The Lost Research of Early Northeastern Spruce-Fir Experimental Forests: A Tale of Lost Opportunities

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Introduction

Long-term research is critical to our understanding of forest dynamics. Observations made over decades or centuries provide valuable insight into the effects of natural and anthropogenic disturbances, and allow scientists and forest managers to determine which management regimes succeed and which ones fail in terms of desired objectives. Unfortunately, many long-term studies are abandoned before the full benefits of the research can be realized. When long-term projects end, it is often because values change and the research is considered less relevant (Innes 2004). Yet many old studies could inform contemporary forest management and policy, especially if combined with new research.

Long-term research in forest ecosystems requires steadfast commitment by more than one generation of scientists and forest managers. The U.S. Forest Service has been conducting research of this kind for over 100 years. Originally the Division of Forestry, the Forest Service was established in 1876 in response to the overwhelming need to conserve forested land and "sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations" (U.S. Forest Service 2010). The Forest Service works to maintain and improve the quality and production of more than 193 million acres of forests, wetlands and grasslands. The organization also serves state and private landowners, working to sustain public benefits from the nation's forests. Serving as a multifaceted organization, the Forest Service pursues many objectives from recreation management to research and development; the latter is conducted by six regional research stations in the United States.

The Northern Research Station (NRS) is the U.S. Forest Service's research and development program that extends across twenty states from the Midwest to the Northeast. It encompasses a diversity of ecosystems and climatic zones, which create a broad array of opportunities for scientific inquiry (Rains 2006). The NRS, which includes the former North Central and Northeastern Forest Experiment Stations, is recognized for its extensive research and long-term projects; it maintains 22 of the Forest Service's 80 experimental forests and ranges (Adams et al. 2008; U.S. Forest Service 2009). Experimental forests provide opportunities for large-scale, long-term research. Studies conducted on experimental forests today have shifted from relatively localized and narrow themes to a broader range of issues relevant to global natural resource management problems (Lugo et al. 2006).

The northern conifer forest extends from eastern Canada and Maine into the Adirondack Mountains of New York. These forests are characterized by a mixture of conifer species and northern hardwoods in varying proportions depending on factors including climate, aspect, elevation and site quality. Previously called "spruce-fir" forests, today these

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forests are described as northern mixed conifer forests or northern coniferous forests. They are typically dominated by red spruce (Picea rubens), black spruce (Picea mariana), white spruce (Picea glauca) and balsam fir (Abies balsamea) with varying amounts of northern hardwoods. Other species commonly present include eastern hemlock (Tsuga canadensis), eastern white pine (Pinus strobus) and northern white-cedar (Thuja occidentalis). Historically, this forest type has been essential to the prosperity and economic well-being of the region. The lumber industry thrived due to favorable species composition and climatic conditions (Irland 1999); by the early 1900s the forests had been high-graded of the finest trees and were in a state of transition in terms of species composition and quality (Judd 1997).

When the NRS was founded in 1923, second-growth spruce-fir forests were increasingly dominated by poor quality hardwoods (Westveld 1938). Depletion of conifers due to high-grading, as well as the return of agricultural land to forests in the late 1800s and early 1900s, created urgency for research about conifer production (Westveld 1937). Because conifers were essential to the northeastern economy, as well as to the overall structure and characteristics of the forest type, early research conducted by the Forest Service in this region focused on methods to grow spruce and fir faster and eliminate hardwood competition. Prediction of forest yield was crucial to the future of the pulpwood industry and the long-term well-being of the forest (Westveld 1953). Experimental forests were the primary location of studies that supported this type of research.

Three spruce-fir experimental forests – the Gale River, Finch-Pruyn, and Paul Smith Experimental Forests (EFs) – were established by the Station shortly after it was founded. Research and funding for these forests were motivated by increasing demand for forest products. Indeed, from the 1920s to the 1940s, national assessments were gloomily predicting the exhaustion of the region's spruce-fir timber supply. As time progressed the relevance of the research faded and the experimental forests were closed, primarily because of a lack of funding and the perception that scientific or practical values had shifted to other areas; damage to research plots by natural disturbances was also a factor (Kenefic et al. in press).

Paul Smith Experimental Forest, NY

The Paul Smith EF, established in August of 1948 near Paul Smith's College in the Adirondack Mountains of New York (44 deg. 26'N, 74 deg. 14'W), is the most recent of the three early spruce – fir experimental forests. The forest was named to honor the famous guide, woodsman and land steward, Paul Smith. Because of its close proximity to the Finch-Pruyn EF, the two forests were jointly administered by the Forest Service's Adirondack Research Center with headquarters located in Paul Smiths, New York. The approximately 2,300-acre Paul Smith EF was administered under a 30-year cooperative agreement between Paul Smith's College and the Forest Service. In a 1954 radio broadcast for WNBZ in Saranac Lake, New York, Francis Rushmore, the lead scientist and research forester with the Forest Service, highlighted the objectives of the Paul Smith EF:

1. The main objective of this cooperative program shall be the exploration, development and demonstration of economical methods of forest management adapted to the natural forests and climatic conditions of the Adirondacks and to the recreational and watershed values of the Adirondack region.
2. That this program is to be undertaken for the public benefits which will accrue, and that the interest of all people using and depending on the Adirondack forest region will be considered in the development of this program.

Selective logging altered the forest composition in New York, as it had in Maine and other areas in northern New England encompassing the eastern spruce-fir forests. A major difference was that the Adirondacks possessed a number of cutover old-growth hardwood stands (Rushmore 1957). Dendrochronology work at the Paul Smith EF in the 1950s indicated that it contained residual old growth. The oldest trees originated in the late 1600s, although repeated partial cutting and fire had since impacted these forests (unpublished memorandum 1954). The existence of these old forests facilitated the investigation of management questions not previously possible in the region.

The hardwood lumber industry in the area was confined to high quality sawlogs, but much of the forest was made up of low-quality, poorly formed trees (Curry and Rushmore 1955). Experiments at Paul Smith EF involved various systems of destroying defective trees. Eliminating hardwoods was a chief goal for scientists and landowners alike. Girdling and application of chemicals were the primary methods used. Sodium arsenite and ammonium sulfamate were applied during different seasons to evaluate dieback and death (Curry and Rushmore 1955). Frilling was also used to kill unwanted trees (Figure 1); this process involved bark removal and application of sodium arsenite to the cambium layer of the tree (Rushmore 1956). Though researchers at the time often turned to chemical-based silviculture, many other studies were conducted and formed the leading edge of eastern spruce-fir management. Understanding the growing public concern surrounding the quality of the forest and the future of the lumber industry, Forest Service researchers at Paul Smith EF conducted a number of studies of stand improvement and regeneration methods.

Compartments

Fifty-five 40-acre compartments, or stand-level experiments, were established on the Paul Smith EF to study a variety of silvicultural methods and harvest intensities (Figure 2). Methods included uneven-aged management with 10-, 20- and 30-year cutting cycles, as well as even-aged treatments such as shelterwood and clearcutting. Timber stand improvement (TSI) methods, including thinning and crop tree release, were also investigated. Emphasis was put on control of competing hardwoods through cultural treatment (unpublished memorandum 1953). Rushmore (1954) said that forests should be tended like a vegetable garden: "We know that weeds must be removed from our gardens or our crops will be choked out; the forester must frequently remove worthless trees or his better ones will not grow as well as they can. And we must harvest our garden crops when they ripen, or they will become worthless; the forester must also harvest his trees as they reach maturity or they will begin to rot and will eventually become worthless." These stand improvement techniques, although commonly used in today's forests, were new concepts for forest managers of the time.

Three of the Paul Smith EF compartments will be discussed here, and are typical of the research on the experimental forest in the 1940s and 1950s. The cutting practice level (CPL) study (compartment 29) on the Paul Smith EF was initiated in 1950 in order to demonstrate a range of silvicultural intensities for the spruce-yellow birch (Betula alleghaniensis) forest type, and would serve as a guide to achieving the most productivity from the forest (unpublished working plan 1949; unpublished establishment report 1951). These demonstrations were common on experimental forests in the 1940s. The cutting levels, which included "high-order," "good," "fair" and "poor-order," were designed to demonstrate forest responses and guide future management decisions. The "high-order" and "good" treatments, which were forms of selection cutting, were intended to provide long-term growth on high-quality trees. These two treatments were intended to build spruce growing stock by removing only poor quality, competing trees. "High-order" treatments were distinguished from "good" by having higher guiding diameter limits for spruce and fir and a shorter cutting cycle (5 to 10 years versus 15 to 20 years). The "fair" treatment was a form of diameter-limit cutting with tending in which all merchantable trees were removed except for spruce smaller than 12 inches in diameter at breast height (dbh). Harvest intervals in the "fair" treatments were 25 to 35 years. The "poor-order" treatment was a commercial clearcut, which left unmerchantable and low-quality timber; the harvest interval was greater than 50 years. Today, remnants of the study are still visible and large-diameter red spruce and yellow birch trees can be found throughout the compartment where the "high-order" treatment was applied (Figure 3).

Compartment 19, a stand improvement study, was composed of two sub-compartments. The first was a spruce-yellow birch stand containing little softwood reproduction; the second was a mixed

Figure 1. Paul Smith EF: A field technician demonstrates the result of frilling. Undated photo courtesy of the U.S. Forest Service.

conifer-paper birch (Betula papyrifera) stand containing a large component of white pine and abundant softwood regeneration. Because of abundant softwood advance reproduction, both sub-compartments were treated with "good" even-aged silvicultural treatments, using a uniform shelterwood system. The first cut left approximately 50 ft2 ac-1 of softwood basal area. Overstory removal was to be conducted 10 years later with poisoning of competing trees ≥ 6 inches dbh (unpublished memorandum 1954). Stand improvement work was conducted in which overstory hardwoods were removed where ample regeneration was present. There was also a small area in the southwest portion of compartment 19 designated for planting red spruce by Paul Smith's College as a part of a forestry class. Although an overstory removal and subsequent thinnings were planned, there is no paperwork to confirm that any harvesting was conducted after the initial regeneration cut and stand improvement treatments. Today, large residual white pine, red spruce and yellow birch are scattered throughout the compartment (Figure 4).

Compartment 35 was also subdivided into two forest types; spruce-yellow birch and spruce-fir. This compartment was assigned "high-order" selection treatments with 10-year cutting cycles. These harvests focused on removing cull or poorly formed trees, building to a growing stock of 2,000 ft3 ac-1 of spruce and fir at the end of the cycle. Poor quality, merchantable sawlogs were cut while cull hardwoods above 5 inches dbh were poisoned or girdled. Results from this study after 10 years showed that objectives had not been met for either forest type, falling below the volume goal. Hardwoods were reduced in numbers, but volume in the spruce-fir type totaled 1,614 cubic feet, while the spruce-yellow birch type contained only 793 cubic feet at the end of the 10 year cycle. Plans for future treatments in this compartment included weeding and timber stand improvement to reduce hardwood competition, but it was concluded that cultural operations would be too costly given market conditions.

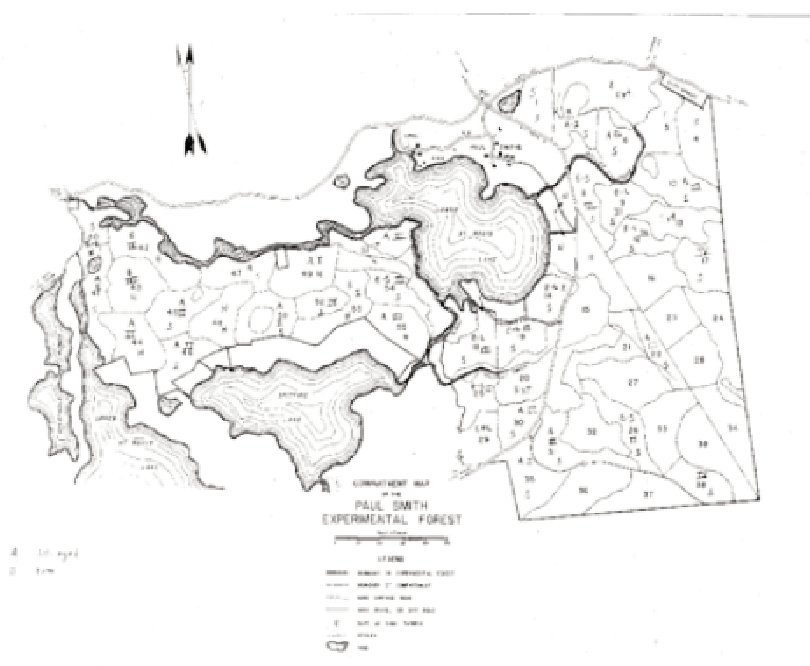

Figure 2. Compartment map of the Paul Smith Experimental Forest (1954). Map courtesy of the U.S. Forest Service and Paul Smith's College.

Finch-Pruyn Experimental Forest, NY

The Finch-Pruyn EF, established by the Forest Service in 1934 near Newcomb, New York (44 deg. 00'N, 74 deg. 13'W), was the second of the spruce-fir experimental forests to be designated. Comprising approximately 623 acres in the Adirondack Mountains, the land was deeded to Cornell University by Finch, Pruyn, and Company, Inc. in 1934 for studies in spruce and northern hardwood management. Cornell subsequently signed a cooperative agreement with the Forest Service. We have very little information about research done on the Finch-Pruyn EF, although a 1942 working plan describes girdling experiments on plots in the red spruce – yellow birch and red spruce-sugar maple (Acer saccharum)-American beech (Fagus grandifolia) forest types. Girdling was conducted on hardwoods to release spruce in the understory. There are no field notes or measurement records of this work in the Forest Service archives, although some publications from this time reference the Finch-Pruyn EF data, e.g. a paper by Recknagel et al. (1933) which describes a series of plots installed to determine the effects of different cutting methods on residual stand composition and tree growth rates.

Both the Paul Smith and Finch-Pruyn EFs remained open until 1961 when the Adirondack Research Center closed. After closing, papers documenting the work, including study plans and data sheets, were left with Paul Smith's College and the Paul Smith EF was integrated into the College forest. Over the years, the files were moved around and eventually forgotten. It wasn't until the summer of 2009 that research materials were discovered in the basement of a dormitory. These file have subsequently been made available for on-site review and will soon be digitized by the Forest Service and made available electronically. Preliminary site visits suggest that while some of the original compartments have been harvested, others remain intact and may yield worthwhile re-measurement data (Figure 5).

Gale River Experimental Forest, NH

Research at the 1,623-acre Gale River EF, located near Bethlehem, New Hampshire (44 deg. 51'N, 68 deg. 37'W) in the White Mountains, began in 1927. The Gale River EF was the first experimental forest in this region. Marinus Westveld (Figure 6), a US Forest Service Senior Silviculturist and the pioneer of spruce-fir silviculture, set up and conducted most of the research on the Gale River EF. It was

Figure 3. Compartment 29, high-order treatment on the former Paul Smith EF (2010). Photo courtesy of U.S. Forest Service.

because of a growing pulpwood industry and the continual reduction in pulpwood-producing land that Westveld began his research in spruce-fir silviculture in order to maintain a strong component of softwood timber where competing hardwoods were present (Westveld 1937). Because many acres of forestland in the early twentieth century occurred on former agricultural fields, hardwood exclusion was also a priority to ensure the continual production of spruce-fir forests. Westveld was particularly interested in partial cutting, including the removal of only sawtimber-sized trees to retain merchantable growing stock (Kenefic et al. in press; Kraemer 1937). His innovative work in modeling growth and yield in these forest types, as well as his "selective" cutting practices, led to the widespread use of uneven-aged management practices (Kenefic et al. in press).

The Great New England Hurricane of 1938 destroyed the majority of the studies at the Gale River EF as well as research plots in Ripton, Vermont and Cherry Mountain and Waterville, New Hampshire (Figure 7). With the exception of several small plantations, the only remaining study was a single weeding experiment initiated in the fall of 1933. Overstory removal during the course of the weeding study left only young crop trees that were not large enough to be damaged by the hurricane seven years later (Westveld 1937). The purpose of this study was to determine the effectiveness of different methods of killing competing hardwoods, and to document the growth dynamics of released white spruce (unpublished memorandum 1933).

Ten plots were established in the weeding study to investigate different methods of killing competing and overstory hardwoods including cherry (Prunus spp.), red maple (Acer rubrum), American beech and birch (Betula spp.) (unpublished memorandum 1948). The treatments included girdling, cutting, and applying a sodium arsenite solution. Cope tools were used in blocks one through eight to deliver the poison in varying levels including one jab, numerous jabs and 100% treatment around the circumference of the tree. In block nine, axes were used for overstory removal; chainsaws and clippers were used in block ten (unpublished memorandum 1936). Six additional 1/10-acre plots were established to ascertain the influence of season on girdling response; these were too severely damaged by the hurricane to provide useful information and were abandoned.

Eventually, the research measurements that had continued after the hurricane were discontinued. By

Figure 4. Compartment 19: residual trees from the Paul Smith EF (2010). Photo courtesy of U.S. Forest Service.

1941, the personnel stationed on the Gale River EF withdrew and the EF was placed in an inactive status. In 1950, another hurricane swept through the area, causing more damage. Salvage was conducted, but Station management's wish to relinquish the property increased because most of the research had been destroyed. Westveld had continued to take measurements for over 15 years after the EF became inactive and believed that the forest had value for research (unpublished memorandum 1956). Ultimately, however, the Gale River EF was closed in 1958 and transferred to the White Mountain National Forest.

A small number of the Gale River EF research files were sent to the field office in Maine and forgotten until their rediscovery in the attic of a now-demolished building in 2008. The bulk of the files had been sent to the Federal Records Center (FRC) (unpublished memorandum 1958). Such files may have been destroyed per a Forest Service-approved disposition schedule, or transferred to the National Archives and Records Administration (NARA). The paperwork needed to recall the records has been lost and recent efforts to locate the Gale River files through the FRC and NARA have been unsuccessful.

Believing there was potential to re-establish the weeding study, we visited what was once the Gale River EF in 2008 and 2009. Arriving there to find mortality from a 1980s windstorm, thinning by the National Forest and no field notes or measurement data from the research conducted decades prior, we determined that there was no possibility for reopening that study. Nevertheless, we re-monumented nine of the ten blocks established by Westveld in 1933 (Figure 8) and a series of measurements were taken to determine species composition and stocking (the tenth block had been converted to a wildlife clearing by the National Forest). Today, approximately 19% of the total basal area per acre and 24 trees per acre in the former study area are white spruce. Regeneration from the white spruce crop trees is also present; these are the remnants and legacy of Westveld's work at the Gale River EF.

Figure 5. Large-diameter residual tree from the silviculture experiment on the former Paul Smith EF (2010).

Figure 6. Marinus Westveld (left), the grandfather of spruce-fir silviculture, at the Gale River EF (note peeled spruce). Undated photo courtesy of the U.S. Forest Service.

Figure 7. The Great New England Hurricane of 1938 destroyed much of the Gale River EF and surrounding areas. Photo courtesy of the U.S. Forest Service and Forest History Society.

Ongoing Research

Shortly before the Gale River EF was transferred to the White Mountain National Forest, another spruce-fir experimental forest was established by the Forest Service in east-central Maine. The Penobscot EF located in the towns of Bradley and Eddington, Maine encompasses approximately 4,000 acres. Research there was profoundly inspired by Westveld's ideas advocating uneven-aged management in spruce-fir forests (unpublished problem analysis 1950), although a full range of silvicultural systems were included in the experiments. Replicated treatments were initiated at the Penobscot EF between 1952 and 1957 (Sendak et al. 2003) and have remain a premier example of collaborative, sustained forestry research (Brissette et al. 2006). Full replication and repeated application of treatments in long-term silviculture studies is uncommon and makes the Penobscot EF a unique and highly valued research site. Results from the research are continually emerging, providing valuable insight to practitioners and policy makers alike (Kenefic et al. 2006). Furthermore, the diversity of stands and associated variability in composition and structure provide opportunities to overlay new research projects (Nowak et al. 1997). Although the Station considered transferring the Forest Service staff at the Penobscot EF to another location in the 1980s, local support for the research prevented this action (Kenefic et al. in press). The Penobscot EF is the product of decades of dedication shown by the foresters and scientists who saw the value of continuing the study.

Summary

On all three of the early spruce-fir experimental forests, treatments were discontinued and the research areas were subjected to the effects of natural disturbances and undocumented management. However, they do provide valuable insight into the early silvicultural research conducted in eastern spruce-fir forests. Failure to fully preserve historical documents hampered our ability to capture the relevance of the work through re-measurement and analysis. Without initial measurements, it is nearly impossible to determine the effects of historical treatments to forest conditions today. In the past 80 years, ownerships have changed, people have come and gone, and the landscape has changed based on the needs of a growing population. The potential

Figure 8. Author Kate Berven and a plot stake found on the Gale River EF during the 2009 remeasurements of original treatments.

value of these studies, had they been maintained, is unknown. At the very least, a glimpse into the past can provide historical reference and offer insight about our predecessors. The 60 years of research at the Penobscot EF are invaluable, but represent only a portion of the Forest Service's eastern spruce-fir research over the past century. The closed experimental forests serve as a reminder of the legacies left by the pioneers of early silviculture in eastern spruce-fir forests and as a cautionary tale of how years of research can be lost if records are not preserved.

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