Vegetation dynamics following low-intensity ground fire on a rare ecosystem subtype - Grass Bald

Masters student thesis proposal for Western Carolina University

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2023-05-17

Table of Contents

# INTRODUCTION

## Round Bald

Round bald is located along the borders of North Carolina and Tennessee of the Appalachian Trail. The site is about 20 miles North of Bakersville, North Carolina and about 13 miles South of Roan Mountain, Tennessee. Round bald has been experiencing woody encroachment from invasive species like *Rubus allegheniensis*, *Rubus canadensis*, *Vaccinium spp.*, *Rhododendrom spp.* and saplings from the surrounding spruce-fir forest. These species are causing the bald to shift from a grass bald subtype into a heath bald subtype. Grass balds are defined as the majority of vegetation is either grasses or sedges. Following woody encroachment, This could potentially extirpate a rare ecosystem subtype that provides panoramic vista views of the adjacent mountaintops and hosts a number of rare and endemic species, such as - Roan Lily, *Lilium grayi*. Nearly 40 years ago, Murdock (1986) and Hamel and Somers (1990) examined the vegetation community of Roan Mountain balds when the decision to protect these landscapes started to change. In 2020, following 30 years of mowing management, Stokes and Horton (2022) re-surveyed plots from Murdock (1986) and Hamel and Somers (1990). In February of 2022, there was a low-intensity ground fire that burned for less than 6 hours and burned approximately 9.7 hectares of Round Bald. Roughly half of the plots that Stokes and Horton (2022) surveyed on Round Bald along the first four transects were within the fire and the other half - along the same four transects - were outside of the fire boundary.

## History

Upper montane treeless meadows - balds - host high floral diversity, panoramic views of the landscape, and origins hotly debated to this day (Gersmehl 1970, Murdock 1986, Hamel and Somers 1990). Many speculate that balds were cleared by Native people for hunting and early settlers for pasturing livestock in the spring and summer seasons (Lindsay and Bratton 1979) - anthropogenic origin. Others believe that they are of a climate-herbivore driven change in the landscape, making it a natural ecosystem (Weigl and Knowles 1995, 2014). True balds are above 1,400 meters in elevation, while any bald can exist on a rock outcrop above 1,200 meters in elevation (Gersmehl 1970). Furthermore, true balds occur only in the Southern Blue Ridge Physiographic Province. Other balds - apparent balds - are distributed globally with sites in Siberia and Australia. There has been much in the way of bald history in the literature, but data regarding vegetation dynamics following disturbance is scant or focused on other balds. Management of these balds varies by managing agency, type of bald - heath or grass, and proposed origin - whether it was cleared, grazed, burned, or some combination of these (Lindsay and Bratton 1979, Weigl and Knowles 1995, 2014). Separating bald origins and subtype vegetation dynamics is key to preserving these dwindling ecosystems and conserving them for future generations (Moravek et al. 2013). Here, I examined changes to Round bald at the plot level to determine change in the vegetation community following a low-intensity ground fire disturbance in February 2022 which burned approximately 9.7 hectares. Stokes and Horton (2022) examined the vegetation composition following 30 years of mowing management on the balds of Carver’s Gap (Murdock 1986, Hamel and Somers 1990).

### Seed bank

The soil seed bank is an ecologists term for the “potential community” layer. It is the prequel layer to the advanced regeneration layer that is currently growing on the forest floor. In this sense, ecologists look at the soil seed bank to predict what can grow in the next few growing seasons. Estimates of the soil seed bank are more accurate when using two methods - seedling emergence and seed extraction (Price et al. 2010, Abella et al. 2013, and Chiquoine and Abella 2018). The first plants the seed bank sample promptly following collection, while the second sieves the seeds from dirt and then planted individually.

### Woody Encroachment

The United States Forest Service (USFS) acquired some of the Southern Appalachian bald lands in the late 1920s after which, active management and general recreation ceased (Lindsay and Bratton 1979). This led to shrub succession in the late 1930s and a management problem in the 1950s (Lindsay and Bratton 1979, Lindsay and Bratton 1980). Despite the shrub succession on these balds, there is debate about whether to protect these areas or not. This is because the literature is unclear about bald origins - whether they are natural formations or human-engineered ecosystems. Following management cessation, the range of grass balds along the Southern Appalachian Mountains (SAMs) has shifted since the study by Murdock (1986), who had surveyed round balds in the 1980s. A repeated survey of the balds of Carver’s Gap in 2020 by Stokes and Horton (2022) examined the first 3.36 km of the balds. Based on preliminary analysis of 2022 sampling data in excel, the cover of *Rubus allegheniensis* and *Rubus canadensis* (Rubus or blackbery) two primary native invasive species helping this grassy bald subtype to succeed into a heath bald subtype. On ideal balds, grass balds are dominated by grasses and sedge, while health balds are dominated by ericaceous shrubs. Without management, natural succession alters these balds from the grass to heath subtype.

Bald management within the Southern Appalachian Mountains varies by managing agency and bald history, with most practices promoting mowing or grazing, and few instances of fire or clearing. When used, fire must be high intensity or high duration to provide a significant effect against woody encroachment (Lindsay and Bratton 1980). Germination requirements of the invasive genus Rubus include scarification - some damage to the seed has to occur for the seed to germinate, fire can provide that damage and could possibly increase growth the following season (Davies 1998). Sufficiently hot or lengthy burns have the potential to prevent the growth of blackberry, however post-burn analyses of the vegetation community indicates that the resulting community is not characteristic of grass balds (Lindsay and Bratton 1980). Likewise, prescribed burns are difficult to manage at such high elevations, soil moisture levels, and effects on rare and endemic species of historic balds.

### Objectives

The objectives of this study are; 1. Quantify vegetation composition and the soil seed bank over the 2020, 2022, and 2023 growing seasons following the low intensity ground fire on Round Bald, and 2. Propose methods to improve management for conservation of these rare ecosystem subtypes. The general question is, how has the low-intensity ground fire affected vegetation dynamics compared to data provided by Stokes and Horton (2022), and are there management practices that could be gleaned from this disturbance?

# METHODS

## 2022

### Study Site

Round bald is located in the Roan Mountain Massif of the Unaka Mountain range of the Southern Appalachian Mountains, between Carver’s Gap and Engine Gap. The Appalachian Trail (AT) bisects the study site into North of the trail and South of the trail. The site itself is spread across Pisgah National Forest in North Carolina and Cherokee National Forest in Tennessee, at approximately 36° 06’N and 82° 60’W. In 2020, Stokes and Horton (2022) surveyed the balds of Carver’s Gap following a 30-year mowing management protocol from Hamel and Somers (1990) and Murdock (1986). They detailed the vegetation composition of the balds according to vegetation genera. Their data were entered into PCORD and produced a schematic of the vegetation communities across the balds of Carver’s Gap (https://independent.academia.edu/slassina n.d.). In February 2022, a low-intensity ground fire burned roughly 9.7 hectares of aboveground vegetation and was quickly expunged before it could spread further. This provided an opportunity to examine the changes in vegetation composition following low-intensity ground fire over two sampling seasons in June of 2022 and 2023.

### Field Methods

In this study I sampled the first four transects reestablished by Stokes and Horton (2022). I quantified vegetation to genera by functional types; *Rubus*, *Vaccinium*, *Rhododenron* (Rhodo), *Angelica*, other forb, grass, sedge, moss, rock, or bare ground. I measured the percent coverage of vegetation using a 1-m^2 PVC quadrat divided into 100 equal sized squares, following Stokes and Horton (2022). Each square was visually assigned by dominant vegetation genera to equal 100% coverage per plot of aboveground vegetation up to 1-meter in height. Using the data collection sheet from Stokes and Horton (2022) and USFS botanist Gary Kauffman - which quantifies vegetation based on focal genera - a total of 226 plots along 12 transects were sampled in 2020, of these, 52 plots - along the first four transects were in the February 2022 fire - and another 47 plots - along the same transects - were unburned. A second survey of vegetation cover was conducted in June 2023 following the same protocol as above.

### Soil Seed Bank

To examine the effects of the fire on the seed bank, seed bank samples were collected in July 2022 and January 2023. In July 2022, approximately 200 grams of soil were obtained from the top 5 cm of soil at six random sites in one of four treatments; over 50% Rubus/burned, over 50% Rubus/unburned, under 25% Rubus/burned, under 25% Rubus/unburned. The first - over 50% Rubus/burned - describes plots with greater than 50% cover of blackberry and burned from the February 2020 fire, followed by greater than 50% blackberry and unburned, less than 25% blackberry and burned, lastly, less than 25% blackberry and unburned. A total of 24 soil seed banks samples were taken, placed in tins, transferred to the greenhouse, then sown in 28x22 cm seedling trays filled with potting mix to 5 cm depth. An additional six trays were filled with unaltered potting mix which acted as greenhouse controls to rule out contamination. Trays were then randomly set in the greenhouse at ambient temperature and humidity and measured continuously with a Govee probe - which continuously measures temperature, percent relative humidity (%RH), dew point (DP), and vapor-pressure-deficit (VPD). As seedlings emerged they were identified, recorded, and removed. The seedlings that could not be identified were re-potted until identifiable following Price et al. (2010). Each month the trays were rotated in random order to rule out growth condition bias. In December of 2022, the soil sample trays were placed outside to simulate winter conditions and potentially germinate seeds in the seed bank over the next spring.

### Greenhouse

A total of 24 soil seed banks samples were taken, placed in tins, transferred to the greenhouse, then sown in 28x22 cm seedling trays filled with potting mix to 5 cm depth. An additional six trays were filled with unaltered potting mix which acted as greenhouse controls to rule out contamination. Trays were then randomly set in the greenhouse at ambient temperature and humidity and measured continuously with a Govee probe - which continuously measures temperature, percent relative humidity, dew point, and vapor-pressure-deficit. As seedlings emerged they were identified, recorded, and removed. The seedlings that could not be identified were re-potted until identifiable following Price et al. (2010). Each month the trays were rotated randomly to rule out growth condition bias. In December of 2022, the soil sample trays were placed outside to simulate winter conditions and potentially germinate seeds in the seed bank over the next spring. A second soil seed bank germination trial following the same protocol will be conducted in mid-to-late March of 2023 onward. These samples will examine what is readily germinable following natural winter weathering and will be compared to the first seed bank set to examine post burn germinable seeds versus post winter germinable seeds.

## 2023

### Soil Seed Bank

In 2022, soil emergence was utilized for the sake of time and I plan to add a modified soil extraction method from Price et al. (2010); Abella et al. (2013); and Chiquoine and Abella (2018) for the second sample set. These authors identify that both methods can provide insight into the potential vegetation community, but a combination of the two provides a more robust estimate of the state of the seed bank. A second set of soil seed bank samples were collected in January of 2023 following the same protocol as the first set. Except this time three samples were taken from each plot and a total of 108 samples were collected from 36 sites on Round bald. One third of these samples were dried, weighed, and underwent seedling extraction. Wherein each sample was sifted through 4000 micron mesh and then sifted through with jewelers forceps to locate and count seeds - a total of 36 samples underwent seed extraction. Another third of the 108 samples were placed in one half of 10x20 inch seedling trays divided down the center, such that each sample was in a 10x10 inch area. To accommodate for space in the greenhouse a total of 15 burned, 15 unburned, and 6 controls samples were sown into eighteen 10x20 inch seedling trays such that one half contained a sample that was burned and the other half had a sample that was unburned.

### Analysis

Differences between the 2020 and 2022 plant community were analyzed using percent covers of vegetation and seedling emergence data. The initial question was to discover whether species percent covers were different between plots that were burned and plots that did not burn. Multi-response permutation procedure (MRPP) is a non-parametric test to describe difference between groups based on a chosen distance function (https://independent.academia.edu/slassina n.d.). Sorensen’s distance was calculated from the percent cover data. Categorical variables were removed from the data matrix and analysis was performed on a matrix of 198 plots by 10 species. The T score produced by MRPP indicates the degree of difference between groups, while the A-value is the effect size within groups, and a p-value to establish the level of test significance. Dominance curves were also used to examine the distribution of vegetation by percent cover between years.

Ordination was conducted in PCORD 6 [PCORD6] to examine the multivariate percent covers of vegetation data. Nonmetric Multidimensional Scaling (NMDS) is used to visualize the data by arranging plots in two-dimensional ordination space. This method is best to represent similarity values calculated from species percent cover data. NMDS is a non-parametric suited for multivariate percent covers using a predetermined distance metric

# References

Abella, S. R., L. P. Chiquoine, and C. H. Vanier. 2013. [Characterizing soil seed banks and relationships to plant communities](https://doi.org/10.1007/s11258-013-0200-3). Plant Ecology 214:703–715.

Chiquoine, L. P., and S. R. Abella. 2018. [Soil seed bank assay methods influence interpretation of non-native plant management](https://doi.org/10.1111/avsc.12393). Applied Vegetation Science 21:626–635.

Davies, R. 1998. Regeneration of blackberry-infested native vegetation. Plant Protection Quarterly 13:189–195.

Gersmehl, P. 1970. A geographic approach to a vegetation problem: The case of the southern appalachian grass balds. Ph.D. Dissertation, University of Georgia, Athens, GA. 463 pp.

Hamel, P., and P. Somers. 1990. Vegetation analysis report: Roan mountain grassy balds. Challenge Cost Share Project.:25.

https://independent.academia.edu/slassina. (n.d.). PC-ORD: Multivariate analysis of ecological data version 6. The Bulletin of the Ecological Society of America 79:144.

Lindsay, M. M., and S. P. Bratton. 1979. [Grassy balds of the great smoky mountains: Their history and flora in relation to potential management](https://doi.org/10.1007/BF01866581). Environmental Management 3:417–430.

Lindsay, M. M., and S. P. Bratton. 1980. The rate of woody plant invasion on two grassy balds. Castanea 45:75–87.

Moravek, S., J. Luly, J. Grindrod, and R. Fairfax. 2013. [The origin of grassy balds in the bunya mountains, southeastern queensland, australia](https://doi.org/10.1177/0959683612460792). The Holocene 23:305–315.

Murdock, N. A. 1986. Evaluation of management techniques on a southern appalachian bald. Unpublished M.S. Thesis. Western Carolina University. 62 pp.

Price, J. N., B. R. Wright, C. L. Gross, and W. R. D. B. Whalley. 2010. [Comparison of seedling emergence and seed extraction techniques for estimating the composition of soil seed banks](https://doi.org/10.1111/j.2041-210X.2010.00011.x). Methods in Ecology and Evolution 1:151–157.

Stokes, C., and J. L. Horton. 2022. [Effects of grassy bald management on plant community composition within the roan mountain massif](https://doi.org/10.2179/0008-7475.87.1.105). Castanea 87:105–120.

Weigl, P. D., and T. W. Knowles. 1995. [Megaherbivores and southern appalachian grass balds](https://doi.org/10.1111/j.1468-2257.1995.tb00176.x). Growth and Change 26:365–382.

Weigl, P. D., and T. W. Knowles. 2014. [Temperate mountain grasslands: A climate-herbivore hypothesis for origins and persistence](https://doi.org/10.1111/brv.12063). Biological Reviews 89:466–476.