The Fernow Experimental Forest and Canaan Valley: A History of Research

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Abstract - The Fernow Experimental Forest (herein called the Fernow) in Tucker County, WV, was set aside in 1934 for "experimental and demonstration purposes under the direction of the Appalachian Forest Experiment Station" of the US Forest Service. Named after a famous German forester, Bernhard Fernow, the Fernow was initially developed with considerable assistance from the Civilian Conservation Corps. Shut down temporarily during World War II, the Fernow was reopened in 1948 as an outdoor laboratory and classroom with the purpose of conducting research that would be useful to the forest landowners and managers throughout the Central Appalachians. Early research focused on the silvicultural management of high-value hardwoods and the effects of various forest management schemes on water quantity and quality. Over time, additional research projects in wildlife, soil science, ecology, air quality, and other environmental topics were included. Today, the Fernow is involved in long-term silvicultural and hydrological research, as well as shorter-term, more topical research projects on the effects of air pollution on wilderness areas, developing management guidelines for threatened and endangered wildlife species, the uses of prescribed fire for managing hardwood stands, and the restoration of the Red Spruce–northern hardwood ecosystem. We include examples of the Fernow's significant findings and conclusions over the years, as well as anecdotes of contributions to West Virginia's quality of life.

History

The Fernow Experimental Forest (hereafter, the Fernow), sited just outside of Parsons, WV, is a 4700-acre (1880-ha) outdoor laboratory and classroom of international reputation. The land around Elk Lick Run, whose watershed encompasses most of The Fernow, was originally granted to Francis and William Deakins by the State of Virginia in 1788. Jonathan Arnold paid the Deakins heirs $4000 for the land in 1856. Later handed down to his son, Thomas J. Arnold, who was a nephew of Thomas "Stonewall" Jackson, the area was first logged between 1903 and 1911. A logging railroad was built to haul logs to the mill, similar to those that operated through much of West Virginia. In 1915, the Arnold tract became the first parcel of land purchased for the Monongahela National Forest.

The original forest on what is now the Fernow was composed mainly of hardwoods, with *Tsuga canadensis* (L.) Carr. (Eastern Hemlock) occurring along streams and on north-facing slopes (Abell 1933). The entire forest area was harvested, but the more accessible areas closer to railroad grades were cut the heaviest. In 1948, many areas far from railroad grades supported heavy stands of old-growth timber comprised predominantly of *Acer saccharum*

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Marsh. (Sugar Maple). Trimble (1977) felt that early reports underestimated the quantity of timber left after the original logging because later merchantability standards were different. For example, a 1960 inventory of one of the Fernow's research watersheds indicated that there were more than 100 Sugar Maple trees of 24 inches (61 cm) in diameter at breast height (dbh) and numerous large *Carya ovata* (Mill.) K. Koch (Shagbark Hickory) and *Quercus rubra* L. (Red Oak) trees, comprising a stand averaging 13,000 board feet per acre (76.8 m^3/ha) (Kochenderfer and Wendel 1983). By this time, most of the watershed's large trees were residuals from the original logging. Fire has not been an issue on The Fernow because a US Forest Service protection unit was organized in 1916 (Trimble 1977) and, unlike many logged areas above 3000 ft (914 m) in elevation in West Virginia, large accumulations of flammable coniferous slash were not left after logging.

In the early 1930s, the US Forest Service made a concerted nationwide effort to establish experimental forests in representative forest types. The Fernow was one of the original 24 Experimental Forests. There are now 81 Experimental Forests and Ranges administered by the USDA Forest Service throughout the nation and its territories. In 1931, four areas on the Monongahela National Forest were examined for possible use as an experimental forest, among which was the Elk Lick Run watershed. The area was recommended because of its variety of sites and timber types, stands older than most on the Monongahela, typical north-central West Virginia topography, and good access. On 28 May 1934, the Fernow Experimental Forest was established by the Chief of the US Forest Service "to make permanently available for forest research and the demonstration of its results a carefully selected area representing forest conditions that are important in Northeastern West Virginia ... Opportunities are afforded for experiments along many lines such as cultivating young stands, studies of growth rates and natural reproduction, and other problems bearing upon forest management in the region" (Fernow Establishment Order, 28 March1934; on file at the USDA Forest Service Timber and Watershed Laboratory, Parsons, WV). With this broad mandate, the Fernow was born with the intent that it develop into a premier research and demonstration forest.

In its first two years, The Fernow developed quickly, thanks to the efforts of the Civilian Conservation Corps (CCC) and the Civil Works Administration, the same groups responsible for outstanding work on the Monongahela National Forest. A CCC camp located at the Nursery Bottom in Parsons supplied labor for building roads, for construction of the reservoir located on the Fernow that supplied the town of Parsons with free, clean, gravity-fed water for almost 50 years, and for trail construction, including the Fernow's Zero-Grade Trail, which became an important demonstration and teaching area.

Early Research

Some of the Fernow's earliest research projects, which dealt with the effects of fire on hardwood forests, were started in 1935 as part of the Appalachian

Experiment Station's fire damage project. Further, Jesse Buell established crop-tree-release and thinning studies (Trimble 1977). Research also started on the reforestation of burned-over *Picea rubens* Sarg. (Red Spruce) lands on the Monongahela National Forest (Minkler 1945, Trimble 1977). Then, in 1941, with the nation gearing up for World War II, work at the Fernow came to a halt, with the exception of remeasurements of spruce plantings. In 1948, the Northeastern Forest Experiment Station established a unit in Elkins, WV that was primarily responsible for activities on the newly reopened Fernow. Sydney Weitzman served as the center's first leader, the equivalent of today's Project Leader. Until an office was built in 1954, the old bunkhouse, built by the CCC and paneled in wormy chestnut, housed the Fernow's office. The research unit officially moved to Parsons in 1964, when a new laboratory, the current Timber and Watershed Laboratory, was constructed at the Nursery Bottom and dedicated by US Senator Robert C. Byrd.

Starting in 1948, two lines of applied research have been pursued at the Fernow: forest management and watershed management. Early research in forest management focused mostly on the mixed hardwood stands found at lower elevations (Trimble 1977). Some research continued on Red Spruce and on northern hardwoods at sites off the Fernow (Adams et al. 2012). These projects addressed questions relating to regenerating, growing, tending, and harvesting trees and stands. The questions included:

- How do different cutting practices affect the yield and value of timber over time?
- What is the best way to reproduce a diverse stand of high-value trees?
- What kinds of management practices are required to insure the survival and rapid growth of desirable crop trees?

Although the Fernow's watershed projects delved more into basic research questions, they also dealt with the following practical issues about forest management and hydrology:

- Does cutting trees increase water yields for downstream municipal water supplies, such as the Parsons reservoir?
- Does cutting trees cause flooding?

As of 2002, the Fernow had hosted about 120 forest research studies and 70 watershed research studies. Some were designed as short-lived projects with specific objectives, while others have continued as long-term studies. A few are still going 60 years later.

Although two separate research units, one devoted to forest management research and the other to watershed research, existed until 1994, many of the large-area studies were conducted jointly by the scientists of these two research units, yielding gains in the research's productivity and relevance. The two units merged in 1994, creating today's unit charged with investigating "Sustainable Forest Ecosystems in the Central Appalachians". Compared to the previous units, this mission includes larger and broader scales of research.

Particularly notable among the long-term forest management studies is the ongoing Study 4101-02, "Large Area Comparisons of Forest Management Practices in Appalachian Forest Types". Three forms of partial cutting, specifically the diameter-limit, intensive, and extensive single-tree selection practices, on three site index classes have been experimentally applied for the past 60 years. For controls, we have been monitoring unmanaged reference stands. Initially, we designed this study to better understand the effects of partial harvesting systems on forests. Using the framework of this study, scientists have addressed numerous forest management concerns, including residual tree quality after partial cutting (Smith et al. 1994, Trimble and Smith 1970), composition of natural regeneration (Smith and Miller 1987), forest economics (Miller 1991), and growth and yield (Trimble 1961, 1970). Although such forestry questions were basically answered in the past half-century, continuing this study is important because it allows us to better understand the long-term impacts of repeated harvesting on the forest's sustainability.

Another value of this long-term project is that some environmental factors, like changes in climate, exotic pests, succession, and nutrients, can cause forests to change. Through this study, scientists will be able to assess the impacts of these factors on current forests by comparing them to past conditions. A key to forest sustainability is understanding the long-term impacts of forest management practices. The Fernow's Study 4101-02 is a rare example of a project that addresses that issue. As an example of its value, the project has indicated that managing second-growth, even-aged hardwood stands in the Central Appalachians using single-tree selection results in a conversion to shade-tolerant species and at least a 20 percent reduction in periodic growth (Lamson and Smith 1991).

Equally of note are the Fernow's long-term watershed studies. Five small watersheds were fitted with flow gauges in 1951, calibrated, and then different cutting practices, such as clear cut, diameter limit, and two types of selection harvests, were applied to four of the watersheds. These studies on the effects of forest harvesting on water yields and hydrology have provided important long-term perspectives that are relevant throughout the United States. From these studies, we demonstrated that the effects of cutting trees on water yield are proportional to the amount of timber removed. We also showed that the effects are relatively short-lived, with the discharge regime returning to pre-treatment levels in only a few years. With proper forest management and best management practices, the effects on stream flow and water quality can be minimized (Kochenderfer and Hornbeck 1999).

From the Fernow's birth, its research has been linked to the issues of Canaan Valley. The logging of 1880–1920, which was often accompanied by fire, provided fertile ground for much research. Montane boreal forests dominated by Red Spruce formerly occurred on about 550,000 acres (220,000 ha) in the Allegheny Mountains of West Virginia. Today, their extent has been reduced to 50,000 acres (20,000 ha; DiGiovanni 1990). The earliest research, described in Trimble's (1977) excellent history of the Fernow, included an evaluation of fire damage on forests. In 1940, Leon Minkler established a number of study plots evaluating reforestation in the cut- and burned-over spruce lands on the Monongahela National Forest, as well as on the Pisgah National Forest in North Carolina. Thomas G. Clark (1954) reported on the success of experimental plantings designed to reestablish Red Spruce, *Pinus resinosa* Ait. (Red Pine), and *Abies balsamea* (L.) Mill. (Balsam Fir) on these areas in West Virginia. That research led to several conclusions:

1. On poor rocky sites, planted Red Spruce survived better than planted Southern Balsam Fir.
2. Spruce grew twice as much as Fir during the first three years, but by 10 years the Fir had gained the advantage in both planted and seeded treatments.
3. Although planting appeared to yield better results than direct seeding for both species, the direct seeding of the Fir was fairly successful (Clark 1954).

Hornbeck and Kochenderfer (1998) evaluated the growth trends and management implications for West Virginia's Red Spruce forests, many of which are located in or adjacent to Canaan Valley. They concluded that, after a period of decline from about 1960 to the early 1980s, annual growth rates in mature forests stabilized. They reported that, even though growth declined in plantations, thinning could reverse it. Their research concluded with an optimistic assessment of the possible future for Red Spruce in West Virginia, and provided an additional impetus for some of our newest research on Red Spruce.

Recent Research

Currently, the Fernow's scientists are developing information needed to restore the montane Red Spruce community in the Central Appalachians. Pressures on this relict spruce community include second-home recreational development, surface coal mining, insect pests, climate change, and perhaps acid deposition. Considered the second most threatened forest landscape in eastern North America, these forests are home to two endangered vertebrates, *Glaucomys sabrinus fuscus* Miller (Virginia Northern Flying Squirrel) and *Plethodon nettingi* Green (Cheat Mountain Salamander). The Red Spruce forest also hosts several other locally and regionally rare plant and animal species. Driven in part by regulatory concerns and the lack of data on suitable habitats for the montane boreal forest's endangered species, the staff at the Northern Research Station's Timber and Watershed Laboratory have embarked on two new research foci: Red Spruce forest restoration and ecology of the Virginia Northern Flying Squirrel.

We have conducted preliminary research on Red Spruce restoration at the Mead Westvaco Wildlife and Ecosystem Research Forest (12 mi [19 km] southwest of Elkins, Randolph County, WV; hereafter called the MW Research Forest). We have sought to understand the establishment and disturbance histories of current Red Spruce forests. The work has provided data for a series of simulation studies designed to answer questions about the usefulness of active forest management to shorten the time until current Red Spruce forests develop the old-growth structure needed by the Virginia Northern Flying Squirrel. Schuler et al. (2002) concluded that restoring Red Spruce may mitigate the Flying Squirrel's decline. Also, work is proceeding to identify and apply forest management methods that would move Red Spruce from its role as a minor understory component of northern hardwood stands to a dominant overstory tree.

Our research on the Flying Squirrel has focused on three topics: den ecology, forest habitat use, and habitat modeling. Using squirrels outfitted with radiotelemetry transmitters, we have been studying denning ecology and habitat use at numerous sites in the Monongahela National Forest. Our study locations have included the old spruce plantations at Canaan Heights and the MW Research Forest. Results show that Flying Squirrels preferentially roost in *Betula alleghaniensis* Britt. (Yellow Birch) snags, though they used several tree species during two years (Menzel et al. 2004). Home-range size is affected by gender, with male squirrels covering larger areas (Menzel et al. 2006b).

The Flying Squirrels's home-range size also reflects habitat quality. Squirrels in relatively undisturbed, large, and mature mixed Red Spruce-northern hardwood forests occupied significantly smaller home ranges than individuals in intensively managed northern hardwood forests (Menzel et al. 2006b). Although the results of habitat modeling have been equivocal, areas less than 3300 ft (1000 m) in elevation and/or not within 3300 ft (1000 m) of Red Spruce or Eastern Hemlock had low odds of hosting Flying Squirrels (Menzel et al. 2006a). Current work is examining the Flying Squirrel's presence/absence as a function of microhabitat data collected via radiotelemetry and satellite imagery.

Other research projects by the Fernow's staff, including relating air quality to forest health, nutrient cycling, long-term relationships between climate and plant communities, and management options for northern hardwoods, are particularly relevant to Canaan Valley. One of the earliest participants in the National Atmospheric Deposition Program, the Fernow has been monitoring atmospheric deposition since 1978. Monitoring has expanded in recent years to include dry deposition, gases such as ozone, and visibility. The Bearden Knob monitoring station, sited on Canaan Heights, was added in 1991. It provides information on air quality in Canaan Valley, further supporting research into the effects of air pollution on forests. The Fernow's air-quality program has delivered two notable observations: (1) West Virginia receives some of the highest levels of nitrogen and sulfur deposition in the East; and (2) Ozone concentrations have exceeded National Ambient Air Quality Standards several times, despite our rural location (Edwards et al. 1991).

Fernow scientists are also gaining a better understanding of how various components of air pollution, particularly nitrogen and sulfur, move through Central Appalachian forests. The best example of a forest that has become nitrogen-saturated, in contrast to experiments that added nitrogen, is The Fernow's much-studied reference Watershed 4 (Adams et al. 2006). Fernow scientists are participating in projects using computer simulation models to evaluate how changing levels of air pollution affect stream and soil chemistry in the Otter Creek and Dolly Sods Wilderness areas.

Conclusions

Through our research on the Fernow, we have learned a great deal that is relevant to the friends of Canaan Valley. The Fernow has also earned an important niche in the larger scientific world. The Fernow participates in several national and international research networks, and our scientists participate in cross-site studies, such as the Long-Term Soil Productivity and Fire Behavior studies that are national and international in scope. Our customers are diverse, including private forest landowners, the wood-products industry, and other research scientists. Research completed on The Fernow will continue to be used in many ways, such as informing state and federal legislators about the storage of carbon in forest soils, helping public health officials understand the long-term patterns in air quality, and evaluating the effects of climate on stream flow. Recently, Fernow scientists were asked to provide information relevant to the statewide debate about forest management and flooding. Fernow staff also host numerous tours, called "show-me trips", for groups ranging from Parsons third-graders to foreign scientists. The Fernow is a valuable resource for the people of Tucker County, the state of West Virginia, the United States, and the world. The Fernow Experimental Forest and Canaan Valley share a long history and will continue to partner in a bright future.

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