The Fall River Long-term Soil Productivity Study: Linking Processes to Operations in Pacific Northwest Douglas-fir

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Forest management practices can significantly affect forest productivity. In the Pacific Northwest, there is a long history of field studies designed to assess tree and stand growth responses to operational management practices. These studies have yielded valuable information for forest managers, particularly on the influence of site preparation, vegetation control, fertilization, initial planting density, and thinning on tree and stand growth, and have helped to develop a basis for site-specific management prescriptions.

Good examples of effective silvicultural response studies are those established by the University of Washington Regional Forest Nutrition Research Project, where tree responses to various forest fertilizer regimes have been examined across hundreds of sites in the region. However, most empirical silvicultural field studies do not explicitly evaluate processes underlying site-specific growth responses, which limit forest managers' ability to translate those responses to other locations.

In addition to their direct effects on tree growth, silvicultural practices can also have unintended effects on site productivity that may influence forest responses years or even decades into the future. For example, harvesting and site preparation could affect forest productivity if they overly remove or redistribute soil organic matter and nutrients or detrimentally disturb the soil. These effects could alter nutrient and water availability, and thus impact tree growth. Forest fertilization, on the other hand, may add to the nutrient pool.

Because long-term forest responses to silvicultural practices may be impossible to quantify and interpret if only tree growth is measured, forest scientists and managers have increasingly recognized the importance of understanding processes controlling these responses. It can be costly to accurately quantify process-level effects because they often involve detailed measurements in the field and laboratory, as well as specialized equipment and personnel. However, understanding these processes is likely to be important for tailoring prescriptions and Best Management Practices (BMPs) for specific site and stand conditions. Evaluating the short-term and long-term effects of management is a critical part of our commitment to sustainable forest management and of providing the environmental values associated with healthy, productive forests. The recognized importance of maintaining long-term site productivity is also a key element in the widespread adoption of forest certification systems.

The dilemma of operational versus controlled factor research designs

While empirical silvicultural field studies have most commonly been used to assess the effects of management operations on tree growth, their utility is limited in several respects. One reason is the high variability associated with forest sites and operations, particularly that related to soil disturbance and the distribution of residues and competing

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Operational forest management practices can result in highly variable site conditions, making it difficult to separate and quantify factors influencing tree growth responses.

vegetation following harvesting and site preparation. Such high variability reduces the ability of investigators to detect treatment effects. Field studies of operational practices also tend to alter many tree growth-controlling factors at once, making it difficult to isolate cause and effect mechanisms. When the same operation is performed at a different site, the inherent site limitations may change or may be differentially affected by the operation. Without quantifying these controlling processes, it becomes difficult to apply operational study results beyond the site from which they were derived.

An alternative to the operational field study is what might be termed the controlled process study, where the system is simplified so that individual factors controlling productivity can be manipulated and quantified. Greenhouse pot experiments are the extreme example of a system where individual factors are manipulated so that their influence on tree growth and physiological/phenological responses can be assessed. While the strength of such studies is the ability to control and assess the influence of individual factors on tree growth and function, their relevance to operational management practices is limited.

In the 1980s, the USDA Forest Service, under the leadership of Robert Powers, developed a network of forest productivity study sites across the United States and in Canada using a creative design for controlling site factors in field settings.

The core design of the Long-Term Soil Productivity (LTSP) study network includes three harvest intensity levels (bole-only, whole-tree and whole-tree plus forest floor); three levels of compaction (none, moderate and severe); and two levels of competition control (none and complete). The objective of the harvest intensity and compaction treatments is to assess how two key site productivity factors, soil organic matter and soil porosity, affect stand productivity with and without competing vegetation. To more consistently reduce soil porosity than would be possible under normal forest operations, entire plots were compacted once or twice using a pneumatic roller or similar equipment in the absence of harvest residues, which were removed to aid soil compaction, then subsequently replaced. The design provides considerable control over important tree growth-controlling factors, but was not intended to mimic operational conditions. Mitigation treatments such as tillage or fertilization are not generally included.

The Fall River study

During the establishment of the LTSP site network, industry scientists and forest managers, university researchers, and LTSP network leaders and collaborators began to discuss the need for a long-term study in the Pacific Northwest region that would have design elements of the LTSP network studies, but would more closely link operational management practices to soil-site processes and forest productivity. This resulted in a cooperative agreement between scientists and managers from the University of Washington, Weyerhaeuser Company and the USDA Forest Service Pacific Northwest Research Station. As a representative of the broader forest products industry, the National Council for Air and Stream Improvement, Inc. (NCASI) provided early and continued endorsement for the establishment of the study and direct support of monitoring and assessment elements. Additional partners include the Pacific Northwest Stand Management Cooperative, Olympic Natural Resource Center and Michigan Technological University. The findings from this study will be integrated with other long-term site productivity studies to refine BMPs to enhance and maintain forest productivity in the Pacific Northwest.

The Fall River study is located on fertile, well-drained, silty clay loam soil (Typic Fulvudand, Boistfort series) on Weyerhaeuser land in the Coast Range west of Centralia, Washington. Like the LTSP network studies, the impacts of organic matter removal, soil compaction and vegetation control on site processes and tree growth are a core part of the study design. The randomized block design (four replications) includes four levels of harvest/biomass removal from an existing Douglas-fir stand: (1) bole-only; (2) bole-only to a five centimeter diameter top; (3) total tree; and (4) total tree plus all legacy wood in the forest floor from the previous stand. All treatments received competing vegetation control for five consecutive years. Adjacent portions of the original stand with similar stand and soil characteristics provided the opportunity to sample non-harvested conditions. Two sets of organic matter removal plots were installed in each replication of the study so fertilizer can be applied to one set of these plots at a later date.

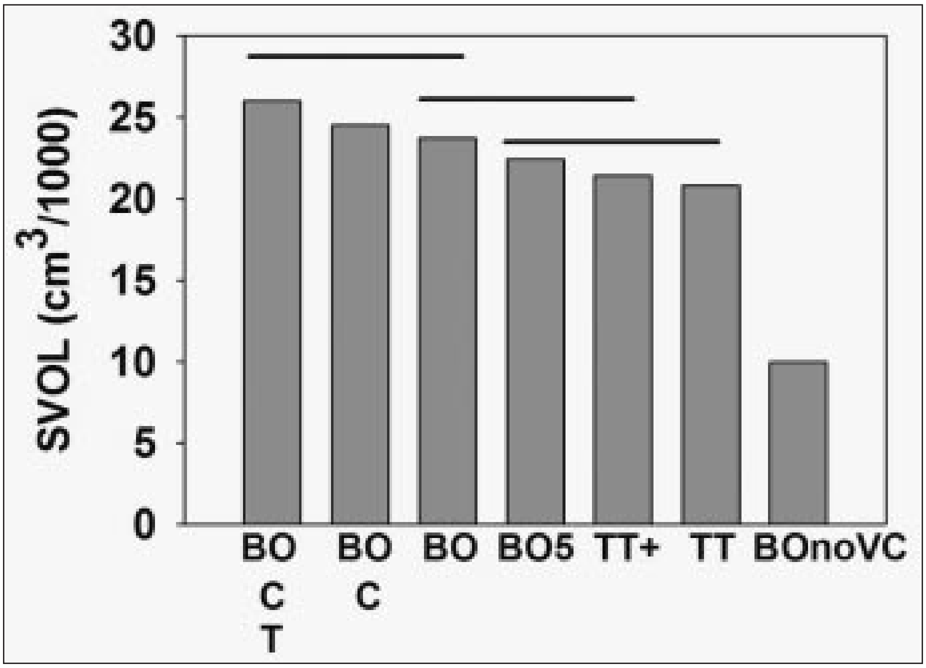
Soil disturbance/compaction treatments were established using one or more passes of a shovel forwarder in eight traffic lanes within bole-only removal treatment plots with harvest residues in place as occurs operationally. Compaction plus tillage was added as an additional treatment to assess the need for soil amelioration in the compaction treatment. Compaction-related treatments received the same control of competing vegetation as the main harvest removal treatments. An additional treatment received bole-only removal, but no control of competing vegetation where the impacts of vegetation control could be assessed. The large size of the plots [0.25 hectares (0.63 acres)] allows for long-term assessment and future thinning. The result was a series of treatments that allow us to assess the influence of operational management practices on key site factors likely to impact forest productivity.

Key early findings and management implications from Fall River

Resilience. Perhaps the most significant finding during the initial six years of the Fall River study is the site's remarkable resilience. At age five, the extreme biomass removal treatments have had only a small, negative influence on tree growth (see Figure 1). Total tree removal slightly reduced stem volume index (stem diameter^2 x height) over the bole-only treatments, while tree response on the total tree and total tree plus treatment were similar.

The most likely cause for the reduced stem volume was drying of the surface soil during the summer dry season rather than nutrient depletion. Compaction treatments substantially increased soil bulk density and soil strength, and reduced soil porosity, but had no significant effect on tree growth at age five and even enhanced tree volume growth at age three, probably due to increased available water holding capacity in the compacted soils. A trend toward greater seedling growth with compaction is still evident after five years. Because the initial soil bulk density at the study site was low, its increase did not lead to values that were above critical levels.

Figure 1. Douglas-fir plantation age five, Volume Index (SVOL = basal diameter (cm2) x total height [cm]) for trees in biomass-removal, soil compaction and tillage, and vegetation control treatments at Fall River. Treatments (all receiving vegetation control) are BO = bole-only removal; BO5 = bole-only up to five centimeter top diameter removal; TT = total tree removal; TT+ = total tree plus all legacy wood removal; C = soil compaction; and T = soil compaction and tillage. BOnoVC = bole-only removal without vegetation control. Means under the same horizontal lines do not differ at P ≤0.05.



Most limiting factor. Despite the severity of the harvest removal and compaction treatments, the factor that has most limited early tree growth has been competing herbaceous vegetation. This appears to be primarily a soil water effect, as the presence of herbaceous competitors significantly reduced soil water availability during the growing season, but had little effect on age five Douglas-fir foliar nitrogen (N) concentrations compared to plots where competition was controlled.

Nitrogen retention. When compared to the non-harvested stands, the bole-only and total-tree plus harvesting treatments increased availability and leaching of N for two years following harvest; however, N concentrations in soil solution declined to negligible levels by year five and only a very small amount of the total on-site N pool was mobilized and lost. Another major finding of the study was the unique nitrate retention capacity of the variable charge, volcanic soils at Fall River, which probably contributed to leaching rates that were too small to be of significance for either site productivity or water quality.

Management implications. The resilience of the site to biomass removal and soil compaction, the high soil N retention capacity, and the strong herbaceous competition as the major factor limiting early tree growth are among the important findings related to site productivity at Fall River. The importance of herbaceous competition in restricting early tree growth has been demonstrated in a majority of the LTSP network studies. One of the interesting findings at Fall River has been the correlation of soil water availability with early tree volume across and within treatments, while the beneficial effects of increased soil temperatures were important only when field season soil water was high. Increased soil water also appears to be responsible for enhanced seedling growth in the compaction treatments in the driest year (age three).

Interpretations of treatment impacts on tree growth should be made in the context of the soil at Fall River, which is near the high end of the fertility range for Douglas-fir and has unique characteristics and resiliency due to its volcanic origin (andic properties). It is important to note that soils of similar origin are broadly distributed in the region. For example, the historic Mt. Mazama (now Crater Lake) eruption about 7,000 years ago deposited some material over nearly all of the Pacific Northwest area north of the eruption site, including the Fall River site. The extent of variable charge soils and their role in increasing forest productivity in the region needs to be assessed. Herbaceous competition was controlled at Fall River longer than in normal operational practices, which should be taken into account when estimating the potential gains that can be achieved with operational levels of vegetation control.

The value of findings from Fall River and the LTSP study network should increase as the treatment effects are observed across a wide range of sites over an extended time period, and as studies are added to the long-term site productivity strategic database in the Pacific Northwest. A recently installed study sponsored by Green Diamond Resource Company, Port Blakely Tree Farms LP, Green Crow Ltd. and the Forest Service/Forest Industry Agenda 2020 program includes core treatments from Fall River at two sites with contrasting soils and will be an important addition to this database.

The broad sponsorship of these studies—forest products companies, NCASI, USFS, University of Washington Stand Management Coop and others—demonstrates the determination of these groups to sustain and enhance forest productivity and will facilitate information transfer as findings are made available. ◆

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OSAF Foundation Forum

Scholarships Awarded to OSU Students

Stephanie Larew and Judd Lehman, both seniors in Forest Management at Oregon State University College of Forestry, have received scholarships from the Oregon SAF Foundation.

Judd Lehman of Trail, Ore., hopes to one day have enough experience and knowledge to use his skills to manage forestland to the benefit of society. He spent last summer working for the OSU student logging crew and this summer is working for the Forest Service in timber sales administration. He will also spend this summer taking panoramic photos of southern Oregon for comparison of past and present landscape conditions in these areas. Judd serves as chair of the OSU Student SAF Chapter and regularly attends Oregon SAF executive committee meetings. This year he also attended the joint WSSAF/OSAF Leadership Conference and the Oregon SAF Annual Meeting.

Stephanie Larew of Roseburg, Ore., has many fond memories of enjoying the wilderness with her family, which has led to her great respect and love of the outdoors.

The OSAF Foundation focuses their efforts within Oregon and at development of future professionals and forestry education in general. Scholarship applicants are asked to address their career goals and aspirations, job experiences and how they believe their education in forestry will prepare them for the future. One criteria the students must meet is to demonstrate potential for future membership in SAF through active participation in the SAF student chapter. For more information on the OSAF Foundation, visit www.forestry.org/or/ foundation. ◆