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# Exploring Foundational Concepts in Reforestation and Early Stand Improvement—a Recap of the 2022 National Silviculture Workshop

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## Abstract

The National Silviculture Workshop (NSW) is a biennial forum on silvicultural advances hosted by the USDA Forest Service. In July of 2022, this gathering brought over one hundred seventy silvicultural workers from all parts of the agency, plus some from academia and industry, to Kellogg, Idaho. Against the spectacular backdrop of the northern Rocky Mountains, NSW participants learned about the various challenges and opportunities faced by Forest Service silviculturists and silvicultural researchers, especially on reforestation and early stand improvement challenges on Forest Service lands. Over three days, oral and poster presentations were given on topics ranging from new legislation and agency policies to decision support tools to forest health threats to regeneration and nursery problems. Additionally, a day-long field tour and hours of less formal conversations and networking helped to continue the tradition of knowledge transfer and collegiality long experienced at the NSW.

**Study Implications:** The 2022 National Silviculture Workshop (NSW) continued a long tradition of bringing together USDA Forest Service silvicultural practitioners and researchers in a forum that helps bridge research with practice and policy. The presentations, field trip, small group meetings, and plenty of networking continued to strengthen the silvicultural work of the Forest Service, laying the groundwork for the next NSW in Olympia, Washington, in July of 2024.

**Keywords:** USDA Forest Service, stand tending, reforestation, forest health

## The 2022 National Silviculture Workshop: an Overview

Between July 12 and 14, 2022, 173 USDA Forest Service silviculturists and silvicultural researchers convened among the rugged and well-timbered mountains of historic Kellogg, Idaho, (figure 1) for the latest installment of the National Silviculture Workshop (NSW). Started in 1973 and held every two years (or so) since, the NSW provides Forest Service managers and scientists a forum to present and discuss the latest silviculture-related research, management challenges, and policy updates. Through a combination of talks, posters, a field trip, and an abundance of networking, the NSW helps to strengthen the agency's capacity to conduct and improve on the management activities so vital to sustaining healthy and productive national forests. Each NSW is developed around an important and timely theme, and the 2022 meeting at the Silver Mountain Resort in Kellogg proved to be exactly that! The "Foundational Concepts in Silviculture" theme emphasizing reforestation and early stand improvement not only proved highly relevant to the complex mixed conifer landscapes of the northern Rockies but to most of the rest of the

National Forest System (and many other public and private lands) as well.

Although not totally escaping the effects of the COVID-19 pandemic, which had delayed the meeting for a full year, this NSW provided many of us the first large-scale face-to-face opportunity to gather and exchange ideas in nearly three years. Featuring two full days of presentations, with an excellent day-long field trip to parts of the nearby 2.5 million acre Idaho Panhandle National Forests (IPNF) and evening awards banquet sandwiched in between, there was much to discuss. As the rest of this recap will describe, the presentations and tour covered a wide range of topics, regions, and forest types oriented around the meeting's themes (see the published conference proceedings [Jain and Schuler 2022] for extended abstracts of each talk). The workshop also recognized a number of persons who have made significant and lasting contributions to silviculture in the Forest Service. This included the Rocky Mountain Research Station's (RMRS) Dr. Terrie Jain's stirring tribute to long-time silvicultural researcher Dr. Russell T. Graham. Dr. Graham, who passed away in 2020, was particularly fond of the workshop.
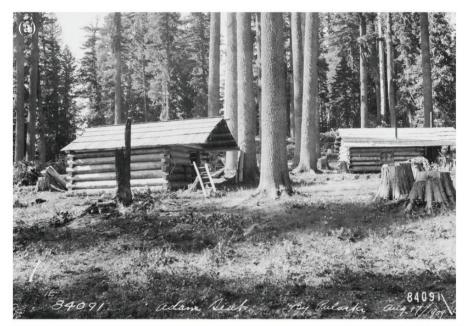
**Figure 1.** From prehistoric times to the lumbering and mining booms to the modern day, the forests of northern Idaho have always been a critical resource, one that continues to be shaped by past and present land use practices and environmental change. (a) An early settler's cabin along the banks of a tributary of the St. Joe River in what was then the Coeur d'Alene National Forest, taken by Ed C. Pulaski in 1909 (Forest Service negative #84091). (b) A landscape in the Idaho Panhandle National Forests where the silvicultural emphasis has become one of balancing the species now present on the site with those desired for long-term resilience and forest health (public domain photograph by Don C. Bragg taken in July 2022).

## Day 1: Opening Welcome

After Jain "rang" us into order, RMRS Director Dr. Monica Lear opened the first session of the NSW on Tuesday morning with a tribute to the retiring Jain. As noted by Lear, the retirements of experienced silviculturists from the Forest Service's Research and Development and National Forest cadres is a significant challenge for the agency, particularly in this period of dramatic environmental shifts. Northern Region Regional Forester Leanne Marten echoed Lear's sentiments and further noted the need to address the staffing challenges in the Forest Service consistent with efforts to diversify the workforce.

Marten acknowledged both the privilege and struggles in managing the more than 193 million acres of federal lands for healthy forests and grasslands to provide as many goods and services as possible while dealing with various forest health issues, staffing challenges, and resource limitations. Recent legislation (such as the REPLANT Act, passed in late 2021) and additional funding will help, but long-term shortcomings in reforestation capacity, restoration needs, and other implementation barriers must be overcome first.

Carl Petrick, IPNF forest supervisor, rounded out the program welcome with a recap of the host forest, including its

history and some of the IPNF's formative events—such as the 1910 "Big Burn," decades of extensive cutting, and later catastrophic losses of western white pine (*Pinus monticola*) from the introduced white pine blister rust (*Cronartium ribicola*)
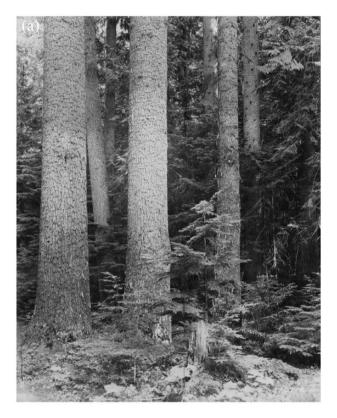


**Figure 2.** Even after decades of extensive lumbering, examples of the old-growth forests of the northern Idaho region, such as those dominated by western white pine (a) and western redcedar (b) were not unusual into the 1930s. However, a combination of this heavy logging along with catastrophic wildfires and storm events and a litany of native and introduced forest pests quickly took their toll on both the remnant old forests as well as vigorous and well-stocked second-growth timber (c). Much of the early work of the experimental forests in this area concentrated on developing silvicultural practices capable of both managing healthy stands as well as restoring the large areas that had been devastated. All Forest Service photographs in this figure were by K.D. Swan: #270712 (taken in 1932) and #436740 (taken in 1945) are from the Kaniksu National Forest and #199197 (taken in 1925) was on the Clearwater National Forest.



Figure 2. Continued

(figure 2)—that influenced the landscapes we witness today. The forest health issues faced by the IPNF, including insects, disease, fire suppression, and catastrophic wildfire, as well as extended droughts and other manifestations of climate change, echo across the western United States, as do the needs of silviculturists looking to develop new partnerships and build public support for the restoration and management challenges before us. For instance, the ability to expand on the use of prescribed fire as a silvicultural tool depends on better science, use of Indigenous knowledge, improved communication, more capable models, a wider range of state, federal, tribal, non-governmental organization, and industry partners, and a less adversarial operational environment.

## Day 1, First Session: A Focus on Reforestation

As mentioned above, one of the primary emphases of the 2022 NSW dealt with the often overwhelming reforestation challenges facing silviculturists. Dr. David Gwaze, national silviculturist, reviewed a series of laws and policies that affect the implementation of reforestation efforts on national forests. Gwaze asserted that the comprehensive—if sometimes dated—rules and regulations related to reforestation did not lead to policy shortcomings that cause reforestation issues, but rather a chronic lack of funding and staffing led to the reforestation backlog. Dr. Kas Dumroese (RMRS senior scientist and national nursery specialist) and Nicole Balloffet (national reforestation and nurseries program manager) followed with a presentation on the six-part National Forest System Reforestation Strategy (USFS 2022), including the laws and executive orders that directly affect the agency's reforestation efforts and capacities. Intended to assess reforestation needs and priorities to provide a blueprint for future



Figure 2. Continued

action, this strategy includes expanding the workforce, nursery, and related supporting infrastructure to provide more and better seedlings, increasing forest health and resilience, and communicating these efforts to the public.

Dumroese also presented a paper for Diane Haase (RNGR western nursery/reforestation specialist) on the daunting work facing forest nurseries, given the rising demand for seedlings to revegetate an increasing area of burned landscapes, some of which have entirely lost their capacity to naturally regenerate. The opportunity to use reforestation to help mitigate climate change also adds pressure to a national nursery system producing significantly fewer seedlings from its peak production in the 1970s and 1980s. For forest nursery systems to become successful and remain sustainable, they must acquire and store the needed seeds, grow the right kinds of seedlings for the proper places, provide the expertise required to ensure successful deployment of those seedlings, improve the ways and means to increase production of better performing seedlings, and help to support the overall economy with their efforts (see also Haase and Davis 2017). In short, seeds, support, staff, selling of a quality product, and communication are required for this critical infrastructure.

Victor Vankus (National Seed Laboratory director) discussed the Forest Service's National Seed Laboratory, focusing on the role of this facility on testing, technical assistance, and germplasm conservation. Such efforts are critical to help to identify and solve problems related to seeds, which are vital to the National Forest System Reforestation Strategy as well as restoration programs elsewhere. Dr. Jeremy Pinto (RMRS scientist) followed with an overview of the Forest Service Reforestation, Nurseries, and Genetic Resources (RNGR) program, including its history starting in 1996 as a collaboration between the three deputy areas to support native plant nursery needs, not just within the Forest Service or other federal agencies but across the public and private sectors. By providing technical assistance through a variety of outlets (e.g., publications, conferences, trainings, workshops, and their website, https://RNGR.net) and developing protocols and technology, RNGR has become a global and invaluable resource for managers, policy makers, and the general public.

During the lunch on the first day of the 2022 NSW, a special workshop for National Forest System silviculturists was led by Nicole Balloffet. The workshop objective was to obtain feedback and insight from the silviculturists from the field concerning the National Forest System Reforestation Strategy and the REPLANT Act, along with their implications for public land management. After lunch, the first session on reforestation continued with a series of more detailed applications of science towards growing a better seedling. Dr. Deborah Page-Dumroese (RMRS senior research soil scientist) discussed the potential for biochar to improve the efficiency of nurseries producing bareroot seedlings. As recently highlighted in an RMRS *Science You Can Use* bulletin (Neukirch 2022), biochar is an intriguing option for using charred organic material (in this case, burned wood chips and residues) to add a more stable source of soil carbon, increase carbon storage, lessen erosion, and diminish fire risks while providing more economic opportunities for restoration projects. Although more work to determine the benefits of biochar for bareroot seedlings is needed, Page-Dumroese highlighted a number of likely advantages for nurseries, including improved soil water availability and nutrient retention. Laura Rueling (University of Minnesota researcher) offered some greenhouse study results

of biochar as a soil amendment for jack pine (*P. banksiana*) seedlings that found no significant benefits in the sandy soils being tested. However, no detrimental impacts were observed either, suggesting that biochar added to soils for other reasons would not be harmful to planted jack pine.

Dr. Jeremy Pinto (RMRS research plant physiologist and tribal nursery specialist) described some research findings using the "target plant concept" focusing on growing seedlings better tailored to local site conditions—in this case, using drought resilience rather than productivity. Applying simulated drought to test the responses of ponderosa pine (*Pinus ponderosa*) and western redcedar (*Thuja plicata*), differences in seedling morphology and physiology were noticeably more apparent between the drought-tolerant ponderosa and the more moisture-demanding redcedar, adaptations that could be exploited to improve planting outcomes in increasingly moisture-stressed environments. The work of Pinto, Rueling, and Page-Dumroese each highlighted the need for continued research into the unique physiological, morphological, and ecological aspects influencing seedling success as a part of efforts to improve both planting and restoration outcomes.

After the Tuesday afternoon break, a different aspect of reforestation became the focus—the role of partnerships. Dr. Chris Looney (Pacific Southwest Research Station [PSW] research forester) and his colleagues presented a paper on the evaluation of options for reforesting fire-affected landscapes in the northern Sierra Nevada Mountains in California. Their work considered the impacts of better matching seedlings from seed zones determined by both current and anticipated climate conditions ("climate-smart seed sources") as well as mixing seedlings from different sources and species and consider planting patterns (e.g., regularly spaced versus clustered) to help improve the chances of success in a rapidly changing environment. Dr. Jianwei Zhang (PSW research forester) stressed the need for cooperation among partners in achieving success in reforestation by highlighting a long history of such work in California, including key work on how chemical competition control can significantly improve tree planting outcomes on burned landscapes. Dr. Marcella Windmuller-Campion (University of Minnesota silviculture professor) offered a case study of a very different set of circumstances (urban riparian site in St. Paul, Minnesota) in which the loss of an important component of this forest (green ash [*Fraxinus pennsylvanica*] to the invasive emerald ash borer [*Agrilus planipennis*]) provided both new opportunities and challenges for reforestation partnerships in the face of a changing climate.

The final segment of the first session of the 2022 NSW concentrated on genetic resource management and how it can help address some of today's challenges. Nick LaBonte (Forest Service Region 9 regional geneticist) presented a paper by Carolyn Pike (also of the Eastern Region) on the Eastern Seed Zones as developed by the Eastern Seed Zone Forum (http://www.easternseedzones.com/). An outcome of the 2018 Seed Zone Summit, these zones provide opportunities to tier a limited resource (seeds) to areas where they can be most effectively deployed, particularly given the substantial climate departures expected in the near future (Pike et al. 2020). Katie Frerker and her colleagues at Superior National Forest discussed an assisted migration plan designed to anticipate climate changes as northern Minnesota warms and dries, including using jack pine (*P. banksiana*) seedlings from more southerly locations. Claire Ellwanger (Forest Service Region 6 eastern Washington-area geneticist) wrapped up this session

with a discussion of the needs and challenges of matching the best genetic characteristics when sourcing seeds for planting locations into an uncertain future. Ellwanger described how the web-based Seedlot Selection Tool (https://seedlotselection-tool.org/sst/) helps managers find the best seedlots for their planting needs based on a range of possible climates.

Tuesday evening provided a chance for meeting participants to socialize and learn from numerous posters. These presentations included a wide range of materials, ranging from long-term change and age class structural changes in ponderosa pine forests to plant species as indicators of circumstances and reforestation success to accelerating forest succession in Port-Orford-cedar (*Chamaecyparis lawsoniana*) to western white pine restoration and crop tree release in plantations of that species to the impacts of prescribed fire on red maple (*Acer rubrum*) in the eastern United States.

## Day 2, Field Trip

After a thunderstorm rattled the conference facility in Kellogg overnight, the second day of the NSW opened breezy and overcast, but our day-long field trip ended up with fine weather. Tour organizers arranged a series of stops highlighting the many challenges and opportunities for the practice of silviculture in the northern Rocky Mountains. Most of these stops discussed the forest health difficulties now unfortunately common on many of the national forests in this region. These include those wrought by a number of root diseases, the changing dynamics of forests no longer subject to historical fire regimes and Indigenous land stewardship but affected by a changing climate, and decades of management practices that favored certain species (sometimes to the detriment of

more diverse taxa). The first two stops introduced tour participants to these impacts. The first stop, in a second-growth mixed conifer stand on the IPNF, presented the impacts of early forest harvesting and forest management, which emphasized the dominant western white pine until white pine blister rust and pole blight greatly reduced this species in the early to mid-twentieth century (figure 3a). The forests that arose following the decline of western white pine were dominated by grand fir (*Abies grandis*), western hemlock (*Tsuga heterophylla*), and Douglas-fir (*Pseudotsuga menziesii*), all of which are more vulnerable to the root and stem diseases found on most sites in this area and which can lead to significant mortality (sometimes over 90%) in these maturing stands. The less desirable timber species that were more successful in regenerating on partially harvested sites also proved more susceptible to decay and toppling (figure 3b), thereby limiting management options.

The second stop, located on the Fernan Ranger District of the IPNF, was held in and around the Montford Creek Research Natural Area (MCRNA) on the Deception Creek Experimental Forest (DCEF). Established in 1937, the 292 ac MCRNA was intended to provide an example of unmanaged old growth in the then-dominant western white pine forests (figure 4a) in an experimental forest dedicated to developing and improving on silvicultural practices (Graham and Jain 2008). Regrettably, within a few decades of its establishment, most of the western white pine in the MCRNA and across the DCEF had succumbed to the diseases sweeping the northern Rockies. The multitudes of bare snags and large downed western white pine logs throughout the MCRNA offer testimony to the past dominance of this species (figure 4b). With the losses in the MCRNA serving as a backdrop, a series of



**Figure 3.** Forest health challenges have long complicated silviculture in the northern Rocky Mountains. In addition to fire, drought, and insect pests, widespread outbreaks of introduced diseases such as white pine blister rust and a syndrome that came to be known as "pole blight" (an example of which can be seen in a, taken of a 75-year-old stand on the Kaniksu National Forest in 1953) devastated many stands of western white pine. The mixed conifer stands that became more dominant after the demise of the western white pine often contained less commercially desirable species (such as grand fir and western hemlock) more susceptible to a variety of root diseases that meant they often started falling apart at smaller, less valuable sizes, making them unappealing and more useful for firewood salvage (b). (a) (Forest Service negative #474537) taken by R.F. Watt in August 1953; (b) by Don C. Bragg in July 2022.

Figure 3.  Continued

additional locations provided examples of how work on the DCEF has evolved over the decades. Studies now look to balance the ecological realities of these mesic, productive sites increasingly dominated by shade-tolerant conifers with the silvicultural needs to retain and even expand on the diminishing western white pine. In addition to providing a comfortable location for lunch, the MCRNA also helped frame an introduction to the "free selection" silvicultural system. Free selection, a hybrid approach that merges elements of even- and uneven-aged treatments, provides managers a means to address a range of silvicultural challenges while better emulating natural patterns and processes (Graham and Jain 2005).

Our final stops illustrated the implementation of free selection on a landscape-scale. Unlike the early national forest management approach of large-scale clearcuts replanted with desired conifers (figure 5a), free selection involves a series of stand tending and regeneration treatments tiered towards the forest types, stand developmental stages, site conditions, planning and operational limitations, and market circumstances for this location. The Lone Cabin Creek stewardship timber sale, located just outside of the DCEF, contains a mixture of stands, with some being reserved from any harvest removals to others cut using modest-sized (20–40 ac) patch clearcuts with reserves (typically of the most desired pines and larches) or thinnings to produce a landscape of greater age class complexity, structural heterogeneity, and improved health, thereby meeting targets for desired composition and resilience (figure 5b). Although free selection offers considerable promise, it also requires patience, treatment flexibility, and adaptive management. Numerous challenges in the application of free selection and other silvicultural tools remain in the forests of the northern Rocky Mountains, including the inability to apply some harvest systems, difficulties in using certain site preparation techniques (such as mastication on steep slopes, effective prescribed fire, or herbicides to control undesirable species), the absence of desired species, the continued presence of forest health threats, shortages of trained staff, and the length of time it can take to get sales approved

and completed. Nevertheless, promising new silvicultural options continue to arise that may help forest managers now and in the future.

The Wednesday evening banquet featured an awards program that honored several researchers and managers for their years of dedicated service to the study and practice of silviculture. Distinguished Service Award research honorees included Dr. Laura Kenefic (Northern Research Station [NRS] research forester) for her work in northern conifers, Dr. Christel Kern (NRS research forester) for her work in the forests of the northern Lake States, Dr. Tara Keyser (Southern Research Station [SRS] center director and research forester) for her work in Appalachian hardwoods, and Dr. Don Bragg (SRS project leader and research forester) for his work in southern pines. Dr. James Guldin (retired SRS project leader/center director and research ecologist) also received a Lifetime Achievement Award for his decades of research, science administration, and educational activities in southern forestlands. National Forest System Distinguished Service awardees including Jason Jerman (IPNF silviculturist, Region 1) and Janet Hinchee (retired Region 8 regional silviculturist). The banquet speaker, Dr. Richard Hallett (NRS research ecologist), provided an address on urban and climate-adapted silviculture in northeastern US cities.

## Day 3, Second Session: Reforestation and Tending

The second session of presentations centered on foundational concepts in silviculture and started off with a presentation by Dr. Tom Schuler (Washington Office national program leader for silvicultural research). He gave a summarization of a large-scale planning model that has been recently developed for users to compare active management scenarios for resilient and productive forests, specifically balancing fire risk with multiple objectives, including timber, wildlife, and restoration targets. With input from silviculturists and researchers from each Forest Service Region and Station, the model allows users to consider alternative management

**Figure 4.** Many of the old-growth stands of western white pine that once dominated the hills of northern Idaho, such as the 200-year-old example (a) from the Deception Creek drainage in 1929, fell to lumbering during the late 1800s and early 1900s; those that did not were largely lost to white pine blister rust in the mid-twentieth century. In the Montford Creek Research Natural Area on the Deception Creek Experimental Forest, the "skeletons" of these western white pines remain (b) as stark reminders of the significance of this species at one time in these forests. (a) (Forest Service negative #235067) taken by K.D. Swan; (b) by Don C. Bragg in July 2022.

outcomes associated with different silvicultural prescriptions for regional and national planning needs.

Next, a group of presentations considered environmental indicators in reforestation and growth. First, Dr. Zachary Hoylman (assistant state climatologist, University of Montana) presented a study of forest regrowth dynamics after silvicultural treatments. Using satellite data to derive net primary production (NPP) rates across the western United States from a variety of silvicultural treatments, this study showed hydroclimate was the dominant driver for NPP (which averaged 313% higher on wet landscapes). Silvicultural treatments affected NPP mostly by the amount of light created; when paired with the hydroclimate variable, it suggests that different management strategies may be needed based on the climatic setting. Dr. Zachary Holden (scientist with the Forest Service Northern Region) then presented on REGEN MAPPER, a web-based tool to help resource managers identify and prioritize potential conifer planting sites after wildfires. This tool requires burn severity, location of seed sources, soil temperature, aspect, and historical climate data, and directs the manager to sites where regeneration will be successful. RMRS research forester Dr. Terrie Jain discussed the effect of canopy opening size on establishment of western white pine. As we saw in the previous day's field trip, a clumpy, variable retention regeneration approach with several management entries is capable of providing both western white pine establishment as well as other resource objectives, including aesthetics, wildlife, and water.

Forest health–related issues affecting reforestation continue to challenge silviculturists across the country. For instance, as the emerald ash borer (*A. planipennis*) devastates ash (*Fraxinus* spp.), it is important for managers to be able to assess their reforestation options. Dr. Rob Slesak (Pacific Northwest Research Station [PNW] Research Forester) evaluated how different tree species reacted to flood duration, water depth, and shade in discussing a study on the reforestation options in flooded areas in the Great Lakes region once occupied by black ash (*F. nigra*). Emily Thyroff (PhD candidate, University of Hawai'i) presented a research project about reforesting 'Iliahi (*Santalum freycinetianum*) trees in degraded dry tropical forests of Hawai'i. Successful reforestation considers the hemiparasitic nature of 'iliahi as well as more typical indicators such as amount of light to seedlings based on overstory gap sizes.

Stand tending–related presentations filled the rest of this final day of the NSW. Jain provided information about trends in stand improvement needs and treatments on National

Figure 4. Continued

Forest lands. To do this, she used the FACTS (Forest Service Activity Tracking System) database between 2010 and 2019 to document the number of acres needing stand improvement (consistently reported to be above 2.0 million acres). Most of these needs related to precommercial thinning (70%) followed by release (26%) and minor levels of pruning and/or fertilization. However, acres reported as treated during this same time period have been far less, averaging just over 240,000 ac per year. This imbalance between needs and accomplishment suggests that for national forests, many challenges remain to comply with the National Forest Management Act, which directs managers to maintain appropriate forest cover, stocking levels, growth and forest health to achieve the maximum benefits of multiple-use, sustained yield management. Later, Slesak discussed the retention of logging debris and vegetation control as treatments in Douglas-fir from western Washington. Whereas both of the studied treatments potentially added nutrients to the seedlings at all sites, lower productivity ones were more positively affected.

Next, Dr. Callie Schweitzer (SRS research forester) started a series of presentations on oak (*Quercus* spp.) management that focused on stand-tending options for thinning and prescribed fire to restore and sustain oak dominance in mixed pine-hardwood forests. Throughout North America, oak declines have been linked to a change in disturbance patterns (including the lack of fire), and consequently, treatments using thinning and prescribed fire to restore oaks are being studied. Schweitzer's work noted that although the ubiquitous red maple persisted through the thinning and prescribed fire treatments, both treatments still helped to move pine-hardwood mixedwoods towards a more oak-dominated

forest. Dr. Stacy Clark (SRS research forester) discussed how high-quality, locally-adapted, 1-0 underplanted northern red oak (*Q. rubra*) seedlings performed under four silvicultural treatments (control, prescribed fire, midstory removal, or shelterwood harvest paired with burning). Prescribed fires alone did not greatly benefit the northern red oak seedlings studied, and the shelterwood harvest treatment showed the most positive effect. However, burning five years after the shelterwood harvest impeded growth and increased mortality. Dr. Wayne Clatterbuck (University of Tennessee emeritus professor) described a number of midstory treatments tested for their influence on white oak (*Q. alba*) regeneration and growth. Clatterbuck reported that although oaks need frequent disturbance to maintain favorable light levels, early indications show the tested midstory treatments did not help white oak development or growth. Dr. Lauren Pile (NRS research forester) gave an interesting presentation on use of domesticated goat (*Capra hircus*) grazing with prescribed burning to aid woodland restoration. Goat grazing can be particularly helpful for development and enhancement of herbaceous groundcover and can be an addition to or an alternative for prescribed burning (if limited by smoke management or other concerns). Dr. Dan Dey (NRS research forester) presented a new use of Gingrich Stocking Guides for managing oak woodlands and savannas. To adapt these guides for the less dense woodlands or savannas, Dey suggested additional stocking thresholds derived from General Land Office witness tree data and contemporary experiments.

A final group of presentations discussed the use of stand tending to promote and sustain diversity. The first talk in this series was presented by Dr. Andrew Larson (University

**Figure 5.** Shifts in public opinion over the decades helped propel national forest management from focusing on large-scale clearcuts and planting, such as the one in a being studied in the Deception Creek Experimental Forest in 1952, with new approaches to retain the silvicultural advantages of even-aged management with the structural and aesthetic advantages of uneven-aged systems. In b, a study of the free selection approach to management of these same landscapes clearly demonstrates the hybrid nature of this system, where larger gaps (often with reserved trees of desired species) are interspersed with thinned stands and "skips" (areas with no harvest treatments) to help generate heterogeneity in structure and better emulate historical conditions (Graham and Jain 2005). (a) (Forest Service negative #478443) by Marvin W. Foiles; (b) by Don C. Bragg in July 2022.

of Montana professor) who stated that Rocky Mountain forests need more diverse structure to be able to meet anticipated ecosystem services as we enter a warming climate. The Forest Service, Bureau of Land Management, and The Nature Conservancy have initiated "Adaptive Complexity Thinning" (ACT) as a variation of traditional thinning methods to meet current and future ecosystem service needs for water, carbon sequestration, and wildlife habitat. ACT is a form of variable density thinning where the prescription varies across the stand and thus creates much more diversity than a standard fixed spacing thin. Using ACT methods, a precommercial thinning in Canadian lynx (*Lynx canadensis*)/snowshoe hare (*Lepus americanus*) habitat can accelerate the development of a complex multistory forest structure needed by both these species as well as balance wildlife habitat needs with timber management, snow accumulation and duration, and carbon sequestration. Next, Dr. Kellen Nelson (PNW research forester) presented a study on the effect of pruning in Sitka spruce (*Picea sitchensis*)–western hemlock forests. The study also looks at several thinning–pruning combinations. In the Pacific temperate rainforest, timber management has become more centered in even-aged second-growth stands that are typically very dense and often

devoid of understory vegetation, which negatively affects many wildlife species. Often prescribed to improve timber quality and boost understory vegetation, pruning and precommercial thinning are expensive and need to be carefully evaluated before being applied.

Building on the much-discussed free thinning treatment, Jain and Dr. Justin Crotteau (RMRS research forester) discussed this selection system as a tool to aid in regeneration and allow for tending to increase stand resilience and functionality. As a management goal, free selection is a highly flexible silvicultural framework to help build desired stand and landscape conditions over time, with the capacity to meet and support complex management objectives while helping to link stands and landscapes. Although it does not fit neatly into current standards of reporting accomplishments through the FACTS database, the increasing use of the free selection system should help alter FACTS reporting definitions. Finally, although a last-minute bout of COVID kept him from presenting on his topic, Dr. Don Bragg (SRS research forester) provided a vision of how the mathematical concept of fuzzy sets could help managers address some of the silvicultural challenges presented by old growth. These ideas can be found in Bragg (2022) and a companion article (Bragg forthcoming).

Figure 5. Continued

## Concluding Thoughts

Dr. Dan Dey (NRS project leader and research forester) joined Janet Hinchee (retired regional silviculturist for the Southern Region) in recapping a busy three days of meeting content, field trip adventures, and spirited networking. Hinchee summarized several recurrent and important themes heard throughout the conference. First, the importance of communication on many different levels—between the public and Forest Service managers, between managers and researchers, between silviculturists and other resource professionals, and between leadership and managers. Many presentations about successful projects emphasized that Forest Service managers need to communicate to the public often and in a common language.

We also heard many stories about successful projects that resulted from excellent communication between researchers and land managers and the need for this level of communication. As management objectives become more complex and often include many different resource areas, silviculturists need to communicate with other professionals. Integration between different resources is key for successful accomplishment of these multiple goals and objectives. A final level of communication happens between the various levels within the Forest Service—that is, managers, technicians, rangers, forest supervisors, and even higher levels of leadership. Managers must communicate to leadership about concerns and needs and leadership must reciprocate with managers. The presentations and field tour of this NSW was a diverse mix of traditional research projects, with other presenters focusing on presenting the management significance of their work in a more narrative style.

Second, a reoccurring theme in many of the presentations, conversations, and field trip stops was the importance of integrating natural disturbances into management prescriptions. The IPNF managers provided numerous insights on their work to identify the natural disturbances and then integrate their expected occurrence—and scale of the event—into their management prescriptions. As the IPNF includes multi-aged management into their projects, they look beyond the concept of managing stands to managing landscapes. Finally, another conference theme concerned future management of genetic resources in the forest, including how geneticists are working to address the impacts of climate change. This understanding is critical in helping forest managers better use genetic resources now and, in the future, to prepare for the major reforestation effort needed in the coming decade. Although much still needs to be done to build the capacity needed to increase seed collection, improve seed storage and seedling quality, and expand seedling production, a solid framework is being set by geneticists across the country.

Third, a unique communication element was added to this NSW. Unlike previous workshops, the proceedings were published (Jain and Schuler 2022) at the time of the meeting, with each speaker providing a brief synopsis of their story. These short narratives were designed to be read in less than five minutes and provide the reader with some information that could be immediately applied in their jobs. Effective knowledge transfer of silvicultural advances and new practices must be accessible to managers, planners, and policy makers for them to be widely adopted, and making the forum less technical and more applied helps achieve that goal.

Finally, as the nation emerges from a global pandemic, perhaps the most sweeping recognition some of us have taken away from our 2022 NSW experience is how valuable and precious is the ability to gather as a community of practice in national forest silviculture to share ideas, challenges, and experiences as we look for opportunities and solutions. This irreplaceable engagement has utility that is hard to measure but critical to future success, and so we look forward to the next NSW in July 2024 in Olympia, Washington!

## Acknowledgments

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