



The Oak Regeneration Study in New River Gorge National River

*Monitoring the effects of prescribed burning and deer exclusion
on tree regeneration and groundlayer diversity in xeric oak-
dominated forests*

Natural Resource Report NPS/ERMN/NRR—2017/1374



ON THE COVER

Photograph of NPS biologists collecting data as part of the Oak Regeneration Study in New River Gorge National River
Photograph courtesy of the National Park Service

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Monitoring the effects of prescribed burning and deer exclusion on tree regeneration and groundlayer diversity in xeric oak-dominated forests

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Stephanie Perles¹, Melissa Forder², Stephen Paull², John Fry³

¹Stephanie Perles

National Park Service

Eastern Rivers and Mountains Inventory and Monitoring Network

424 Forest Resources Building

University Park, PA 16802

²Melissa Forder and Stephen Paull

National Park Service

Shenandoah National Park

3655 U.S. Highway 211 East

Luray, VA 22835

³John Fry

National Park Service

New River Gorge National River

PO Box 246

Glen Jean, WV 25846

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Executive Summary

Oak-dominated forests are an important resource in the Appalachian Mountains, covering vast areas of dry ridgetops and mesic hillsides. Within New River Gorge National River (NERI), oak forests cover nearly half of the park area; however, the future of these forests is uncertain due to the lack of regeneration. Oak-dominated forests are a critical park resource because of the many ecosystem services they provide, including habitat and food for a wide diversity of animals and plants.

This report describes a study examining the individual and combined effects of prescribed fire and deer herbivory on tree regeneration and ground layer diversity in dry oak-dominated forests. We establish a randomized split-plot design experiment with treatments of prescribed fire (burned or unburned) and deer exclosure fence (present or absent) at two sites (Grandview and Backus) in NERI. Standard vegetation sampling methods are used to monitor the effects of the treatments alone and in combination on seedling and sapling growth and on understory diversity. Site selection, sample design, field methods, data management and a project timeline are described herein.

This study directly supports the understanding of prescribed fire, deer herbivory, and regeneration in oak forests. This will allow park managers throughout the Appalachian Mountains to plan more effective treatments to meet resource objectives.



Photo 1. Although small oak seedlings are common in New River Gorge, few survive to become saplings or trees.

Background

Oak-dominated forests are an important resource in the Appalachian Mountains, covering vast areas of dry ridgetops and mesic hillsides (Dyer 2006). Within New River Gorge National River (NERI), oak forests cover nearly half of the park area (Vanderhorst et al. 2007). However, the future of these forests is uncertain due to insufficient regeneration of oak trees (*Quercus* spp.; Perles et al. 2014a). Throughout the Appalachian Mountains, oak regeneration is typically underrepresented in oak-dominated forests, such that vast areas of oak forest will be replaced by maples (*Acer* spp.) and other mesophytic trees in future decades (Abrams 2003, Woodall et al. 2008). Studies published by the National Park Service's (NPS) Inventory and Monitoring Program and numerous other studies in the eastern United States have documented the underrepresentation of oak seedlings and saplings in forests with canopies dominated by oaks (Abrams 2003, Widmann and McWilliams 2007, Brose et al. 2008, Iverson et al. 2008, Perles et al. 2014a). Paleoecological studies show oak dominance has been relatively stable throughout most of the eastern United States for >9,000 years (Watts 1979, Maenza-Gmelch 1997). In presettlement land surveys, oak species comprised 35–75% of witness trees (Russell 1981, Abrams and Ruffner 1995, Black and Abrams 2001). However, in recent decades, shade-tolerant species (such as maples) that are capable of displacing oaks on mesic and dry-mesic sites have established in many oak forests (Abrams 1992, Abrams and Downs 1990, Abrams and Nowacki 1992).

Forests dominated by oak trees are a critical park resource because they support diverse communities of animals and plants. Within the mid-Atlantic region, acorns produced by oak trees are a valuable food resource for more than 100 vertebrate species (Brose et al. 2014). Acorn availability and masts affect weight, condition, reproductive rates, dispersal, survival, and population dynamics of numerous mammal and bird species (Pelton 1989, Wentworth et al. 1992, McShea 2000, Rodewald 2003). Furthermore, oak forests host higher abundance and greater species richness of birds than maple-dominated forests because oak leaves, bark, and flowers support more insects that are important food sources for birds (Rodewald and Abrams 2002). Oak leaves are consumed by more than 530 native butterfly and moth (Lepidoptera) species, the highest diversity of Lepidoptera of any genera of woody plant native to the mid-Atlantic region (Tallamy and Shropshire 2009). Oak bark supports many species of insects because the rough texture provides refuge from predators and weather compared to the smooth bark of birches (*Betula* spp.) and maples.

Canopies of oak forests are generally heterogeneous in structure (e.g., contain small gaps, vary in height, support diversity of branch sizes) which is important habitat for bats and crown-nesting birds like the cerulean warbler (Hamel et al. 2004). Canopies of oak trees are penetrated easily by sunlight which facilitates the development of diverse herbaceous and shrub communities on the forest floor. The oak leaves are slow to decompose and are an excellent fuel source for low-intensity surface fires that further diversify forest-floor plant communities (Brose et al. 2014).

Prescribed fire has been recommended as one of the most important tools for restoring oak regeneration. A recent synthesis (Brose et al. 2014) of decades of oak-fire research identifies the challenges of using fire to promote oak regeneration in closed canopy forests similar to those in

NERI. Brose et al. (2014) also highlights that deer browse can be a significant factor affecting oak regeneration after prescribed burns. Canopy gaps, such as those created by fire, facilitate the recruitment of understory trees into canopy, but deer herbivory can play a large role in determining how the recruitment process proceeds (Collins and Carson 2002). Two recent studies have demonstrated the impacts of deer herbivory on the lack of oak regeneration in Mid-Atlantic deciduous forests (McGarvey et al. 2013; Abrams and Johnson 2012); however, these studies did not include prescribed fire. Therefore, park managers need better information on how to apply prescribed fire in closed-canopy oak forests and how burned forests are affected by deer browse.

Objectives

The objective of this project is to study the effects of prescribed fire and deer herbivory alone, and in combination, on hardwood regeneration and understory plants in dry oak-dominated forests. We establish a randomized split-plot design experiment with treatments of prescribed fire and deer exclosure fence. Standard vegetation sampling methods are used to monitor the effects of the treatments on seedling and sapling growth and on understory diversity. This study directly supports the understanding of how prescribed fire and deer herbivory influence regeneration in oak forests, which will allow park managers throughout the Appalachian Mountains to plan more effective treatments to meet resource objectives.

Site Selection and Sample Design

To locate potential study sites, areas of Oak – Ericad Forest (CEGL006271) and Oak – Hickory Forest (CEGL007267) that were greater than 20 ha in size were identified from the park’s vegetation map (Vanderhorst et al. 2007). A team of park natural resource managers and fire experts then evaluated, in the field, each of five potential sites: Grandview, Highland Mountain, two sites on Backus Mountain, and Polls Plateau Trail. Based on current forest condition and required logistics for prescribed burning and installation of deer fencing, one site on Backus Mountain and the Grandview site were selected.

The two 20-ha study sites were each divided into four units of roughly equal area and then prescribed burning treatment was randomly assigned to two units, leaving the remaining two units as unburned. Next, two 4-ha sample areas were identified in each burned or unburned unit and a treatment of fenced or unfenced was randomly assigned to each area, such that each unit contained one fenced and one unfenced area (Figures 1 and 2). Thus, the prescribed burning treatment was the whole-plot factor and the fencing treatment was the split-plot factor.

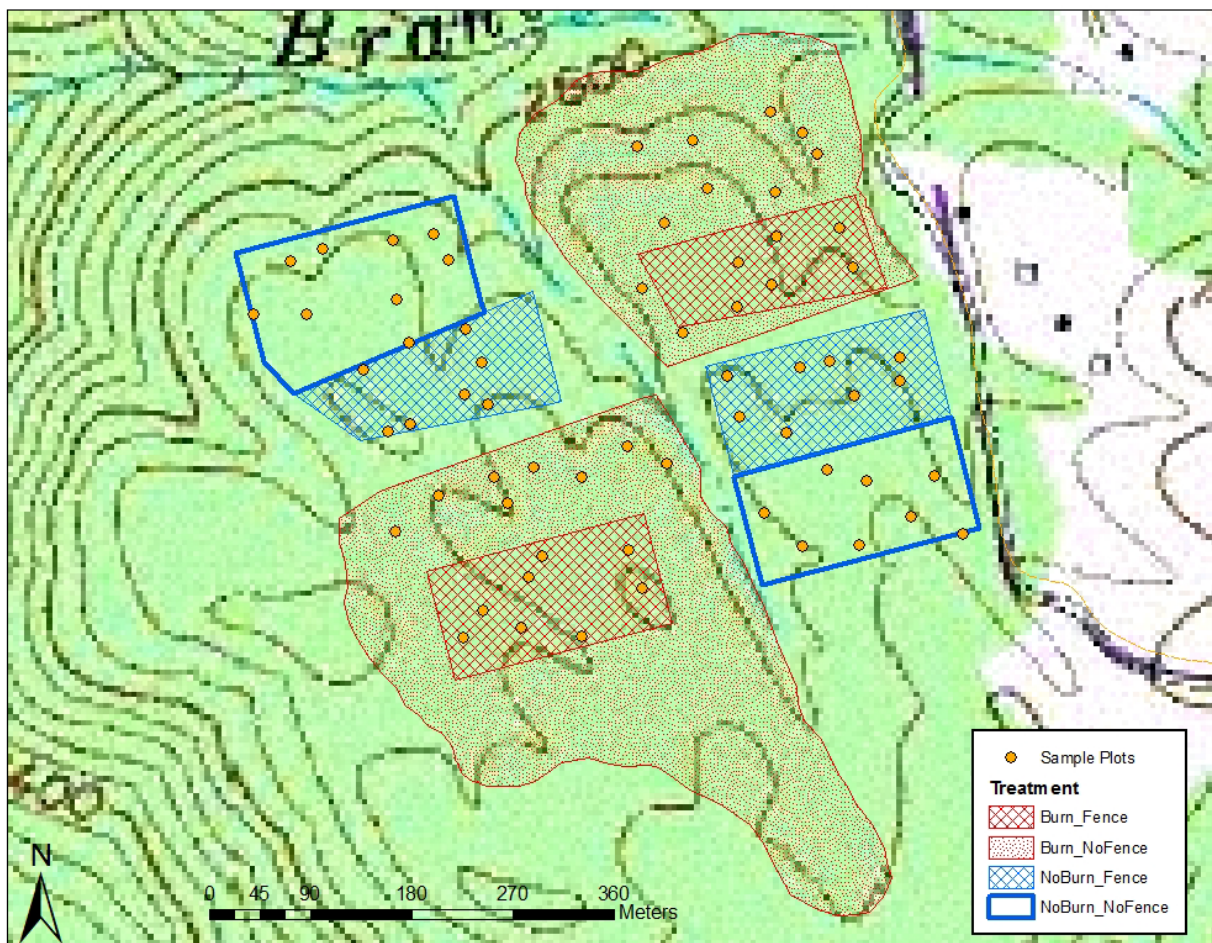


Figure 1. Randomized split-plot sample design of four treatments and 64 plots at the Backus site. Each site has two replicates of each treatment.

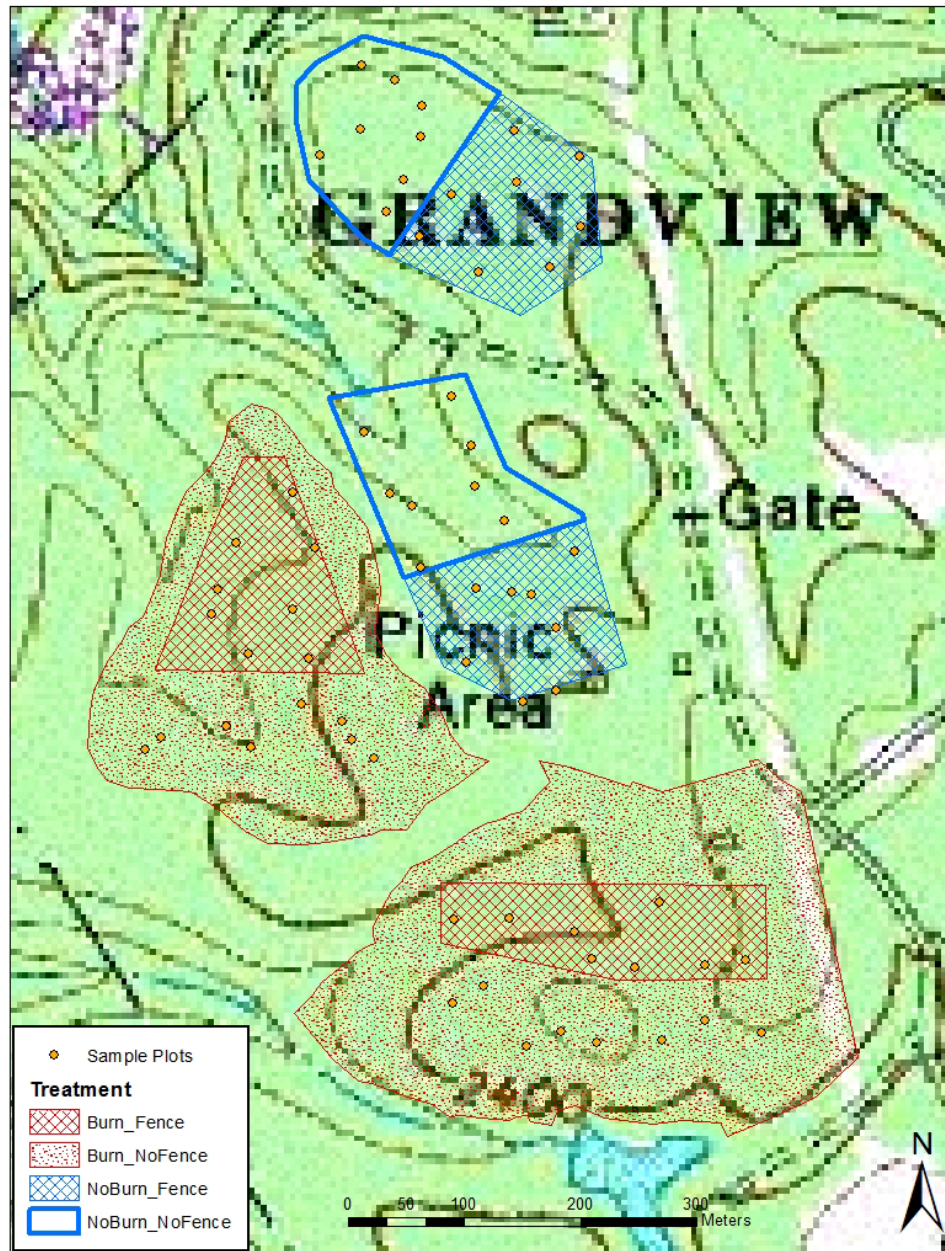


Figure 2. Randomized split-plot sample design of four treatments and 64 plots at the Grandview site. Each site has two replicates of each treatment.

Plots were used to sample vegetation within each treatment area. Because prescribed fire can be heterogeneous, we used restricted random sampling to ensure that plots were spatially distributed throughout each sample area. Each sample area was divided into eight equal polygons and those polygons were internally buffered by 8 meters so that plots would not spatially overlap. One plot was then randomly located within each buffered polygon creating eight plots within each sample area.

Field Methods

The 128 plots are sampled using established methods from three prominent monitoring programs:

- US Forest Service Forest Inventory and Analysis Program for measuring trees and tree regeneration (USDA 2015);
- National Park Service Eastern Rivers and Mountains Inventory and Monitoring Network (ERMN) Vegetation Monitoring Program for site characterization, groundstory diversity metrics, and browse-sensitive species (Perles et al. 2014b);
- National Park Service Fire Monitoring Program for fuel load measurements and photo documentation (USDI National Park Service 2003).

The plot design includes several embedded sampling units (Figure 3). Details of the data collection Standard Operating Procedures, can be found in the NPS Data Store within the Integrated Resource Management Applications (IRMA) at <https://irma.nps.gov/DataStore/Reference/Profile/2237838>. Tree, stand, and site measurements are collected within fixed-area, circular plots, 15 m (49.2 ft) in radius. Pole-sized trees are tallied within a 26.6 m² (286.3ft²) triangular quarter plot. Tree regeneration and shrub measurements are collected in one 2 m (6.6 ft) radius circular microplot embedded within each plot. Data on understory plant composition are monitored using four 1-m² quadrats. Fuel load data are collected along one 15.2 m (50 ft) long transect. Two photographs of the plot are taken from specified locations along the plot's boundary to document change in vegetation structure through time.

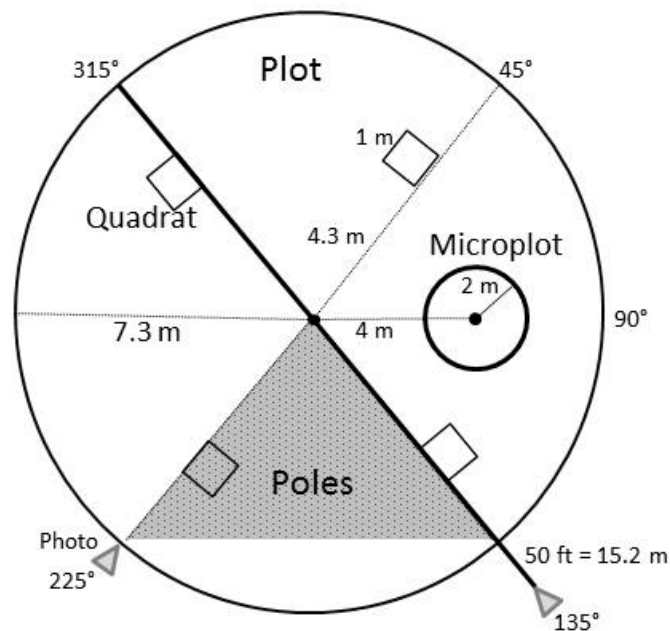


Figure 3. Plot design for the Oak Regeneration Study in New River Gorge National River.

These methods will be followed for the remainder of the study, with revisions tracked by year. The Northeast Region Fire Monitoring Crew will conduct the plot installations and data collection, with assistance from NPS biological technicians employed by NERI and ERMN. Additional field technicians will be contracted in the event that future NPS staffing levels are below current levels.

Interim data collection will occur during the growing season following each prescribed burn. The same field methods will be used during interim data collection, but only 25% of the site's plots will be sampled, as determined by a random selection.

Data Management and Analysis

Based on the Vegetation Monitoring Database stewarded by ERMN for the Vegetation Monitoring Program (Perles et al. 2014b), a project-specific database was built to house site and vegetation data for the duration of this project. The fuel load data will be managed in the FEAT/Firemon Integrated Database (USDI National Park Service 2003) by the NPS Fire Effects Monitoring Team based in Shenandoah National Park.

The metrics that will be monitored over time and summarized following each sampling event include:

- Canopy tree composition, growth, and mortality
- Pole-sized tree composition, growth, and mortality
- Tree sapling height and abundance by species
- Tree seedling height and abundance by species
- Shrub and herbaceous plant cover and diversity
- Counts and reproductive status of herbaceous plants preferred by deer

To test for differences in these metrics among the burn and fence treatments (n=4), we will employ mixed effects models in the lmerTest package in R 3.2.3, using the following general format (Schwartz 2015):

$$\text{Forest Metric} \sim \text{BurnLevel} + \text{FenceLevel} + \text{BurnLevel:FenceLevel} + (1 \mid \text{Site}) + (1 \mid \text{Site:BurnLevel}) \\ + (1 \mid \text{Unit}) + (1 \mid \text{FenceLevel:Site}) + (1 \mid \text{FenceLevel:BurnLevel:Site})$$

in which BurnLevel includes Burned and Unburned; FenceLevel includes Fenced and Unfenced; Site is either Grandview or Backus, and Unit includes the eight burned or unburned units.

Project Timeline, Roles and Responsibilities

Data were collected in June 2015 from each treatment area before fences were installed or prescribed burns were conducted. A timeline of future project activities is shown in Table 1.

Table 1. Timeline for project activities at two research sites in New River Gorge National River.

Activity	Backus	Grandview
Plot Installation and Pre-treatment Data Collection	June 2015	June 2015
Deer Fence Installation	November 2015 – April 2016	November 2015 – April 2016
Prescribed Burn	May 2017	May 2017
Interim Data Collection (32 plots)	June 2017	June 2017
Full Data Collection (128 plots)	June 2020	June 2020
Prescribed Burn	May 2021	May 2021
Interim Data Collection (32 plots)	June 2021	June 2021
Full Data Collection (128 plots)	June 2024	June 2024

The 4-year cycle outlined above can be repeated, if funding and interest warrant continuation of the study. The length of future cycles can be modified (e.g., 5-7 years instead of 3-4), based on the goals and objectives of park management and the outcomes of the treatments.

Deer fences will be checked for integrity regularly throughout the project by NERI Fire Program staff. The NERI Fire Management Office will take the lead on implementing the spring prescribed burns with assistance from the Northeast Region Fire Program. Interim data collection will be conducted by the Northeast Region Fire Monitoring Crew in order to document fire effects as part of the existing fire effects monitoring program. The ERMN Vegetation Monitoring crew will assist the NER Fire Monitoring Crew with full data collection. The Plant Ecologist for the ERMN will be responsible for data stewardship and will conduct data analyses.

We will present results from this study as they are analyzed to NERI staff, fire management staff, and Inventory and Monitoring staff in 2-3 presentations. A final report detailing the study findings will be published on the NPS Data Store in IRMA and the ERMN website. Our results will also be presented at numerous professional scientific and management meetings (e.g., Central Appalachians Fire Learning Network annual meeting, George Wright Society Conference, Association of Fire Ecologists, and Rx Effects Newsletter). We expect this work to result in 1-2 peer-reviewed scientific articles in notable journals in the fields of ecology, fire management and forestry.

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1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

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