>Betula alleghaniensis</i> ,<br><i>Abies fraseri</i> ,<br><i>Acer spicatum</i> ,<br><i>Sorbus americana</i>                      |       |
| Most abundant saplings                    | <i>Picea rubens</i> ,<br><i>Abies fraseri</i> ,<br><i>Acer spicatum</i> ,<br><i>Fagus grandifolia</i> ,<br><i>Acer pensylvanicum</i>                        | <i>Picea rubens</i> ,<br><i>Abies fraseri</i> ,<br><i>Acer spicatum</i> ,<br><i>Fagus grandifolia</i> ,<br><i>Betula alleghaniensis</i>                     |       |
| Most abundant seedlings                   | <i>Betula alleghaniensis</i> ,<br><i>Abies fraseri</i> ,<br><i>Acer spicatum</i> ,<br><i>Picea rubens</i> ,<br><i>Betula species</i>                        | <i>Amelanchier laevis</i> ,<br><i>Picea rubens</i> ,<br><i>Betula alleghaniensis</i> ,<br><i>Abies fraseri</i> ,<br><i>Sorbus americana</i>                 |       |
| shrub density (#/m <sup>2</sup> )         | 0.22                                                                                                                                                        | 0.21                                                                                                                                                        | -5%   |
| herbaceous species richness (#/plot)      | 9.86                                                                                                                                                        | 12.57                                                                                                                                                       | 22%   |
| deadwood abundance (#/plot)               | 18.86                                                                                                                                                       | 20.43                                                                                                                                                       | 8%    |

## High Elevation Hardwood Forests



### Condition Ranking



Caution & Declining  
(High Confidence)

As the name implies, the high elevation hardwood forests occupy the upper slopes and ridges of GRSM, occurring just below the spruce-fir zone and often mingling with spruce. Yellow birch is the most dominant and important species here and depending on the community type can be mixed with red spruce, eastern hemlock (*Tsuga canadensis*), sugar maple (*Acer saccharum*), American beech, American basswood (*Tilia americana*), and northern red oak (*Quercus rubra*). This vegetation category also includes beech gaps, nearly monospecific stands of small-statured American beech that occurs along ridgetops and saddles. The most significant stressor for high elevation hardwood forests are climate and deposition changes, especially soil acidification and climatic warming. Other stressors include wild hog (*Sus scrofa*) foraging, beech bark disease (causal agents – *Neonectria faginata* and *N. ditissima*), and loss of hemlocks from hemlock woolly adelgid (*Adelges tsugae*). Due to these stressors, high elevation hardwoods are currently listed as Caution and Declining (High confidence). Important metrics for monitoring change in these stands includes overstory tree growth and mortality rates, presence of nonnative forest pests, and change in the herb layer from wild hog foraging.

### Plot Data Summary

The below table summarizes changes between cycles for high elevation hardwood plots that have more than one cycle of data. This data is preliminary as it is only based on 2 of 5 years of repeat data. Current trends based on these 9 plots include steady growth in live tree density and basal area, low tree mortality and a slight increase in herbaceous species richness.

**Table 2:** An overview of repeat measures for High Elevation Hardwoods Plots

| Metric                                    | First_Cycle_Data                                         | Second_Cycle_Data                                             | Delta |
|-------------------------------------------|----------------------------------------------------------|---------------------------------------------------------------|-------|
| Community Type                            | High Elevation Hardwood Forests                          | High Elevation Hardwood Forests                               |       |
| # Plots                                   | 9                                                        | 9                                                             |       |
| live tree basal area (m <sup>2</sup> /ha) | 33.87                                                    | 35.26                                                         | 4%    |
| live tree density (#/ha)                  | 463.73                                                   | 484.42                                                        | 4%    |
| snag density (#/ha)                       | 145.34                                                   | 112.33                                                        | -23%  |
| tree mortality rate (#/ha/yr)             |                                                          | 4.84                                                          |       |
| tree recruitment rate (#/ha/yr)           |                                                          | 9.15                                                          |       |
| tree vigor                                | 3                                                        | 3                                                             | 0     |
| Most abundant canopy species              | <i>Betula alleghaniensis</i> ,<br><i>Quercus rubra</i> , | <i>Betula alleghaniensis</i> ,<br><i>Halesia tetraptera</i> , |       |

| Metric                               | First_Cycle_Data                                                                                                                                             | Second_Cycle_Data                                                                                                                                           | Delta |
|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
|                                      | <i>Halesia tetraptera</i> ,<br><i>Acer rubrum</i> ,<br><i>Acer saccharum</i>                                                                                 | <i>Quercus rubra</i> ,<br><i>Acer rubrum</i> ,<br><i>Acer saccharum</i>                                                                                     |       |
| Most abundant midstory species       | <i>Fagus grandifolia</i> ,<br><i>Betula alleghaniensis</i> ,<br><i>Picea rubens</i> ,<br><i>Acer pensylvanicum</i> ,<br><i>Halesia tetraptera</i>            | <i>Fagus grandifolia</i> ,<br><i>Betula alleghaniensis</i> ,<br><i>Picea rubens</i> ,<br><i>Acer pensylvanicum</i> ,<br><i>Halesia tetraptera</i>           |       |
| Most abundant saplings               | <i>Fagus grandifolia</i> ,<br><i>Acer pensylvanicum</i> ,<br><i>Acer saccharum</i> ,<br><i>Betula alleghaniensis</i> ,<br><i>Acer rubrum</i>                 | <i>Fagus grandifolia</i> ,<br><i>Acer pensylvanicum</i> ,<br><i>Acer saccharum</i> ,<br><i>Betula alleghaniensis</i> ,<br><i>Acer rubrum</i>                |       |
| Most abundant seedlings              | <i>Quercus rubra</i> ,<br><i>Acer pensylvanicum</i> ,<br><i>Acer rubrum</i> ,<br><i>Prunus serotina</i> v. <i>serotina</i> ,<br><i>Betula alleghaniensis</i> | <i>Acer rubrum</i> ,<br><i>Fagus grandifolia</i> ,<br><i>Betula alleghaniensis</i> ,<br><i>Quercus rubra</i> ,<br><i>Prunus serotina</i> v. <i>serotina</i> |       |
| shrub density (#/m <sup>2</sup> )    | 0.29                                                                                                                                                         | 0.29                                                                                                                                                        | 0%    |
| herbaceous species richness (#/plot) | 20                                                                                                                                                           | 22.11                                                                                                                                                       | 10%   |
| deadwood abundance (#/plot)          | 15.11                                                                                                                                                        | 13.44                                                                                                                                                       | -12%  |

## Cove Hardwood Forests



### Condition Ranking



Good & Declining  
(High Confidence)

Cove hardwoods are the centers of plant diversity in GRSM, often having spectacular displays of wildflowers, ferns, and woodland grasses in the understory. The overstory is a mix of species, with tulip poplar, American basswood, mountain silverbell (*Halesia tetraptera*), and sugar maple all being important components. These stands are generally found at mid to low elevations in cove topographic positions, where water is readily available, and soils have accumulated in depth. Acidic coves, where eastern hemlocks co-dominate and rosebay rhododendron (*Rhododendron maximum*) cover is very high, are often included in this group but for this report are considered as a hemlock vegetation type.

Major stressors in cove hardwood forests include non-native forest pests such as emerald ash borer (*Agrilus planipennis*), thousandcanker disease (causal agent – *Geosmithia morbida*), and butternut canker (causal agent – *Ophiognomonia clavignenti-juglandacearum*), as well as large scale and diffuse stress from climate changes and historic poor air quality. These stands also hosts multiple herbaceous plants that are at risk of over-exploitation from poaching. Currently, cove forests are rated as Good and Declining (High Confidence). Important metrics for monitoring trends will be overall species richness, vigor and mortality of specific host trees with non-native pests, and changes in abundance of at-risk exploitable plants.

### Plot Data Summary

The below table summarizes changes between cycles for cove hardwood plots that have more than one cycle of data. This data is preliminary as it is only based on 2 of 5 years of repeat data. Current trends based on these 7 plots include increase species richness, which could be a real trend or just reflect growing crew ability to identify tricky herbaceous species. Tree mortality and recruitment are similar, but both relatively low. Also, key canopy species for this type are present in all growth classes, showing stable recruitment and lack of community shift.

**Table 3:** An overview of repeat measures for Cove Hardwood Plots

| Metric                                    | First_Cycle_Data                                                                                                                                               | Second_Cycle_Data                                                                                                                                     | Delta |
|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| Community Type                            | Cove Hardwoods                                                                                                                                                 | Cove Hardwoods                                                                                                                                        |       |
| # Plots                                   | 7                                                                                                                                                              | 7                                                                                                                                                     |       |
| live tree basal area (m <sup>2</sup> /ha) | 45.61                                                                                                                                                          | 47.04                                                                                                                                                 | 3%    |
| live tree density (#/ha)                  | 334.31                                                                                                                                                         | 323.28                                                                                                                                                | -3%   |
| snag density (#/ha)                       | 98.64                                                                                                                                                          | 69.75                                                                                                                                                 | -29%  |
| tree mortality rate (#/ha/yr)             |                                                                                                                                                                | 5.32                                                                                                                                                  |       |
| tree recruitment rate (#/ha/yr)           |                                                                                                                                                                | 3.43                                                                                                                                                  |       |
| tree vigor                                | 3                                                                                                                                                              | 3                                                                                                                                                     | 0     |
| Most abundant canopy species              | <i>Liriodendron tulipifera</i> ,<br><i>Acer rubrum</i> ,<br><i>Quercus rubra</i> ,<br><i>Tilia americana</i> ,<br><i>Halesia tetraptera</i>                    | <i>Liriodendron tulipifera</i> ,<br><i>Acer rubrum</i> ,<br><i>Halesia tetraptera</i> ,<br><i>Quercus rubra</i> ,<br><i>Tilia americana</i>           |       |
| Most abundant midstory species            | <i>Acer rubrum</i> ,<br><i>Halesia tetraptera</i> ,<br><i>Aesculus flava</i> ,<br><i>Acer saccharum</i> ,<br><i>Liriodendron tulipifera</i>                    | <i>Acer rubrum</i> ,<br><i>Acer saccharum</i> ,<br><i>Halesia tetraptera</i> ,<br><i>Aesculus flava</i> ,<br><i>Liriodendron tulipifera</i>           |       |
| Most abundant saplings                    | <i>Halesia tetraptera</i> ,<br><i>Acer saccharum</i> ,<br><i>Fagus grandifolia</i> ,<br><i>Acer pensylvanicum</i> ,<br><i>Betula lenta</i> v. <i>lenta</i>     | <i>Halesia tetraptera</i> ,<br><i>Acer saccharum</i> ,<br><i>Fagus grandifolia</i> ,<br><i>Acer pensylvanicum</i> ,<br><i>Betula alleghaniensis</i>   |       |
| Most abundant seedlings                   | <i>Prunus serotina</i> v. <i>serotina</i> ,<br><i>Acer rubrum</i> ,<br><i>Quercus rubra</i> ,<br><i>Liriodendron tulipifera</i> ,<br><i>Halesia tetraptera</i> | <i>Acer rubrum</i> ,<br><i>Prunus serotina</i> v. <i>serotina</i> ,<br><i>Acer saccharum</i> ,<br><i>Halesia tetraptera</i> ,<br><i>Quercus rubra</i> |       |
| shrub density (#/m <sup>2</sup> )         | 0.19                                                                                                                                                           | 0.17                                                                                                                                                  | -11%  |
| herbaceous species richness (#/plot)      | 28.57                                                                                                                                                          | 34.57                                                                                                                                                 | 17%   |
| deadwood abundance (#/plot)               | 13.29                                                                                                                                                          | 12.43                                                                                                                                                 | -7%   |

## Hemlock Forests



### Condition Ranking



Poor & Stable  
(High Confidence)

Perhaps no other vegetation type has been more altered in recent years than hemlock forests. These hemlock communities, with acidic coves included here, are typified by at least co-dominance of eastern hemlock over acidic understories. Other common overstory species can vary with elevation, from white pine (*Pinus strobus*) and tulip poplar in the lower elevations to yellow birch and red spruce in the upper elevations. These stands are found in deep streamside drainages throughout the drier west side of the park and work up to north and east facing slopes as you moving to the wetter and higher elevations of the eastern half of GRSM.

The largest stressor of hemlock is the introduction of hemlock woolly adelgid into GRSM in the early 2000s. This non-native forest pest has caused widespread canopy mortality across all hemlock forest communities, altering species composition, forest structure, nutrient cycling, and wildlife use of these stands. Currently, hemlock forests are rated as Poor and Stable (High Confidence). Important monitoring metrics will be deadwood abundance, seedling and midstory species diversity, and shifts in community classification.

### Plot Data Summary

The below table summarizes changes between cycles for hemlock plots that have more than one cycle of data. This data is preliminary as it is only based on 2 of 5 years of repeat data. Current trends based on 4 plots show stable live tree density, but a large decrease in snag densities as old dead hemlocks continue to fall. Live basal area is slightly increased, mostly due to incremental annual growth of existing trees. Recruitment and mortality rates are both extremely low. Living hemlock is not present in the top-five list for any growth class. These numbers indicate a forest that is recovering from catastrophic loss of hemlock and has not begun to recruit a new cohort of trees into the canopy yet.

**Table 4:** An overview of repeat measures for Hemlock Plots

| Metric                                    | First_Cycle_Data                                                                                                                                                | Second_Cycle_Data                                                                                                                                                    | Delta |
|-------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| Community Type                            | Hemlock Forests                                                                                                                                                 | Hemlock Forests                                                                                                                                                      |       |
| # Plots                                   | 4                                                                                                                                                               | 4                                                                                                                                                                    |       |
| live tree basal area (m <sup>2</sup> /ha) | 36.24                                                                                                                                                           | 37.43                                                                                                                                                                | 3%    |
| live tree density (#/ha)                  | 328.17                                                                                                                                                          | 325.21                                                                                                                                                               | -1%   |
| snag density (#/ha)                       | 72.67                                                                                                                                                           | 50.76                                                                                                                                                                | -30%  |
| tree mortality rate (#/ha/yr)             |                                                                                                                                                                 | 3.87                                                                                                                                                                 |       |
| tree recruitment rate (#/ha/yr)           |                                                                                                                                                                 | 3.22                                                                                                                                                                 |       |
| tree vigor                                | 3                                                                                                                                                               | 3                                                                                                                                                                    | 0     |
| Most abundant canopy species              | <i>Liriodendron tulipifera</i> ,<br><i>Betula lenta</i> v. <i>lenta</i> ,<br><i>Tilia americana</i> ,<br><i>Fagus grandifolia</i> ,<br><i>Quercus rubra</i>     | <i>Liriodendron tulipifera</i> ,<br><i>Betula lenta</i> v. <i>lenta</i> ,<br><i>Betula alleghaniensis</i> ,<br><i>Fagus grandifolia</i> ,<br><i>Magnolia fraseri</i> |       |
| Most abundant midstory species            | <i>Magnolia fraseri</i> ,<br><i>Betula lenta</i> v. <i>lenta</i> ,<br><i>Rhododendron maximum</i> ,<br><i>Betula alleghaniensis</i> ,<br><i>Tilia americana</i> | <i>Magnolia fraseri</i> ,<br><i>Rhododendron maximum</i> ,<br><i>Betula lenta</i> v. <i>lenta</i> ,<br><i>Tilia americana</i> ,<br><i>Acer rubrum</i>                |       |
| Most abundant saplings                    | <i>Halesia tetraptera</i> ,<br><i>Tilia americana</i> ,<br><i>Magnolia fraseri</i> ,<br><i>Aesculus flava</i> ,<br><i>Fraxinus pennsylvanica</i>                | <i>Halesia tetraptera</i> ,<br><i>Tilia americana</i> ,<br><i>Aesculus flava</i> ,<br><i>Acer pensylvanicum</i> ,<br><i>Betula lenta</i> v. <i>lenta</i>             |       |
| Most abundant seedlings                   | <i>Betula alleghaniensis</i> ,<br><i>Quercus rubra</i> ,<br><i>Tilia americana</i> ,<br><i>Acer rubrum</i> ,<br><i>Halesia tetraptera</i>                       | <i>Acer rubrum</i> ,<br><i>Betula alleghaniensis</i> ,<br><i>Fraxinus pennsylvanica</i> ,<br><i>Liriodendron tulipifera</i> ,<br><i>Aesculus flava</i>               |       |
| shrub density (#/m <sup>2</sup> )         | 1.23                                                                                                                                                            | 0.93                                                                                                                                                                 | -24%  |
| herbaceous species richness (#/plot)      | 18.5                                                                                                                                                            | 22.67                                                                                                                                                                | 18%   |
| deadwood abundance (#/plot)               | 13                                                                                                                                                              | 15.75                                                                                                                                                                | 17%   |

## Oak/Hickory Forests



### Condition Ranking



Caution & Stable  
(Medium Confidence)

Constituting around one third of all forests in GRSM, oak-hickory forests are the most abundant vegetation type in the park. These stands occur across all low and mid-elevation areas on mid and lower slope positions. They are typified by overstory dry-mesic and mesic oak (*Quercus*) species mixed with hickory (*Carya*) species and various other hardwoods. Common species include eastern white oak (*Q. alba*), northern red oak, chestnut oak (*Q. montana*), black oak (*Q. velutina*), pignut hickory (*C. glabra*), mockernut hickory (*C. tomentosa*), and red hickory (*C. ovalis*).

The understory can be quite variable, ranging from dense rosebay rhododendron thickets to abundant and rich herbaceous floras. Historically, these stands would have been co-dominated by American chestnut (*Castanea dentata*), which succumbed to a non-native fungus (*Cryphonectria parasitica*) in the early 20th century to the point of being functionally extinct. Reduction in fire frequency over the last century has also altered oak/hickory forests but to a lesser extent than the more xeric pine/oak forests that often occur on the drier ridgetops nearby. A list of other non-native fungal and insect pests has further degraded ecological integrity in these stands, leading to a current rating of Caution and Stable (Medium Confidence). Important metrics for monitoring these forests will be overstory composition and vigor, presence of oak and hickory in the midstory and seedling layer, and overall stand diversity.

### Plot Data Summary

The below table summarizes changes between cycles for oak-hickory plots that have more than one cycle of data. This data is preliminary as it is only based on 2 of 5 years of repeat data. Current trends based on these 13 plots include balanced, low recruitment and mortality rates with a decreasing snag density. Red maple continues to dominate in abundance for nearly all growth classes, with oak species being absent from the top five sapling and midstory lists. This reflects a forest type that is stable in structure but continues to diverge in species composition as oak seedling fail to recruit into sapling size classes.

**Table 5:** An overview of repeat measures for Oak/Hickory Plots

| Metric                                    | First_Cycle_Data                                                                                                                             | Second_Cycle_Data                                                                                                                             | Delta |
|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|-------|
| Community Type                            | Oak/Hickory Forests                                                                                                                          | Oak/Hickory Forests                                                                                                                           |       |
| # Plots                                   | 13                                                                                                                                           | 13                                                                                                                                            |       |
| live tree basal area (m <sup>2</sup> /ha) | 30.72                                                                                                                                        | 32.04                                                                                                                                         | 4%    |
| live tree density (#/ha)                  | 510.8                                                                                                                                        | 504.34                                                                                                                                        | -1%   |
| snag density (#/ha)                       | 98.15                                                                                                                                        | 80.69                                                                                                                                         | -18%  |
| tree mortality rate (#/ha/yr)             |                                                                                                                                              | 6.32                                                                                                                                          |       |
| tree recruitment rate (#/ha/yr)           |                                                                                                                                              | 5.57                                                                                                                                          |       |
| tree vigor                                | 3                                                                                                                                            | 3                                                                                                                                             | 0     |
| Most abundant canopy species              | <i>Acer rubrum</i> ,<br><i>Quercus montana</i> ,<br><i>Quercus alba</i> ,<br><i>Quercus rubra</i> ,<br><i>Quercus velutina</i>               | <i>Acer rubrum</i> ,<br><i>Quercus montana</i> ,<br><i>Quercus rubra</i> ,<br><i>Quercus alba</i> ,<br><i>Quercus velutina</i>                |       |
| Most abundant midstory species            | <i>Acer rubrum</i> ,<br><i>Oxydendrum arboreum</i> ,<br><i>Rhododendron maximum</i> ,<br><i>Tsuga canadensis</i> ,<br><i>Nyssa sylvatica</i> | <i>Acer rubrum</i> ,<br><i>Oxydendrum arboreum</i> ,<br><i>Rhododendron maximum</i> ,<br><i>Nyssa sylvatica</i> ,<br><i>Tsuga canadensis</i>  |       |
| Most abundant saplings                    | <i>Acer pensylvanicum</i> ,<br><i>Acer rubrum</i> ,<br><i>Castanea dentata</i> ,<br><i>Halesia tetraptera</i> ,<br><i>Sassafras albidum</i>  | <i>Acer pensylvanicum</i> ,<br><i>Acer rubrum</i> ,<br><i>Halesia tetraptera</i> ,<br><i>Castanea dentata</i> ,<br><i>Oxydendrum arboreum</i> |       |
| Most abundant seedlings                   | <i>Acer rubrum</i> ,<br><i>Quercus montana</i> ,<br><i>Quercus rubra</i> ,<br><i>Quercus velutina</i> ,<br><i>Nyssa sylvatica</i>            | <i>Acer rubrum</i> ,<br><i>Quercus montana</i> ,<br><i>Quercus rubra</i> ,<br><i>Quercus velutina</i> ,<br><i>Liriodendron tulipifera</i>     |       |
| shrub density (#/m <sup>2</sup> )         | 0.3                                                                                                                                          | 0.41                                                                                                                                          | 37%   |
| herbaceous species richness (#/plot)      | 14.23                                                                                                                                        | 17.77                                                                                                                                         | 20%   |
| deadwood abundance (#/plot)               | 11.08                                                                                                                                        | 9.92                                                                                                                                          | -12%  |

## Pine/Oak Forests



### Condition Ranking



Poor & Declining  
(High Confidence)

Pine-Oak forests are the most xeric, fire-adapted communities found in GRSM. Characterized by dominance of yellow pine (*Pinus*) species mixed with xeric oaks. Common species include Virginia pine (*P. virginiana*), shortleaf pine (*P. echinata*), pitch pine (*P. rigida*), table mountain pine (*P. pungens*), scarlet oak (*Q. coccinea*), chestnut oak, black oak, southern-red oak (*Q. falcata*), and blackjack oak (*Q. marilandica*). These forests are most common on low ridges and south-southwest facing slopes that had historically seen regular fire disturbance. These communities occur abundantly in the lower elevation western third of GRSM but can be found all throughout low and mid-elevations of the park where topography and aspect create a drier habitat. Historically, these communities would have appeared as a mosaic of different-aged stands across the landscape as a result of fluctuations in fire intensity and would have had lower stand densities than what is seen today. Understory diversity would have varied based on soil acidity and moisture availability, with some stands dominated by mountain laurel (*Kalmia latifolia*) and other acid-loving shrubs, while others having a diverse understory of grasses and fire-adapted forbs.

Currently, pine/oak forests in GRSM are stressed from the past century of reduced fire frequency brought on by land-use changes and fire suppression policies. Less fire on the landscape have left stands with dense duff layers and closed canopies that suppress regeneration of pines and xeric oaks while favoring more mesic-loving species such as red maple (*Acer rubrum*), sourwood (*Oxydendrum arboreum*), black gum (*Nyssa sylvatica*), Fraser magnolia (*Magnolia fraseri*), and white pine (*Pinus strobus*). The lack of fire also creates denser stands of pines, which become increasingly susceptible to infestation from the native southern pine beetle (*Dendroctonus frontalis*). Due to these issues, pine-oak stands are currently ranked as Caution and Declining (High Confidence). Important metrics needed to assess condition include midstory density and composition, species richness, unvegetated surface cover, and overstory composition and vigor.

### Plot Data Summary

The below table summarizes changes between cycles for pine-oak plots that have more than one cycle of data. This data is preliminary as it is only based on 2 of 5 years of repeat data. Current trends based on these 15 plots include increasing shrub density and relatively equal tree mortality and recruitment rates. Snag densities continue to decrease, largely driven by dead pines and understory hemlock falling down. Pine-oak forests are facing similar mesophication changes to species composition as oak-hickory, reflected by red maple, black gum, and sourwood being the most abundant species in the sapling and midstory layers.

**Table 6:** An overview of repeat measures for Pine/Oak Plots

| Metric                                    | First_Cycle_Data                                                                                                                      | Second_Cycle_Data                                                                                                                     | Delta |
|-------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|-------|
| Community Type                            | Pine/Oak Forests                                                                                                                      | Pine/Oak Forests                                                                                                                      |       |
| # Plots                                   | 15                                                                                                                                    | 15                                                                                                                                    |       |
| live tree basal area (m <sup>2</sup> /ha) | 31.93                                                                                                                                 | 33.94                                                                                                                                 | 6%    |
| live tree density (#/ha)                  | 657.52                                                                                                                                | 672.84                                                                                                                                | 2%    |
| snag density (#/ha)                       | 143.82                                                                                                                                | 120.09                                                                                                                                | -16%  |
| tree mortality rate (#/ha/yr)             |                                                                                                                                       | 7.65                                                                                                                                  |       |
| tree recruitment rate (#/ha/yr)           |                                                                                                                                       | 9.8                                                                                                                                   |       |
| tree vigor                                | 3                                                                                                                                     | 3                                                                                                                                     | 0     |
| Most abundant canopy species              | <i>Quercus montana</i> ,<br><i>Acer rubrum</i> ,<br><i>Pinus strobus</i> ,<br><i>Quercus coccinea</i> ,<br><i>Pinus pungens</i>       | <i>Pinus strobus</i> ,<br><i>Quercus montana</i> ,<br><i>Acer rubrum</i> ,<br><i>Quercus coccinea</i> ,<br><i>Pinus pungens</i>       |       |
| Most abundant midstory species            | <i>Acer rubrum</i> ,<br><i>Oxydendrum arboreum</i> ,<br><i>Pinus strobus</i> ,<br><i>Quercus montana</i> ,<br><i>Nyssa sylvatica</i>  | <i>Acer rubrum</i> ,<br><i>Oxydendrum arboreum</i> ,<br><i>Pinus strobus</i> ,<br><i>Quercus montana</i> ,<br><i>Nyssa sylvatica</i>  |       |
| Most abundant saplings                    | <i>Acer rubrum</i> ,<br><i>Nyssa sylvatica</i> ,<br><i>Oxydendrum arboreum</i> ,<br><i>Pinus strobus</i> ,<br><i>Tsuga canadensis</i> | <i>Acer rubrum</i> ,<br><i>Pinus strobus</i> ,<br><i>Nyssa sylvatica</i> ,<br><i>Oxydendrum arboreum</i> ,<br><i>Quercus coccinea</i> |       |
| Most abundant seedlings                   | <i>Acer rubrum</i> ,<br><i>Quercus montana</i> ,<br><i>Quercus coccinea</i> ,<br><i>Quercus rubra</i> ,<br><i>Pinus strobus</i>       | <i>Acer rubrum</i> ,<br><i>Quercus montana</i> ,<br><i>Pinus strobus</i> ,<br><i>Nyssa sylvatica</i> ,<br><i>Quercus coccinea</i>     |       |
| shrub density (#/m <sup>2</sup> )         | 0.34                                                                                                                                  | 0.49                                                                                                                                  | 44%   |
| herbaceous species richness (#/plot)      | 8.27                                                                                                                                  | 8.6                                                                                                                                   | 4%    |
| deadwood abundance (#/plot)               | 9.53                                                                                                                                  | 8.87                                                                                                                                  | -7%   |

## Early Successional Forests



### Condition Ranking



Good & Stable  
(High Confidence)

Early successional is the only forest type in GRSM wholly defined by previous land use. These stands are the result of pre-park settlement and farming activities, and therefore occur in the lower and mid elevation heavily settled areas of the park. These stands are generally even-aged and dominated by successional hardwood species, especially tulip poplar. Understory are impoverished compared to unsettled areas around them, due to soil compaction and loss of seed banks. While these stands are still successional in composition, they are nearly 100 years in age and beginning to transition to a more mixed-aged forest stage. Historically, many of these stands would have been oak-dominant, and long-term monitoring will be needed to understand their future trajectory. Currently, early successional forests are rated as Good and Stable (High Confidence). Important monitoring metrics include overstory mortality, shifts in overstory composition, and overall species richness.

### Plot Data Summary

The below table summarizes changes between cycles for early successional plots that have more than one cycle of data. This data is preliminary as it is only based on 2 of 5 years of repeat data. Current trends based on these 8 plots include a large decrease in snag density, possibly reflecting a forest type that is moving beyond the self-thinning stage and having less new tree mortality, while aging snags are falling down. Herbaceous diversity is up 16%, which again may reflect real change or refined ability to access herbaceous species. More data will be needed to assess this trend. Overall, these communities appear to be in the late stages of succession, and perhaps will be converted over to a mature forest type in the future, such as cove hardwoods or oak-hickory.

**Table 7:** : An overview of repeat measures for Early Successional Plots

| Metric                                    | First_Cycle_Data                                                                                                                                               | Second_Cycle_Data                                                                                                                                           | Delta |
|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| Community Type                            | Early Successional Forests                                                                                                                                     | Early Successional Forests                                                                                                                                  |       |
| # Plots                                   | 8                                                                                                                                                              | 8                                                                                                                                                           |       |
| live tree basal area (m <sup>2</sup> /ha) | 31.57                                                                                                                                                          | 33.13                                                                                                                                                       | 5%    |
| live tree density (#/ha)                  | 539.76                                                                                                                                                         | 532.87                                                                                                                                                      | -1%   |
| snag density (#/ha)                       | 146.99                                                                                                                                                         | 108.24                                                                                                                                                      | -26%  |
| tree mortality rate (#/ha/yr)             |                                                                                                                                                                | 7.36                                                                                                                                                        |       |
| tree recruitment rate (#/ha/yr)           |                                                                                                                                                                | 6.95                                                                                                                                                        |       |
| tree vigor                                | 3                                                                                                                                                              | 3                                                                                                                                                           | 0     |
| Most abundant canopy species              | <i>Liriodendron tulipifera</i> ,<br><i>Acer rubrum</i> ,<br><i>Betula lenta</i> v. <i>lenta</i> ,<br><i>Halesia tetraptera</i> ,<br><i>Pinus strobus</i>       | <i>Liriodendron tulipifera</i> ,<br><i>Betula lenta</i> v. <i>lenta</i> ,<br><i>Acer rubrum</i> ,<br><i>Tsuga canadensis</i> ,<br><i>Pinus strobus</i>      |       |
| Most abundant midstory species            | <i>Acer rubrum</i> ,<br><i>Tsuga canadensis</i> ,<br><i>Betula lenta</i> v. <i>lenta</i> ,<br><i>Liriodendron tulipifera</i> ,<br><i>Betula alleghaniensis</i> | <i>Acer rubrum</i> ,<br><i>Tsuga canadensis</i> ,<br><i>Betula lenta</i> v. <i>lenta</i> ,<br><i>Halesia tetraptera</i> ,<br><i>Liriodendron tulipifera</i> |       |
| Most abundant saplings                    | <i>Betula lenta</i> v. <i>lenta</i> ,<br><i>Acer pensylvanicum</i> ,<br><i>Acer rubrum</i> ,<br><i>Amelanchier arborea</i> ,<br><i>Fagus grandifolia</i>       | <i>Betula lenta</i> v. <i>lenta</i> ,<br><i>Acer pensylvanicum</i> ,<br><i>Oxydendrum arboreum</i> ,<br><i>Pinus strobus</i> ,<br><i>Tsuga canadensis</i>   |       |
| Most abundant seedlings                   | <i>Acer rubrum</i> ,<br><i>Quercus rubra</i> ,<br><i>Acer pensylvanicum</i> ,<br><i>Liriodendron tulipifera</i> ,<br><i>Betula lenta</i> v. <i>lenta</i>       | <i>Acer rubrum</i> ,<br><i>Betula lenta</i> v. <i>lenta</i> ,<br><i>Acer pensylvanicum</i> ,<br><i>Quercus rubra</i> ,<br><i>Liriodendron tulipifera</i>    |       |
| shrub density (#/m <sup>2</sup> )         | 0.14                                                                                                                                                           | 0.18                                                                                                                                                        | 29%   |
| herbaceous species richness (#/plot)      | 20.75                                                                                                                                                          | 24.75                                                                                                                                                       | 16%   |
| deadwood abundance (#/plot)               | 16.38                                                                                                                                                          | 12.62                                                                                                                                                       | -30%  |

## Montane Alluvial Forests



### Condition Ranking



Poor & Stable  
(Medium Confidence)

Montane alluvial forests occupy a narrow band along creeks and rivers in GRSM and so naturally occupy less than 1% of park area. Forest composition varies widely depending on stream size, elevation, soils and local topography. Generally, stands alongside lower elevation and larger streams have high coverage of sweetgum (*Liquidambar styraciflua*), American sycamore (*Platanus occidentalis*), tulip poplar, black walnut (*Juglans nigra*), box elder (*Acer negundo*), and green ash (*Fraxinus pensylvanica*) while higher elevation stands along smaller rivers may include more typical cove species such as eastern hemlock, sweet birch (*Betula lenta*), yellow birch, and American basswood. The understory is variable, ranging from dense patches of dog-hobble (*Leucothoe fontanesiana*) and rosebay rhododendron in bouldery, acidic positions to forb-dominated stands where soils are more neutral and deeper. Often, pockets of alluvial wetlands can be found within the floodplains.

Due to flat topography and often fertile soils, montane alluvial forests were heavily settled and farmed during European settlement. Additionally, current park infrastructure, such as campgrounds, picnic areas, and roadways often occupy these forest communities. Such historic and current disturbances are the largest stressor of this system, followed by forest pests and invasive plant species. Currently, montane alluvial forests are rated as Poor and Stable (Medium Confidence). Important metrics for monitoring trends in this forest type include overstory vigor and mortality, non-native species abundance, and changes in herbaceous layer abundance and percent cover.

### Plot Data Summary

To date, no repeat data have been collected on Montane Alluvial Plots.

## Appendix B Repeat Measure Soils Data for 2023 field season plots

Appendix B includes change tables for soil pH, Sulphur ppm, and Cation Exchange Capacity (CEC). This is only a small subset of soils data, but tracked here as these metrics are of interest to other vital signs. At this point, repeat measure data only includes 1 year of plots (Cycle 2, 2017 and 2023) so data are limited.

| LOC_NAME | STRATUM          | Metric | First | Second | Delta | Delta Percent |
|----------|------------------|--------|-------|--------|-------|---------------|
| VSA004   | Abrams_Low       | SoilpH | 4.7   | 5.2    | 0.5   | 0.10          |
| VSA005   | Abrams_Low       | SoilpH | 4.2   | 4.9    | 0.7   | 0.14          |
| VSA006   | Abrams_Low       | SoilpH | 4.1   | 4.7    | 0.6   | 0.13          |
| VSA038   | Abrams_Mid       | SoilpH | 4.6   | 4.8    | 0.2   | 0.04          |
| VSA046   | Abrams_Mid       | SoilpH | 4.3   | 4.8    | 0.5   | 0.10          |
| VSE389   | LR_Goshen_Low    | SoilpH | 5.2   | 5.0    | -0.2  | -0.04         |
| VSE390   | LR_Goshen_Low    | SoilpH | 4.4   | 4.4    | 0.0   | 0.00          |
| VSE391   | LR_Goshen_Low    | SoilpH | 4.5   | 4.8    | 0.3   | 0.06          |
| VSE424   | LR_Goshen_Mid    | SoilpH | 4.6   | 5.1    | 0.5   | 0.10          |
| VSE437   | LR_Goshen_Mid    | SoilpH | 4.2   | 5.2    | 1.0   | 0.19          |
| VSE438   | LR_Goshen_Mid    | SoilpH | 4.4   | 4.7    | 0.3   | 0.06          |
| VSE457   | LR_Goshen_High   | SoilpH | 3.8   | 4.1    | 0.3   | 0.07          |
| VSG303   | LP_Porters_Low   | SoilpH | 4.1   | 4.9    | 0.8   | 0.16          |
| VSG304   | LP_Porters_Low   | SoilpH | 4.9   | 4.8    | -0.1  | -0.02         |
| VSG341   | LP_Porters_Mid   | SoilpH | 4.3   | 4.1    | -0.2  | -0.05         |
| VSD193   | Deep_Creek_High  | SoilpH | 4.2   | 4.7    | 0.5   | 0.11          |
| VSD194   | Deep_Creek_High  | SoilpH | 3.8   | 4.0    | 0.2   | 0.05          |
| VSH223   | Hazel_Creek_Low  | SoilpH | 4.7   | 4.9    | 0.2   | 0.04          |
| VSH224   | Hazel_Creek_Low  | SoilpH | 4.8   | 4.7    | -0.1  | -0.02         |
| VSH252   | Hazel_Creek_Mid  | SoilpH | 4.3   | 5.2    | 0.9   | 0.17          |
| VSH277   | Hazel_Creek_High | SoilpH | 4.3   | 4.4    | 0.1   | 0.02          |
| VSG362   | LP_Porters_High  | SoilpH | 3.8   | 3.6    | -0.2  | -0.06         |
| VSC069   | Cataloochee_Mid  | SoilpH | 4.7   | 4.7    | 0.0   | 0.00          |
| VSC070   | Cataloochee_Mid  | SoilpH | 4.6   | 4.6    | 0.0   | 0.00          |
| VSC071   | Cataloochee_Mid  | SoilpH | 4.4   | 4.9    | 0.5   | 0.10          |
| VSC103   | Cataloochee_High | SoilpH | 3.6   | 3.9    | 0.3   | 0.08          |
| VSC104   | Cataloochee_High | SoilpH | 4.6   | 4.3    | -0.3  | -0.07         |
| VSD133   | Deep_Creek_Low   | SoilpH | 4.4   | 5.3    | 0.9   | 0.17          |
| VSD134   | Deep_Creek_Low   | SoilpH | 5.0   | 5.3    | 0.3   | 0.06          |
| VSD163   | Deep_Creek_Mid   | SoilpH | 4.6   | 5.0    | 0.4   | 0.08          |
| VSD164   | Deep_Creek_Mid   | SoilpH | 4.9   | 5.5    | 0.6   | 0.11          |

| LOC_NAME | STRATUM          | Metric | First | Second | Delta | Delta Percent |
|----------|------------------|--------|-------|--------|-------|---------------|
| VSA004   | Abrams_Low       | S_ppm  | 14    | 16     | 2     | 0.12          |
| VSA005   | Abrams_Low       | S_ppm  | 14    | 13     | -1    | -0.08         |
| VSA006   | Abrams_Low       | S_ppm  | 17    | 20     | 3     | 0.15          |
| VSA038   | Abrams_Mid       | S_ppm  | 23    | 17     | -6    | -0.35         |
| VSA046   | Abrams_Mid       | S_ppm  | 15    | 20     | 5     | 0.25          |
| VSE389   | LR_Goshen_Low    | S_ppm  | 19    | 15     | -4    | -0.27         |
| VSE390   | LR_Goshen_Low    | S_ppm  | 25    | 39     | 14    | 0.36          |
| VSE391   | LR_Goshen_Low    | S_ppm  | 22    | 20     | -2    | -0.10         |
| VSE424   | LR_Goshen_Mid    | S_ppm  | 12    | 12     | 0     | 0.00          |
| VSE437   | LR_Goshen_Mid    | S_ppm  | 19    | 19     | 0     | 0.00          |
| VSE438   | LR_Goshen_Mid    | S_ppm  | 14    | 14     | 0     | 0.00          |
| VSE457   | LR_Goshen_High   | S_ppm  | 15    | 13     | -2    | -0.15         |
| VSG303   | LP_Porters_Low   | S_ppm  | 18    | 23     | 5     | 0.22          |
| VSG304   | LP_Porters_Low   | S_ppm  | 17    | 19     | 2     | 0.11          |
| VSG341   | LP_Porters_Mid   | S_ppm  | 20    | 19     | -1    | -0.05         |
| VSD193   | Deep_Creek_High  | S_ppm  | 22    | 16     | -6    | -0.38         |
| VSD194   | Deep_Creek_High  | S_ppm  | 18    | 15     | -3    | -0.20         |
| VSH223   | Hazel_Creek_Low  | S_ppm  | 17    | 15     | -2    | -0.13         |
| VSH224   | Hazel_Creek_Low  | S_ppm  | 19    | 20     | 1     | 0.05          |
| VSH252   | Hazel_Creek_Mid  | S_ppm  | 17    | 15     | -2    | -0.13         |
| VSH277   | Hazel_Creek_High | S_ppm  | 25    | 28     | 3     | 0.11          |
| VSG362   | LP_Porters_High  | S_ppm  | 12    | 10     | -2    | -0.20         |
| VSC069   | Cataloochee_Mid  | S_ppm  | 20    | 15     | -5    | -0.33         |
| VSC070   | Cataloochee_Mid  | S_ppm  | 19    | 15     | -4    | -0.27         |
| VSC071   | Cataloochee_Mid  | S_ppm  | 19    | 15     | -4    | -0.27         |
| VSC103   | Cataloochee_High | S_ppm  | 18    | 12     | -6    | -0.50         |
| VSC104   | Cataloochee_High | S_ppm  | 20    | 13     | -7    | -0.54         |
| VSD133   | Deep_Creek_Low   | S_ppm  | 18    | 18     | 0     | 0.00          |
| VSD134   | Deep_Creek_Low   | S_ppm  | 18    | 15     | -3    | -0.20         |
| VSD163   | Deep_Creek_Mid   | S_ppm  | 24    | 18     | -6    | -0.33         |
| VSD164   | Deep_Creek_Mid   | S_ppm  | 13    | 12     | -1    | -0.08         |

| LOC_NAME | STRATUM       | Metric | First | Second | Delta | Delta Percent |
|----------|---------------|--------|-------|--------|-------|---------------|
| VSA004   | Abrams_Low    | CEC    | 2.6   | 1.8    | -0.8  | -0.44         |
| VSA005   | Abrams_Low    | CEC    | 5.7   | 2.3    | -3.4  | -1.48         |
| VSA006   | Abrams_Low    | CEC    | 4.3   | 2.0    | -2.3  | -1.15         |
| VSA038   | Abrams_Mid    | CEC    | 2.6   | 2.4    | -0.2  | -0.08         |
| VSA046   | Abrams_Mid    | CEC    | 3.0   | 1.5    | -1.5  | -1.00         |
| VSE389   | LR_Goshen_Low | CEC    | 3.1   | 3.7    | 0.6   | 0.16          |
| VSE390   | LR_Goshen_Low | CEC    | 2.6   | 2.1    | -0.5  | -0.24         |
| VSE391   | LR_Goshen_Low | CEC    | 2.4   | 1.9    | -0.5  | -0.26         |
| VSE424   | LR_Goshen_Mid | CEC    | 8.6   | 3.2    | -5.4  | -1.69         |
| VSE437   | LR_Goshen_Mid | CEC    | 4.7   | 1.7    | -3.0  | -1.76         |

| LOC_NAME | STRATUM          | Metric | First | Second | Delta | Delta Percent |
|----------|------------------|--------|-------|--------|-------|---------------|
| VSE438   | LR_Goshen_Mid    | CEC    | 3.4   | 2.6    | -0.8  | -0.31         |
| VSE457   | LR_Goshen_High   | CEC    | 4.6   | 5.9    | 1.3   | 0.22          |
| VSG303   | LP_Porters_Low   | CEC    | 4.6   | 1.6    | -3.0  | -1.87         |
| VSG304   | LP_Porters_Low   | CEC    | 4.6   | 1.9    | -2.7  | -1.42         |
| VSG341   | LP_Porters_Mid   | CEC    | 4.7   | 6.1    | 1.4   | 0.23          |
| VSD193   | Deep_Creek_High  | CEC    | 4.0   | 2.3    | -1.7  | -0.74         |
| VSD194   | Deep_Creek_High  | CEC    | 5.7   | 6.5    | 0.8   | 0.12          |
| VSH223   | Hazel_Creek_Low  | CEC    | 4.0   | 2.0    | -2.0  | -1.00         |
| VSH224   | Hazel_Creek_Low  | CEC    | 1.9   | 2.0    | 0.1   | 0.05          |
| VSH252   | Hazel_Creek_Mid  | CEC    | 2.6   | 1.7    | -0.9  | -0.53         |
| VSH277   | Hazel_Creek_High | CEC    | 3.5   | 5.5    | 2.0   | 0.36          |
| VSG362   | LP_Porters_High  | CEC    | 6.5   | 6.1    | -0.4  | -0.07         |
| VSC069   | Cataloochee_Mid  | CEC    | 2.4   | 3.5    | 1.1   | 0.31          |
| VSC070   | Cataloochee_Mid  | CEC    | 2.4   | 3.1    | 0.7   | 0.23          |
| VSC071   | Cataloochee_Mid  | CEC    | 3.7   | 2.7    | -1.0  | -0.37         |
| VSC103   | Cataloochee_High | CEC    | 9.4   | 5.6    | -3.8  | -0.68         |
| VSC104   | Cataloochee_High | CEC    | 7.0   | 7.1    | 0.1   | 0.01          |
| VSD133   | Deep_Creek_Low   | CEC    | 3.1   | 1.6    | -1.5  | -0.94         |
| VSD134   | Deep_Creek_Low   | CEC    | 2.1   | 1.7    | -0.4  | -0.24         |
| VSD163   | Deep_Creek_Mid   | CEC    | 2.4   | 2.2    | -0.2  | -0.09         |
| VSD164   | Deep_Creek_Mid   | CEC    | 5.1   | 3.3    | -1.8  | -0.55         |

## Appendix C Completed and rejected plots from the 2023 field season

**Table 8:** Completed plots, included QA revisits, for 2023 field season

| LOC_NAME | STRATUM         | X_COORD   | Y_COORD   | Event_Date | QA Data?        |
|----------|-----------------|-----------|-----------|------------|-----------------|
| VSA004   | Abrams_Low      | 240,462.2 | 3,945,381 | 6/5/2023   |                 |
| VSA006   | Abrams_Low      | 245,093.0 | 3,941,018 | 6/13/2023  |                 |
| VSA006   | Abrams_Low      | 245,093.0 | 3,941,018 | 6/13/2023  | Yes             |
| VSA046   | Abrams_Mid      | 250,496.0 | 3,942,289 | 6/7/2023   |                 |
| VSD133   | Deep_Creek_Low  | 281,967.1 | 3,929,909 | 7/5/2023   |                 |
| VSD134   | Deep_Creek_Low  | 280,294.0 | 3,932,552 | 6/28/2023  | Yes             |
| VSD134   | Deep_Creek_Low  | 280,294.0 | 3,932,552 | 6/28/2023  |                 |
| VSD164   | Deep_Creek_Mid  | 282,145.0 | 3,932,572 | 6/26/2023  |                 |
| VSH223   | Hazel_Creek_Low | 254,827.3 | 3,929,660 | 7/10/2023  |                 |
| VSG304   | LP_Porters_Low  | 285,207.3 | 3,954,186 | 5/30/2023  | Yes             |
| VSG304   | LP_Porters_Low  | 285,207.3 | 3,954,186 | 5/30/2023  |                 |
| VSG334   | LP_Porters_Mid  | 283,103.0 | 3,949,577 | 9/7/2023   | *Soil Data Only |

| LOC_NAME | STRATUM          | X_COORD   | Y_COORD   | Event_Date | QA Data? |
|----------|------------------|-----------|-----------|------------|----------|
| VSG362   | LP_Porters_High  | 296,035.4 | 3,954,535 | 8/30/2023  |          |
| VSE391   | LR_Goshen_Low    | 261,267.0 | 3,952,085 | 6/8/2023   |          |
| VSE391   | LR_Goshen_Low    | 261,267.0 | 3,952,085 | 6/8/2023   | Yes      |
| VSE424   | LR_Goshen_Mid    | 268,432.0 | 3,946,522 | 7/3/2023   |          |
| VSA005   | Abrams_Low       | 234,844.2 | 3,945,910 | 5/15/2023  |          |
| VSG303   | LP_Porters_Low   | 280,911.0 | 3,955,252 | 5/17/2023  |          |
| VSE389   | LR_Goshen_Low    | 269,176.0 | 3,947,263 | 5/31/2023  |          |
| VSE389   | LR_Goshen_Low    | 269,176.0 | 3,947,263 | 5/31/2023  | Yes      |
| VSE390   | LR_Goshen_Low    | 257,301.5 | 3,949,803 | 6/15/2023  |          |
| VSE390   | LR_Goshen_Low    | 257,301.5 | 3,949,803 | 6/15/2023  | Yes      |
| VSE437   | LR_Goshen_Mid    | 261,369.0 | 3,948,113 | 6/14/2023  |          |
| VSE437   | LR_Goshen_Mid    | 261,369.0 | 3,948,113 | 6/14/2023  | Yes      |
| VSD163   | Deep_Creek_Mid   | 281,982.0 | 3,934,420 | 6/27/2023  | Yes      |
| VSD163   | Deep_Creek_Mid   | 281,982.0 | 3,934,420 | 6/27/2023  |          |
| VSA038   | Abrams_Mid       | 242,535.2 | 3,937,369 | 7/27/2023  |          |
| VSH252   | Hazel_Creek_Mid  | 257,205.7 | 3,931,889 | 7/12/2023  |          |
| VSH224   | Hazel_Creek_Low  | 257,057.0 | 3,933,428 | 7/11/2023  |          |
| VSC071   | Cataloochee_Mid  | 311,488.6 | 3,946,921 | 8/2/2023   |          |
| VSG341   | LP_Porters_Mid   | 282,347.0 | 3,950,133 | 7/17/2023  |          |
| VSE457   | LR_Goshen_High   | 275,519.2 | 3,942,638 | 8/1/2023   |          |
| VSD194   | Deep_Creek_High  | 276,278.3 | 3,940,856 | 7/26/2023  |          |
| VSD194   | Deep_Creek_High  | 276,278.3 | 3,940,856 | 7/26/2023  | Yes      |
| VSC070   | Cataloochee_Mid  | 309,546.0 | 3,951,241 | 8/16/2023  |          |
| VSC103   | Cataloochee_High | 303,169.1 | 3,949,114 | 8/8/2023   |          |
| VSC104   | Cataloochee_High | 301,029.2 | 3,946,681 | 8/9/2023   |          |
| VSE438   | LR_Goshen_Mid    | 269,118.9 | 3,946,302 | 8/22/2023  |          |
| VSD193   | Deep_Creek_High  | 277,313.4 | 3,936,769 | 8/17/2023  |          |
| VSD193   | Deep_Creek_High  | 277,313.4 | 3,936,769 | 8/17/2023  | Yes      |
| VSC069   | Cataloochee_Mid  | 306,855.0 | 3,939,973 | 9/5/2023   |          |
| VSH277   | Hazel_Creek_High | 262,173.9 | 3,930,769 | 7/11/2023  |          |