Two Decades of Learning about Thinning in the Ecosystem Management Era

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Introduction

Adoption of the Northwest Forest Plan (NWFP, USDA and USDI 1993, 1994) in the early 1990s signaled a major shift in forest management on federal lands in western Oregon and Washington. The Plan reflected composite concerns raised by various resource managers, conservation groups, scientists, and the general public about the sustainability of production-oriented forestry as practiced from the early 1900s. Specifically, the plan addressed concerns regarding clearcutting, the harvest of old-growth trees and loss of related habitat, and threats to more than 1,000 potentially sensitive species (Thomas et al. 1993; USDA and USDI 1993), including regionally iconic salmonids and the Northern Spotted Owl (*Strix occidentalis caurina*). As new objectives such as ecosystem function and biodiversity became higher priorities, federal land managers strove to define new silvicultural practices that would provide ecologically sustainable alternatives to clearcutting and old-growth harvest while still providing for wood production and economic benefits. As a result, partial overstory removals —mostly alternative thinning methods—have replaced clearcutting as the predominant form of harvest on federal lands over the past two decades.

Two concepts that crystallized in the 1990s have been important to the development of contemporary thinning practices: 1) existing old-growth stands with large trees, complex crowns, and multiple canopy layers often developed at lower densities than those typical of current young, unthinned stands (Tappeiner et al. 1997); and 2) retained down wood, snags, and large older trees with complex crowns perform important functions in providing habitat for late-seral flora and fauna in young, managed stands (Franklin et al. 1997). When aligned with an objective to accelerate development of late-successional forests, these two concepts provide the rationale for thinning young, dense stands in unconventional ways to increase structural and compositional variability.

In addition, the 1990s ushered in an era of more holistic aquatic-riparian conservation and restoration in western forests, with a new emphasis on watershed values. The Aquatic Conservation Strategy (ACS) outlined in the Northwest Forest Plan conceptually shifted the aquatic management emphasis from individual stream-reach conditions to larger-scale watershed conditions, in accordance with evolving concepts of streams functioning as branched networks (Fisher 1997). In this regard, the ecological importance of small headwater stream reaches emerged as potentially significant. Small streams drain typically 70 to 80 percent or more of a watershed in the Northwest (Gomi 2002). Hence, they encompass significant habitat within a watershed context, but also potentially contribute significantly to downstream conditions as well as providing ecological subsidies to uplands (Baxter et al. 2005). Riparian reserve designations of the ACS extended protections to small non-fish-bearing streams by codifying interim streamside buffer widths. Within riparian reserves, harvest activity was not precluded, but must contribute to, or not retard, the attainment of ACS objectives. However, harvest, predominantly

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commercial thinning, occurred on only about 2 percent of total riparian reserve area in the first decade of ACS (Reeves et al. 2006).

Application, refinement, and validation of northwest forest ecosystem management concepts has occurred concurrently in local operational trials by practitioners and in formal studies conducted as research-management collaborations. Given 20 years of learning from research and operational experiences, there is much to discuss about thinning as a forest management tool relevant to local programmatic applications and broader regional strategies and policies.

Workshop Purpose & Scope

In October 2011, the principal partners of the Density Management and Riparian Buffer Studies of western Oregon (DMS, Cissel et al. 2006), the Bureau of Land Management, Forest Service, and Oregon State University, convened a 3-day conference, entitled *Density Management in the 21st Century: West Side Story*, as a means to present and discuss findings of nearly twenty 20 years of density management research. In a narrow sense, the conference provided a capstone to a first phase of monitoring, analysis, and inference of the varied terrestrial, riparian, and aquatic ecosystem responses to the initial implementation of the DMS experimental treatments in the late 1990s. While various facets of the DMS were intentionally featured, the conference organizers recognized that the science related to thinning within the Northern Spotted Owl range of western Oregon and Washington has been developed through several important studies and in various disciplinary, ownership, and interest-group contexts. A broader intent of the conference was to highlight this wide array of thinning-related science to stimulate a discussion of what we know and understand, or have yet to resolve, about thinning as a silvicultural practice to meet contemporary and future management objectives. We purposefully sought representation from other west-side studies for comparison and synthesis. Stimulation of meaningful dialogue was dependent on broad representation of the researchers who generated information and the practitioners and decision-makers who translate the science into outcomes of ecological and social importance. To this end, the conference included 40 oral and 16 poster presentations by more than 65 authors, including decision-makers, practitioners, and researchers from 11 different government, private industry, and academic institutions.

Proceedings Overview

We present a number of papers and abstracts which highlight the conference themes. These themes include: The Regional and Landscape Context for Density Management in the Northwest Forest Plan Era; Implementation and Influences of Density Management in the Terrestrial Ecosystem; Riparian and Aquatic Ecosystems and Their Responses to Thinning and Buffers; Socioeconomics and Operations; and looking forward, Thinning and Adaptation. Collectively, the papers and abstracts illustrate the degree to which the realm of thinning extends beyond a narrow focus on trees to broader forest ecosystem considerations. To view the oral presentations, visit the interagency ECOSHARE website: *http://ecoshare.info/products/completed-workshops/thinning-workshop/*

To set the context for contemporary thinning, Kenneth Ruzicka and coauthors provide an overview of the origins of the Density Management and Riparian Buffer Study in relation to the Northwest Forest Plan. The importance of public perceptions of forest management activities in determining social acceptability is addressed by Robert Ribe. At the regional landscape scale, trends in harvest intensity and the relationships to land ownership patterns and ecological gradients are addressed by Robert Kennedy and coauthors and by Janet Ohmann.

Application of thinning and subsequent

vegetation responses are addressed in several papers. Klaus Puettmann and coauthors describe understory species abundance and diversity responses as observed in the DMS and the Young Stand Thinning for Diversity Study (Poage and Anderson 2007). Peter Gould and Constance Harrington describe the development of new models of understory tree development. Kyle Dodson and coauthors address tree mortality and snag recruitment in the DMS. Mark Harmon addresses the fundamentals of thinning effects on carbon stores, and Julia Burton and coauthors discuss trade-offs between development of diverse understory vegetation communities and the accumulation of carbon stores. Daniel Luoma and Joyce Eberhart look below the soil surface to characterize mycorrhizal responses to the level and pattern of green-tree retention harvests as implemented in the Demonstration of Ecosystem Management Options (DEMO) study (Franklin 1999). Heather Root and Bruce McCune describe potential benefits to lichen diversity associated with retention of large legacy trees and decreased stand densities in young stands. The variable pathways which can lead to old-growth structures are described by Tom Spies and Robert Pabst. The effectiveness of alternative density management approaches to placing young stands on trajectories toward late-seral structure is the focus of John Tappeiner and of Mike Newton.

The impact of contemporary density management practices on enhancing terrestrial habitat for a variety of organisms was an important conference focus. From the perspective of the Northern Spotted Owl, Todd Wilson and Eric Forsman discuss the relationships between thinning and habitat suitable for flying squirrels, the principle prey base in portions of the owl's range. John Cook and Rachel Cook discuss the importance of understory vegetation nutritional value as a determinant of possible Elk (*Cervus elaphus*) forage benefits of thinning. The finding that different taxonomic and functional groups of birds benefit differentially from thinning is discussed by Joan Hagar.

The contemporary aquatic and riparian issues associated with forest management strategies at longer-term, landscape scales are framed in the context of integrated watershed analysis by Gordon Reeves. Kelly Burnett outlines concepts of intrinsic potential—the persistent characteristics of streams that define the potential to provide quality fish habitat. The hydro-geomorphic processes responsible for delivering wood to streams, and therefore realized fish habitat are reviewed by Dan Miller. Influences of thinning and riparian buffer width on aquatic and riparian attributes at a finer reach scale include works addressing microclimate and stream temperature responses (Bianca Eskelson and coauthors; Paul Anderson and coauthors; Jeremy Groom), and stream wood recruitment (Mark Meleason and coauthors; Paul Anderson and coauthors). Deanna Olson summarizes DMS findings on the impacts of thinning and alternative riparian buffer widths on amphibian habitats and species abundances and assemblages. The responses of invertebrates, mollusks, fishes and small mammals to alternative streamside buffers in the presence clearcutting in western Washington are presented by Peter Bisson and coauthors and Martin Raphael and Randall Wilk. Jason Dunham and coauthors describe fish responses to harvest in a paired watershed study. Robert Danehy and Sherri Johnson distill many of the salient lessons into four principles of stream ecology applicable to forest management.

From an operations perspective, Kurt Steele draws attention to the practical challenges associated with applying variable density thinning. David Marshall addresses the implications of contemporary thinning practices for growth and yield. Loren Kellogg and Steven Pilkerton discuss the forest engineering issues of harvest planning requirements, production costs, and stand damages associated with contemporary thinning operations.

Looking to the future, Deanna Olson and Kelly Burnett define new concepts for providing

habitat connectivity in headwater-dominated landscapes. Possible implications of climate change on stream flow, thinning, and riparian buffer needs are addressed in a poster by Julia Burton and coauthors. The impact of thinning on the resilience of wildlife habitat to climate variation is discussed in a poster by Andrew Neill and coauthors.

Personal Perspectives

The conference papers serve well to illustrate the science underlying current harvest practices as well as some of the larger policy questions surrounding forest management. However, as pointed out by Mike Haske (Deputy State Director for Resources, USDI BLM) and Jerry Ingersoll (Forest Supervisor, USDA Forest Service Siuslaw National Forest) in their reflections on the presentations, unanswered questions remain, some of which are science-oriented and many that are social or political. In the following, I take the opportunity to address from my perspective as a scientist some of the points of discussion that occurred outside of the presentations and are not necessarily addressed in the proceedings papers.

Thinning isn't rocket science, but...

Principles of thinning and density management have been established over centuries of "conventional" silviculture practice in Europe and more recently in North America and elsewhere. So what is novel about the contemporary application of thinning in western Oregon and Washington? For me the answer is driven by both why and how we thin. If we change the "why" we thin, the "how" we thin changes also. When the primary objective of silviculture has been meeting wood-production objectives, thinning served primarily to harvest slower-growing trees, some destined to die, and to reallocate site resources to fewer stems of the most economically productive species, thereby promoting increased stand vigor and growth. Two common consequences of conventional thinning practices have been increased uniformity of forest structure and composition, and removal or delay in the development of dead wood as snags or down wood to meet decadence and habitat functions. Variable densities, skips and gaps, retention of minor species and snags, active creation of snags and down wood, and underplanting are elements that have been explored in contemporary density management prescriptions at the stand level. The fundamental ecological and physiological principles underpinning thinning effects on residual trees remain the same, but the interactive influences of increased spatial variability and structural complexity may alter stand development. Our experiences with contemporary thinning practices are still too few and too recently adopted to state with certainty that the broadened array of ecological objectives is being met.

Have we chosen the correct references from which to gauge observed thinning effects?

A concern raised by some conference field trip participants was that many of the contemporary thinning studies base inferences on the responses of thinned young stands relative to responses for similarly young but untreated stands: in effect, a comparison between active management and a passive, no-treatment alternative. While this is perhaps a statistically sound approach, are young, unthinned stands the most relevant standard, given the common objective of developing late-seral attributes? There are few if any 30- to 50-year-old stands developing under natural, unmanaged conditions that can provide contemporary references to the managed stands that are the current target of thinning. Further, it has been difficult to locate late-seral stands to serve as valid references to desired conditions. During initial planning of the DMS, representative late-seral reference stands were sought, but where located, the late-seral stands tended to occupy settings incomparable to the younger managed stands to be thinned—they were often at higher elevations, were forest fragments, and did not include

streams. In the absence of site-specific late-seral reference stands, there are a limited number of published studies that provide definitive stand structure and composition characteristics either qualitatively (e.g., Bauhus et al. 2009) or quantitatively (e.g., Poage 2005), that can provide late-seral benchmarks. However, published characterizations were derived retrospectively, and reflect an unknown range of variability in developmental trajectory.

The earliest of the contemporary west-side thinning studies was implemented in 1992 and 1993 on the Siuslaw National Forest (Poage and Anderson 2007). The study has generated data from 17 years of post-treatment monitoring; thus, we are only 15 to 20 percent of the way to observing the planned late-seral objective. The developmental path that these recently treated stands will ultimately take in approaching late-seral conditions is both empirically unknown and relatively poorly modeled. Regardless of these uncertainties and the lack of clear standards, our research studies may better serve managers by focusing on thinning response trends as deviations from the desired late-seral conditions rather than deviations from untreated, young-stand references.

Morticulture—the management of death and decay

Critical to managing for late-successional habitats is an improved understanding of how alternative silvicultural practices interact with processes of tree death and decay and how silviculture can be used to augment or enhance those processes. Over the past several decades our ecological understanding of decadence and its importance to habitat and biogeochemical processes has increased substantially, but translation of the fundamental knowledge into coherent goals is lagging. There is likely consensus that decadence is needed; however, questions of how much, what form, where, and when continue to be a subject of debate. We have some valuable tools such as DecAID (Mellon et al. 2002) that describe the landscape variability of terrestrial snag and down wood abundances as well as rudimentary wood abundance-species use relationships, and NetMAP (Benda et al. 2007), which can quantify the probability for delivery of wood to stream channels. However, it remains a challenge to quantify the incremental gain in ecological benefits associated with incremental increases in snag and down wood abundance. Increasingly, simulation modeling is being used to explore trade-offs among benefits associated with alternative silvicultural approaches at stand or landscape scales. Our readily accessible forest-growth simulation models (e.g. Forest Vegetation Simulator; ORGANON) were developed from relatively strong tree-growth data, but unfortunately they prove to be rather poor platforms for projecting tree mortality and down wood recruitment and persistence. Improvement of these simulators will require that we invest in the analysis of the empirical snag and down-wood data accruing in our long-term silviculture experiments to provide more robust functions for model improvement. Further, uncertainties in stochastic mortality events may require novel coupling of stand-level simulators with larger-scale process or disturbance models to better project snag and down-wood dynamics at multiple scales of ecological importance.

Riparian buffers and the ACS

Thinning as conducted in the DMS, other studies, and operationally on federal lands is a much different disturbance than clearcutting when it comes to potential harvest alterations of riparian habitats, including microclimate and stream temperature. The NWFP interim guidelines for riparian reserves were relatively conservative, and we have learned that in some contexts such as small headwater streams, key ecological functions such as shading or habitat for aquatic and riparian dependent vertebrates can often be fulfilled with narrower buffers. However, as we consider more intensive thinning or retention harvests, or other ecosystem functions

and their interactions, questions remain regarding the efficacy of various buffer configurations. At a larger scale, the intent of the ACS was to provide a watershed focus to assessments of stream condition—particularly, recognition that natural dynamics will result in periods of poor condition at the fine scales of stream or stream reaches, and therefore trends at the watershed scale may be more meaningful for assessing overall landscape condition and restoration efficacy. There is a need to reconcile a large-scale ACS approach with management actions and condition criteria applied at the finer stream-reach scale. Until we can effectively think about important aquatic and riparian management issues in the context of integrated, multi-scaled ecosystems, conflicts between management toward large-scale outcomes and finer-scale regulatory objectives are likely to recur.

What is the future for thinning?

Whether on BLM or Forest Service lands, thinning has become a very important silvicultural tool. In the Pacific Northwest Region, thinning and fuels-reduction treatments targeting forest restoration objectives account for about 97 percent of the Forest Service vegetation management budget (Jeff Walters, Region 6 Director of Natural Resources, U.S. Forest Service). Perhaps the continued predominance of thinning is uncertain, both in terms of continued availability of suitable stands for thinning and in terms of the limited ability of thinning to provide some desired landscape elements such as early-seral habitat. I am not overly concerned about either issue as a determinant to whether or not thinning continues to be an important silvicultural tool into the future. For example, recent discussions proposing increased regeneration harvest on federal lands using green-tree-retention (Franklin and Johnson 2012) as a means to increase the abundance of early-seral forest do not preclude restoration thinning. Rather, variable-density thinning conceivably can be an important intermediate treatment in silvicultural systems featuring legacy retention, natural regeneration, and longer rotations or cutting cycles. However, long production-cycle strategies involving the eventual harvest of large trees may continue to be constrained by a lack of social acceptance. At larger spatial and temporal scales, a very large palette of silvicultural approaches and management strategies is available to meet diverse ecological and societal objectives. Given that forests are complex systems with varying capacities to respond and adapt to disturbance or stressors, uncertainty will be the norm that justifies using a variety of management approaches.

In my opinion, the greatest challenge facing forest resources management has long been, and will continue to be, the development and fulfillment of the implicit social license permitting management of public and private forest lands to sustainably meet the breadth of needed ecological and societal services. As a scientist my intent, similar to that of my peers, is to objectively deliver information and tools that are used to inform forest management options and policy. Although scientists may suggest the management implications of their work, it is intended that considerable room be allowed for natural resource managers to exercise innovations in application as they integrate among themes and prioritize their own goals. To this end, it has been personally rewarding to serve as one principal investigator for the Density Management and Riparian Buffer Studies, and to have participated in the planning and conduct of the conference which is captured in the individual papers and abstracts that follow in this volume.

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Photos, facing page—Top: View from Green Peak toward the Willamette Valley. Photos by Paul Anderson. **Center left:** Variable-width buffer at Green Peak. Photo by Paul Anderson. **Center right:** Unthinned two tree-height buffer at Keel Mountain, with Andy Neill for scale. Photo by Paul Anderson. **Bottom left:** Stream wood and Western Skunk Cabbage (*Lysichiton americanus*) at Keel Mountain. Photo by Mark Meleason, USFS. **Bottom right:** Edge of federal and private forest industry ownerships, Green Peak. Photo by Paul Anderson.