REFERENCE CONDITIONS FOR SILVICULTURAL FIELD STUDIES IN MAINE: LIMITATIONS AND OPPORTUNITIES

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ABSTRACT. There are many types of controls or reference conditions for silvicultural experiments. The most basic are pretreatment records of composition and structure, but such data provide little information about response to treatment compared to natural developmental and disturbance patterns. Ideally, experiments should have untreated stand replicates in which development can be tracked over time. Unfortunately, experimental controls in field studies are seldom ideal. This is the case on the Penobscot Experimental Forest in Maine, where a 50-year-old replicated silvicultural experiment has an unreplicated, atypical control. An even greater challenge is the identification of stands that represent desired endpoints or natural states, especially if based on rare conditions such as old growth. The Big Reed Forest Reserve in Maine represents the largest area of middle to low elevation old growth in the state and may serve as a benchmark for management.

KEYWORDS. Silviculture, experimental control, old growth, benchmark

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Introduction

Silviculture Research

Silviculture is the art and science of managing forests for desired outcomes. These outcomes are myriad and range from biodiversity maintenance to timber production. Within this context, treatments, or harvests, are the tools that foresters use to achieve their goals. Silvicultural treatments often are modeled after natural disturbances. Knowledge about the stand development patterns of unmanaged forests is thus important to the development of effective sequences of treatments, or systems.

However, there are substantial gaps in our knowledge. In particular, information is needed about ecosystem response to natural and harvesting disturbances, acknowledging inherent differences between the two. Long-term and large-scale perspectives are important because trees live a long time and the return interval between natural disturbance events at any one location may be quite long. Both factors constrain the rate of change in forested ecosystems. It is thus imperative that silvicultural research encompass large spatial and temporal scales.

Experimental controls. There are numerous controls that can be used in silvicultural experiments. One of the simplest is preharvest or pretreatment inventory, which allows pair-wise comparisons (pre- versus post-treatment) for a given stand. Though this provides a temporally restricted view of the untreated condition, it is usually better than inferring preharvest conditions from untreated stands in a retrospective study. A second type of control is untreated replicate stands. Here a stand intended for treatment is paired with a similar stand that remains untreated

and, if monitored through time, allows differences to be attributed to treatment. These are better than a single pretreatment inventory because they provide information about stand development and natural disturbances in the absence of management. The ideal silvicultural experiment would combine these two types of controls, including randomization of plot locations and treatment allocations, with adequate replication and long-term monitoring. Such studies are quite uncommon. A third type of control, which has appeared more recently in the literature, is provided by old-growth forests, which often are assumed to be benchmarks to which management activities can be compared.

Study Area

This study was conducted in the Acadian region, which stretches from Maine into eastern Canada. The Acadian forest is an ecotone between the eastern broadleaf and boreal forests. Species composition is diverse and common species include eastern hemlock (*Tsuga canadensis* (L.) Carr.), balsam fir (*Abies balsamea* (L.) Mill.), northern white-cedar (*Thuja occidentalis* L.) and spruce (*Picea* spp.) in combination with other softwoods and hardwoods such as red maple (*Acer rubrum* L.), American beech (*Fagus grandifolia* L.), birch (*Betula* spp.), and aspen (*Populus* spp.). Natural disturbances are predominantly small scale, resulting in mortality of single or few trees, with periodic disturbances of higher severity, such as cyclic outbreaks of the spruce budworm (*Choristoneura fumiferana* Clemens). The return interval for natural stand-replacing disturbances in this region can exceed 1,000 years (Lorimer 1977) but varies considerably with forest type and topographic position (Lorimer and White 2003).

Penobscot Experimental Forest

The Penobscot Experimental Forest (PEF) occupies more than 4,000 acres in central Maine. It was purchased in 1950 by a number of pulp and paper and land-holding companies and leased to the U.S. Department of Agriculture Forest Service, Northeastern Research Station, for a long-term silvicultural study. Ownership transferred to the University of Maine in 1994 but the Forest Service retained control of its research areas. The largest study is the 600-plus acre silviculture experiment, which began in 1950 and provides more than 50 years of data.

The silviculture experiment. The objective of the PEF experiment is to determine the effects of silvicultural treatment on a number of response variables, including growth and yield, species composition, growing stock quality, stand structure, and regeneration. Treatments include even-aged silviculture (uniform shelterwood with two- and three-stage overstory removal, with and without precommercial thinning), uneven-aged silviculture (5-, 10-, and 20-year single tree and group selection cutting), and exploitative cuttings (fixed and flexible diameter-limit and commercial clearcutting, or unregulated harvest). Each treatment is replicated twice at the stand level with an average stand size of 25 acres. Data are collected before and after every harvest and at 5-year intervals between harvests for regeneration and numbered trees larger than 0.5 inches in diameter at breast height (dbh) on permanent inventory plots. Treatment application and data collection are thus unusually intensive.

Interpreting the Data

The PEF experiment provides an excellent example of the utility of controls. The experiment includes an untreated or "natural" area, which is used as a control for the entire study. Spruce composition (percentage of basal area (BA) for trees > 0.5 in. dbh) in years 0 (pretreatment) and

45 of the experiment in the 20-year selection stands (Figure 1) suggest that selection cutting resulted in an increase in the proportion of spruce. The fact that the percentage of spruce in the untreated area decreased during that time supports this conclusion. Without the untreated area, it would be difficult to determine if the changes over time in the selection stands were due to natural disturbance (which is not precluded from the experiment), stand development, succession, or the periodic harvest.

Unfortunately, the inventoried untreated area is not replicated, which complicates statistical analysis. It was not originally included in the experimental design, but was instead designated as a natural area and, fortunately, inventoried on the same schedule as the treated stands. Furthermore, the stand chosen to represent the untreated condition is atypical in drainage and composition. For example, the percentage of eastern white pine (*Pinus strobus* L.) in year 0 of the experiment was much higher in the untreated area (20%) than in the areas used for the partial harvest treatments (< 5% each) (Figure 2). This suggests meaningful differences in site and/or disturbance history.

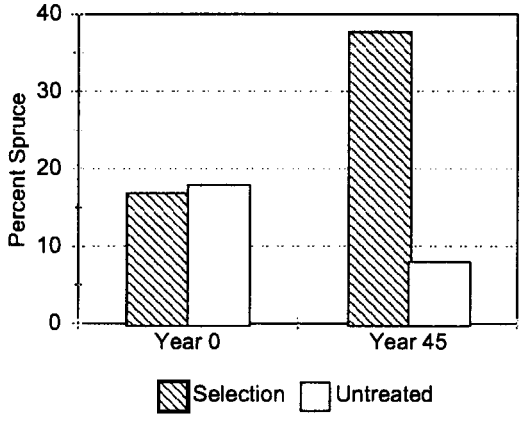

Figure 1. Spruce composition

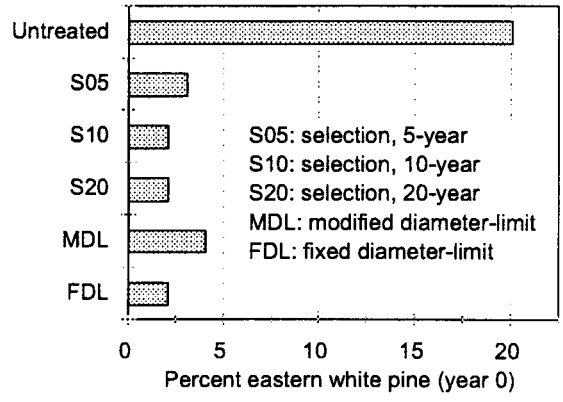

Figure 2. Pretreatment eastern white pine

Additionally, the PEF untreated area, like the rest of the forest, was repeatedly partially harvested prior to the 20th century. Though no harvests are believed to have been conducted between 1900 and the initiation of the experiment in 1950, the forest was used for many purposes prior to that time. In fact, a water-powered sawmill was located on the site in the late 1700s and likely motivated harvesting of timber throughout the forest. Though never cleared for agriculture, there is evidence of cutting throughout the property, as well as fencing and homesteading in some areas. Thus, although the untreated area serves as an index of what may have happened between 1950 and the present without management, it does not indicate what an unmanaged stand would look like.

Reference Conditions

What constitutes an appropriate reference condition, benchmark, or desired future condition? One possible answer is old-growth forests. However, their utility depends in part on the answers to the following questions:

- Do they exist on sites comparable to those being treated?
- Are they large enough to allow natural disturbance processes?
- Is the historical range of variation in disturbance history, composition, and structure known?

Old-Growth Forest

One example of a potential benchmark or reference condition for the PEF silviculture study is the Big Reed Forest Reserve. This 5,000-plus acre old-growth forest in northern Maine is owned by The Nature Conservancy. It has diverse topography and composition ranging from forested wetlands to ridge hardwoods, and includes many of the stand and site types on which forestry is practiced in northern Maine.

University of Maine researchers have been studying Big Reed for nearly 10 years and have amassed data on composition and structure, dead wood, and disturbance history. Figures 3-5 compare Big Reed data (calculated as the mean of 21 plots in mixedwood stands) to that from the inventoried untreated area on the PEF. Note the similarity in the shape of the diameter distribution, although there appear to be more small trees on the PEF (Figure 3), a conclusion supported by total stem density data (Figure 4). This may be due to a large portion of the PEF untreated area that remains in the stem exclusion stage of development. Basal area is also higher in the PEF untreated area (Figure 5), perhaps for the same reason, but more likely due to an intense windstorm that affected many of the Big Reed mixedwood stands in 1983.

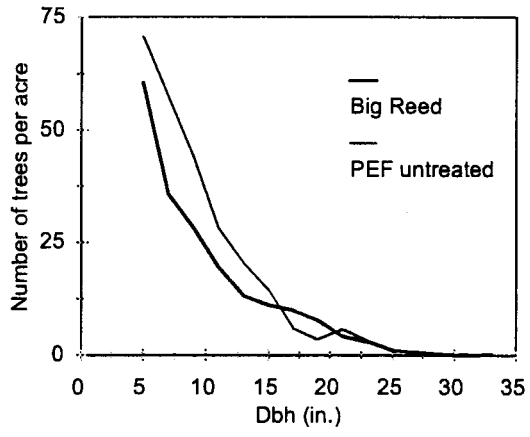

Figure 3. Diameter distribution

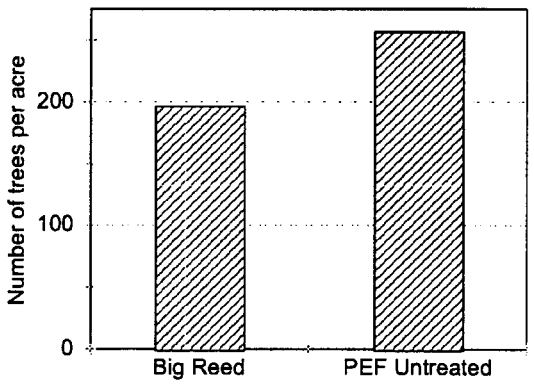

Figure 4. Stem density

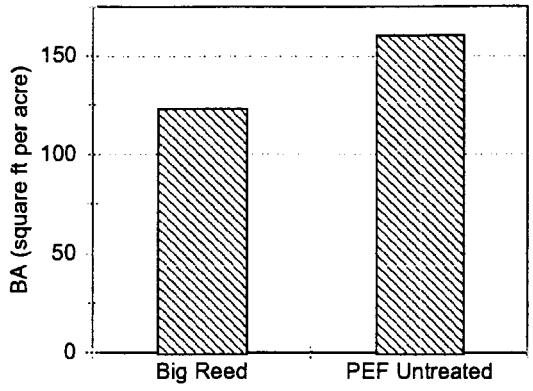

Figure 5. Basal area

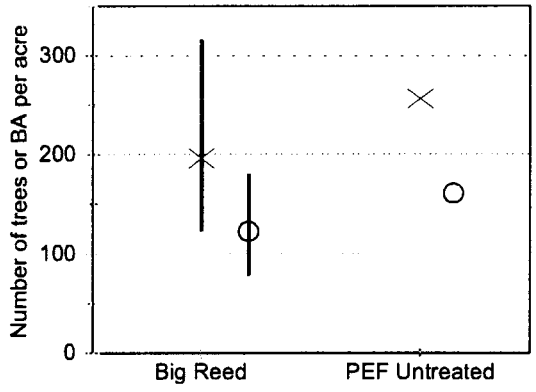

Figure 6. Range of variation

Other considerations. Though the above data provide useful examples of the types of comparisons that can be made, the range of variation in time and space must also be considered. At Big Reed we only have composition and structure data to address the latter. The stem density and BA data provide us with an example (Figure 6). The 'x' marks the mean density, the 'o' marks the mean BA, and the vertical lines show the range of variation among sample plots, i.e. stands. The unreplicated natural area on the PEF falls within the range of variation at Big Reed and may represent densities and stockings included within the old-growth mixedwood. We do not have sufficient data to compare the full range of conditions on both sites.

The distance between Big Reed in northern Maine and the PEF in central Maine (approx. 110 miles) must also be considered. Big Reed is the best large-scale example of old-growth in the state. However, there are differences in latitude, elevation, biophysical zone, distance from maritime influence, and species abundance. For example, the current percentages of eastern hemlock and eastern white pine in the Big Reed mixedwood stands are very low compared to the PEF natural area (Figures 7 and 8). These compositional differences between the sites potentially have important impacts on stand dynamics, disturbance regime, and response to treatment.

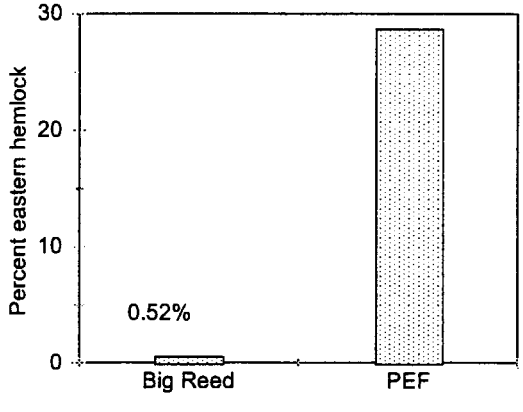

Figure 7. Eastern hemlock composition

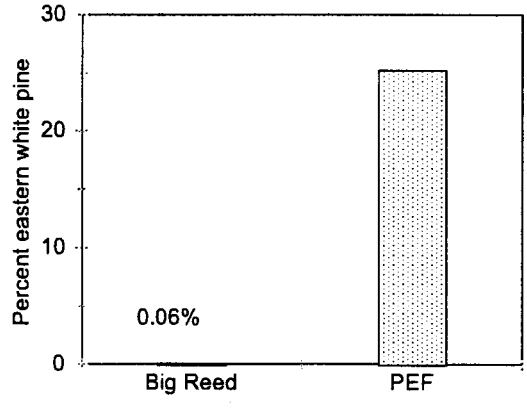

Figure 8. Eastern white pine composition

Summary
There are different types of controls or reference conditions, including preharvest inventory, untreated replicates, and benchmark conditions. We feel it takes more than one kind of control to adequately evaluate silvicultural treatments. Additionally, both mean condition and range of variation are important considerations. These include temporal and spatial variation and necessitate a large-scale, long-term perspective to optimally evaluate silviculture treatments. We are fortunate to have excellent data from more than 600 acres for more than 50 years on the PEF, and are well on the way to building a similar database at Big Reed. Despite the limitations of the controls discussed in this paper, we are fortunate to have more information over a longer period than most studies provide.

Literature Cited

LORIMER, C.G. 1977. The presettlement forest and natural disturbance cycle of northeastern Maine. Ecology 58:139-148.

LORIMER, C.G. and A.S. White. 2003. Scale and frequency of natural disturbances in the northeastern US: Implications for early successional forest habitats and regional age distributions. Forest Ecology and Management 185:41-64.

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PROCEEDINGS

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