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What Does it Mean to be a Silviculturist?

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Abstract

Silviculture has been a dynamic discipline for over a century in North America. During that time, silviculture has been closely tied with dominant trends in society, from reforestation in the early nineteenth century to incorporating climate change, invasive species, and shifts in disturbance regimes during the twenty-first century, and the discipline continues to evolve. In this evolution, there have also been shifts to the definition of silviculture, from an art to art and science to recent proposals that it is strictly a science. We offer an alternative viewpoint in support of maintaining the contemporary definition that includes both art and science, supported by the role that silviculture plays in contemporary resource management and that silviculturists play in conducting both the strategic and tactical components of forest management. Despite the desire to recast silviculture as solely science, we argue that silviculturists need to be more artistic than ever, given the current era of rapidly changing social, ecological, and economic conditions. In addition to having a firm basis in science, silviculturists must also understand and practice their very important role as the honest broker between other resource professionals and society at large in the application of management on the ground.

Study Implications: Silviculture has been practiced in North America for over 100 years. It is being shaped by remarkable developments in technology, evolving suites of interested parties and landowner objectives, and considerable climatic uncertainty. Silviculturists are being tasked with interpreting and applying science to accomplish increasingly complex objectives, often with scarce resources at large spatial scales; and all of this is being done in anticipation of further change. Silviculturists understand and accept these challenges and embrace the opportunity to be active stewards of the forests of tomorrow.

Keywords: art, complexity, creativity, flexibility, innovation

Silviculture has played a central role in effective forest management since the advent of the forestry profession in North America over 100 years ago (Barrett 1995). Commonly, silviculture is where planning intersects with action when it comes to forest resource management in the name of sustainability, and it has been referred to as the "keystone of American forestry" (Seymour 2004). The theme that silviculture is situated in the center of the forestry universe has been repeated many times over in important texts (e.g., Assmann 1970). Although silviculture can be thought of as a discipline, it also necessarily integrates many other aspects in forestry, linking the many subdisciplines (e.g., forest pathology, forest management, soils, etc.) within natural resource management. Smith (1994, 19) argued that "the practice of silviculture lies at the very core of the decision-making process, and it is through the implementation of silvicultural practices that the goals of forest management will be achieved." See, for example, the latest edition of *The Practice of Silviculture* (Ashton and Kelty 2018).

When practiced, silviculture is a strategic tool that is achieved through the articulation of goals and objectives for stand and landscape management. For example, an analysis of multiple possible alternatives and the extent to which they meet predetermined evaluation criteria over reasonable timeframes can then inform the proposed action. It is also a tactical tool; a silvicultural prescription is a plan for accomplishing goals that is sensible in thought and action (e.g., Long et al. 2010). Silviculture is based in science, but requires the acknowledgment of the complexity of forest ecosystems and their management and the flexibility (or adaptability) to adjust the plan based on current or anticipated future conditions (whether they be environmental, economic, or social, D'Amato et al. 2023). Science alone cannot capture the integration of the complexity of forested ecosystems, social values, views, and biases that shape the interdisciplinary nature of practicing silviculture and the necessary creativity involved. Art, however, tackles complexity through creativity and also addresses ways of knowing other than western science, for

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example, the depth of knowledge from living or working in a landscape for decades (i.e., experience), observational knowledge (i.e., natural history), cultural or traditional ecological knowledge, etc. (Gilmour 2017). In other words, silviculture *requires* art, both for strategizing and for implementation. Currently accepted definitions of silviculture include elements of both art and science.

Given silviculture's universal place in forestry and forestry curricula, a background in its principles and practice is common to all foresters (e.g., Society of American Foresters accreditation standards, US Office of Personnel Management 460 Forestry Series). The introduction and advanced study of silvicultural concepts and their practical implementation in forestry curricula provides a foundational toolbox of what may be possible for a given set of goals and starting conditions. With further on-the-job training, silviculturists use this basic information as a launching point to develop prescriptions that can be adaptable to contemporary (and future) demands on management (Nagel et al. 2017). However, fundamental changes in resource management objectives over the last century have contributed to considerable pressure for serious reflection on what silviculture is and is not, and what it means to be a silviculturist (e.g., Achim et al. 2022). Shifts in perceptions of commodity production (Seymour 2004), public participation in public land policy (Cowan et al. 2022, Kennedy et al. 1998), emerging ideas regarding disturbance-based management approaches (Hunter 1990, Long 2009), and the recognition that forests and forestry play important roles in climate adaptation (D'Amato et al. 2011) and mitigation (Giebink et al. 2022) have each catalyzed fundamental shifts in the perception, practice, and teaching of silviculture. Concurrent with these changes, there have been extraordinary advances in the technical tools available to silviculturists (e.g., Achim et al. 2022, Cosenza et al. 2022, DeRose 2023, Wing et al. 2019). What has been certain for decades now is that the silviculture being taught in undergraduate and graduate classes (personal observation by the authors) and the silviculture being practiced do not center timber production as the sole management priority (e.g., Emmingham et al. 2000, Oliver et al. 2018, Great Lakes Silviculture Library). In this article, we review 100 + years of the development of silviculture as a discipline in North America, including subtle and not so subtle changes in definition, changes to resource management objectives, and the evolution of silviculture education. We examine these changes in the context of how silviculture is practiced and close with a look to the future regarding what it means to be a silviculturist.

Development of Silviculture Definition

The Silviculture and Silvics section of the 1917 Forest Terminology was compiled by a four- or five-person committee and is still remarkably relevant. It includes this early definition of silviculture: "The art of producing and tending a forest; the application of the knowledge of silvics in the treatment of a forest." At about the same time, Toumey (1916, 10) in his textbook, *Seeding and Planting*, offered this definition: "Silviculture is a branch of forestry that deals with the establishment, development, and reproduction of forests. It is an art which depends for its intelligent practice upon the principles of silvics." This definition was repeated in slightly modified form in Toumey's (1928) *Foundations of Silviculture*, where silviculture is divided into its foundations, the scientific basis, and the practice of silviculture, which is the application of the scientific basis. This is a foreshadowing of the "art and science" that follows in later definitions. There was an early recognition that good forest reproduction and tending had more than one approach, was not a cookbook, and was not simply an exercise in value optimization.

However, the practice of silviculture would be evaluated through the lens of dominant societal values during the early twentieth century (Ashton and Kelty, 2018, but see Menominee Tribal Enterprises 2023 at https://www.mtewood.com/SustainableForestry). For example, Hawley's (1946, 14) statement that "the practice of silviculture for the production of wood crops is pointless unless these crops are harvested and utilized," hints at the attempts by silviculturists to use emerging industrialized agricultural methods that focused on the "production of wood," which were largely to justify returns on investment. This focus on a "command and control" approach favored artificial regeneration and heavily managed plantations. Although heavily managed plantations are an important tool (e.g., the TRIAD approach [Himes et al. 2022]), plantations fail to capture the full range of stand development and objectives that are part of managed forest systems. Additionally, the commodity driven lens has continued to receive criticism from both silviculturists (e.g., Puettman et al. 2012) and ecologists (e.g., Huettmann and Young 2022) for more than 100 years. Across spatial and temporal scales, economics has been the dominant objective. However, is this assumption, that silviculture has had primarily a singular, economic goal, realistic? Although this may have been a dominant viewpoint, and one that has had a lasting impact, silviculture and maximizing economic returns are not synonymous. Rather, the rich history of silvicultural practices across North America present a more nuanced, complex view that captures a fuller range of goals and objectives (e.g., noncommercial thinning for fuels reduction in the western United States (Keyes and O'Hara 2002), treatments to meet restoration objectives in the Southwest (Moore et al. 1999), and an expansion of the number of seats at the planning and management table to ensure all voices are heard (Cheng et al. 2019)

A boom in construction following World War II drove sharply increased demand for timber, particularly on the national forests (Smith 1972). This resulting change in forest management has been characterized as a shift from essentially custodial to largely production management (Seymour 2004). Not surprisingly, these fundamental changes in management were associated with changes in silvicultural systems. Uneven-aged systems were often replaced by even-aged systems, particularly clearcutting. The considerable pushback accompanying these changes were exemplified by the Monongahela and Bitterroot controversies (Fairfax and Achterman 1977). The National Forest Management Act (NFMA), passed in 1976, was in large part a response to these controversies. It required the USDA Forest Service to emphasize both interdisciplinary management and public involvement in management decision-making. On one hand, environmental regulations of the 1970s like NFMA represented a shift in resource management objectives, but they were also a direct reaction to the way silviculture was being practiced in the postwar era (Smith 1972).

Indeed, statements of the primary importance of fiber utilization can be found throughout the silviculture literature and can have, and have had, lasting impacts on the perception of

silviculture. For example, the Johnston (1977, 1) Managers Handbook for Black Spruce notes the "overall objective in managing black spruce type should be to produce a high sustained yield of pulpwood and other forest values as efficiently as possible." Statements like this, from opinion-leaders, can strongly influence how silviculture is perceived and practiced. Indeed, the type of silviculture one practices is strongly informed by formal education and mentoring (more on this below), and if a forester first learns silviculture at 20 years old and then practices that same silviculture for 40 years, the legacy built through time reflects a lack of evolution in practice that fails to reflect the discipline of silviculture as a whole.

There has been an intimate relationship between silviculture practitioners and researchers that has influenced our evolving definition. The research and science of silviculture in the United States has coexisted with the practice nearly since the advent of the Forest Service, which early on was structured such that the Research and Development branch conducted research on experimental forests that subsequently informed management on National Forest System lands (Seymour et al. 2006). The early recognition that a built-in check on the systems of management was important in the face of how society values forests resulted in the establishment of a system of experimental forests (Schmaltz 1980). A similar "partnership" exists between academic silviculturists and land managers to conduct research to improve management of forests (private, state, federal, tribal), in addition to training future foresters. Early in the twentieth century, silvicultural research was responsive to the need for regeneration or maintenance of degraded forest ecosystems. By the mid-century, research was focused strongly on production, in response to the post–World War II building boom. Later silvicultural research helped cement ideas surrounding natural disturbance–based approaches to silviculture and new forestry (e.g., Franklin et al. 2007; Long 2009).

The current standard definition of silviculture (Deal 2018, 167) emphasizes both art and science and also makes it clear that silviculture is used to meet a diversity of objectives: "The art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the diverse needs and values of landowners and society on a sustainable basis." Changes to this definition have been proposed as our understanding of silviculture continues to evolve (e.g., Achim et al. 2022). Silviculturists are tasked with interpreting and applying science in anticipation of change—in a way that is more difficult than it ever has been. Numerous authors, including those of the 1986 *Journal of Forestry* series on the future of silviculture, Oliver (1986) and Smith (1994), and, more recently, D'Amato et al. (2017) and Jain (2019), also make this claim. One primary theme that emerges from all of these articles is that silviculturists will always be tasked with being more dynamic, both in response to rapidly changing science and societal goals, knowing that these will change more quickly than the forests that are being managed. Rapidly changing forest conditions due to factors including climate change and invasive species will require an additional level of dynamic response by silviculturists as forests may change just as rapidly as science and society.

Dynamics of Silvicultural Objectives

Since the beginning of silviculture in North America, the basic elements of silvicultural practice have not changed; however, the mixing and matching of those elements has evolved as silviculturists respond to dramatically changing resource management objectives, and these fundamental changes are evident today. Diverse objectives and resource values have been the driving force behind silvicultural practice in the United States since its inception. Simplifying the rich silvicultural history as a dichotomy between timber production and multiple uses, as is often done in the literature (e.g., Smith and DeBala 1978), ignores the decades-long history of multiple-use management in many areas of the country (e.g., Intermountain West, Great Lakes region, Northeast, etc.). Aesthetics, wildlife habitat, restoration, resistance and resilience to natural disturbances, and fuels reduction are all examples of management objectives with which silviculturists are dealing (e.g., Himes et al. 2022).

Wildlife habitat management is often a central goal of management, especially on public land, but not uncommonly on private land (e.g., hunting, habitat, etc.). Sometimes the focus is on maintaining or protecting habitat for species on threatened, endangered, or species of concern lists (e.g., the Mexican spotted owl in the Southwest, [Fiedler and Cully 1995]); additionally, there is a rich history of forest management to increase populations of game species (e.g., ruffed grouse and aspen age class diversity in the Great Lakes Region [Zimmerman et al. 2007]). For example, private landowners may enter into a safe harbor agreement for protection of an endangered species (e.g., red-cockaded woodpecker). A safe harbor agreement is a voluntary agreement involving private or other nonfederal property owners whose actions contribute to the recovery of species listed as endangered or threatened under the Endangered Species Act. And while wildlife biologists are of course critically involved with planning and decision-making, it is the silviculturists who are tasked with designing prescriptions that create the necessary vegetation structure and composition in response to the needs of the species that use the forest (Lilieholm et al. 1994, Shaw and Long 2007, Smith and Long 1987).

In many landscapes, particularly in the western United States, a central goal has become the creation and maintenance of resistance and resilience to a variety of environmental challenges such as fire, bark beetle outbreaks, and invasive species introductions and spread (Crouch et al. 2021). Although many of these disturbances are not novel, some are increasing in frequency and/or severity. Climate change–induced changes in wildfire (Parks and Abatzoglou 2020) and drought-related mortality, recently exacerbated by bark beetle outbreaks (Raffa et al. 2008), have affected millions of hectares of forest land in the West, in particular, public lands where implementation of silvicultural treatment is often thwarted by legislative gridlock. Accomplishing goals in the face of these disturbances requires an understanding of the mutual influences of stand and landscape structure and composition on resistance and resilience (DeRose and Long 2014) and/or realignment (Millar et al. 2007). The use of prescribed or cultural fire to reduce the risk of wildfire is hotly debated as a treatment for resilience in the dry West, and the role of silvicultural in landscape planning in the context of fire reduction is a key challenge to the profession moving forward (Maguire et al. 2015). These changing disturbance regimes are part of larger uncertainty about the biophysical context for management and forest sustainability in the face of climate change. Unknowns about species distributions, changing resource dynamics, and changing disturbance regimes have created a setting of excessive zeal surrounding

the potential uncertainty associated with practicing silviculture (e.g., Seastedt et al. 2008) but have also led to new collaborations to develop silvicultural alternatives (Nagel et al. 2017).

Another driver of changing objectives is the diversity of interested parties increasingly involved in helping define resource goals (Cowan et al. 2022). This can result in conflicting, even mutually exclusive, goals. Indeed, the current amount of political discord is likely to slow the pace of silvicultural treatment in the western United States, where forest land is primarily under public ownership. Despite this, there is an increase in collaboration among resource disciplines, stakeholder groups, including those with treaty rights, and landowners (e.g., Cyphers and Schultz 2019) that reflects the huge range of societal goals that need to be considered under the broad scope of silvicultural practice. The Forest Service has been navigating and adapting to the complex legal and policy frameworks associated with the National Environmental Policy Act, the Multiple Use and Sustained Yield Act, and the National Forest Management Act for ~50 years now. For example, the Superior National Forest is likely to become the first in the nation to approve assisted migration of tree species—done in consultation with tribal nations—as part of their management plan (Freker et al. 2022).

Although the objectives of industrial private landowners have historically emphasized maximizing timber production and economic return, many of these companies are becoming certified by third-party accrediting bodies such as the Sustainable Forestry Initiative, which set standards of sustainability and focus on minimizing site degradation (Sustainable Forestry Initiative, 2022). Many states also have best management practices to minimize site degradation and protect aquatic systems (e.g., Barkley et al. 2015). These rules, along with state and local regulations, can help lead to more diversified management, including on private land where silviculturists will become increasingly required to balance objectives of revenue flows from traditional timber production with protection or maintenance of ecosystem services, including carbon sequestration, and nontimber economic goals, including land value for development (e.g., real estate investment trusts and timber investment management organizations). Nonindustrial private forest landowners also have opportunities to become involved in nontimber silviculture, such as for wildlife habitat or carbon storage management, through opportunities with state agencies or nonprofit organizations. For example, the Family Forest Carbon Program (n.d.), a collaborative effort between The Nature Conservancy and the American Forest Foundation, enables small forest landowners to access carbon markets while managing forest health and carbon storage.

Finally, concurrent with these changes in objectives, there have been extraordinary advances in the technical tools available to silviculturists (Achim et al. 2022, 145; D'Amato et al. 2017). For example, in the last three decades, geographical information systems, centralized database repositories, and more recently, LiDAR, have become routinely used by silviculturists. Although these technological advancements have improved the way we monitor and analyze forest systems in real time, they have done little to improve our understanding of societal values and goals. In large part because of these technical advances, it has been argued that the discipline of silviculture is progressing "from an art and science to an advanced scientific discipline" (Achim et al. 2022, 149). Their proposed definition is: "Silviculture is the science of observing forest conditions and anticipating its development to apply tending and regeneration treatments adapted to a multiplicity of desired outcomes in rapidly changing realities." Is it true that in 100 years, silviculture has morphed from an art to an art and science to strictly a science?

Development of Silviculture Education

Becoming a silviculturist is a lengthy process. Smith (1994, 21) outlined some of the basic requirements of being a silviculturist as including "(1) a thorough understanding of ecological concepts and principles across a range of ecosystems; (2) a comprehensive knowledge of the silvical characteristics of all tree species encountered; (3) a mastery of the research that deals with tree and forest responses to disturbance; (4) a history of lengthy discussions and dialogues about silvicultural issues and forest stand dynamics with colleagues and clients from many places; (5) a thorough understanding of the potential values and uses that are, or may be, available within the forest systems in question; and (6) a full awareness of the economic, social, and political implications and constraints that are in force at a particular place and time." Although becoming a silviculturist requires a basic education in ecology, science, and resource management, it also requires substantial nonscientific understanding. Being mentored, mentoring, understanding social values, and understanding the huge variability in successes and failures of application across a wide range of forest types and sites are all components that must come from experience.

Education and mentoring began early in forestry. In the early twentieth century, as forestry curricula were becoming more formalized, "technically" trained foresters began entering the workforce under the mentorship of nontechnically trained staff (Toumey 1915). Toumey predicted at the time that the influx of technically trained foresters would usurp nontechnical management, which it fortunately did, for the benefit of the profession and the forest! Still, the mentoring provided during this critical transition from workers educated in the field to incoming professionals with technical knowledge occurred at a critical time during the formation of the national forests and state forest lands that led to the current structure, with educated foresters managing the lands using critical thinking and knowledge of the best available science. The ongoing focus on accredited forestry education programs and the US Office of Personnel Management guidelines helps ensure that future foresters continue to evolve.

The practice of mentoring across generations of silviculturists was, and is, a feature of this profession, whether in research, science and academia, or practice. The intricacy of dealing with variable constraints has been historically navigated in silviculture largely through mentoring. For example, the annual SAF Silviculture Instructors Tour is a way for fellow academic silviculturists and their students to meet and learn about regional silviculture (Silviculture Instructors n.d.). The certification process for silviculturists in the Forest Service requires years of mentoring and interaction with other resource managers, including outside their immediate forest, as part of the process. With mentoring comes the ability to continue to be open to different thoughts and perspectives, necessary to a profession where there is no one right answer. This openness is critical to help silviculturists avoid dogma (we have always done it that way, we "know" the system), not

giving another discipline credit, a newly graduated forester ignoring advice from someone with experience, or, vice versa, not giving someone credit due to perceived lack of experience.

Given the complexity of the profession and the time commitments to becoming a silviculturist (Smith 1994), it is not surprising that silviculturists are tasked with both extra continuing education and lifelong learning to do their job. For example, silviculturists with the Forest Service are required to become Certified Silviculturists to write and implement prescriptions and then maintain their certification through continuing education; the National Advanced Silviculture Program serves as continuing education for those seeking to obtain or maintain their certification. The value of such programs has outsized importance in moving the discipline forward. In addition to continuing education, it encourages discourse among managers, a look at current research and critical evaluation of current practices, and open dialogue among practicing professionals (Gwaze et al. 2020). Although not all are open to change, there is certainly more change among those that engage in continuing education than those who do not.

The Future of Silviculture

Before we speculate about the future of silviculture, let us review what being a silviculturist means: that you engage in the creative endeavor (i.e., the art) of balancing activities that are based in science, especially ecology, but that include a whole host of other skills (Assmann 1970). Silviculture is organic and dynamic, but it is not a deterministic science like physics, and silviculturists are not engineers. Silviculturists are required to balance multiple resource objectives, unlike intensive agriculture (Ashton and Kelty 2018). Unlike engineers, silviculturists do not have complete control over the systems with which they are working. Silviculturists can, however, shift forest stands and landscapes in the direction necessary to meet management goals and objectives, but this requires much more than science and technology to achieve. The silviculturist also understands and practices their very important role as the honest broker between other resource professionals and society at large in the application of management on the ground. The silvicultural prescription necessarily involves balancing the intricacies of stand dynamics with management goals, including the inherent understanding that it will be impossible to achieve all goals at the same time, in the same stand, and on the same site. Silviculturists must be humble, curious, and observant in assessing forest ecosystems; not all aspects of a forest ecosystem can be documented or quantified and we cannot predict the future nor anticipate all the variability in systems or their responses to treatment. Thus, a silviculturist must take on the additional responsibility of

Box 1 Tablet Marking in Silviculture

Tablet marking has been embraced as part of the USDA Forest Service's Four Forests Restoration Initiative (figure 1). This innovative tool was developed in part in response to the goal of increasing the pace and scale of forest restoration efforts across four adjacent forests in Arizona. Tablet marking (the creation of a digital prescription guide) incorporates several recent advances in technology, including powerful cloud-based mapping software, compact high-accuracy Bluetooth-enabled GPS receivers, and various highly detailed mapping products derived from aerial LiDAR surveys, to allow forest practitioners to digitally "mark" individuals and groups of trees in lieu of traditional leave tree paint marking (figure 1A). In doing so, tablet marking dramatically enhances the rate at which practitioners move through a stand making decisions about which trees to leave and cut, and it also changes the way those decisions are communicated to a logger (e.g., via points or polygons on a tablet screen rather than painted bands on trees, figure 1B, D). However, even with this technological advancement, creativity is still a requirement for successful implementation—including making decisions about where it may or may not be appropriate. Factors weighing into these decisions include understanding the level of precision required to adequately meet silvicultural objectives for a particular stand and acknowledging that there is a tradeoff between "getting it perfect" on a few acres and "getting it close enough" on a lot of acres (figure 1C), particularly when wildfire mitigation and avoiding total loss of forest cover are primary objectives.

Box 2 Breeding Habitat for Neotropical Migrants using Silviculture

Neotropical migratory birds breed in the United States and Canada and then winter in Mexico, the Caribbean, and Central and South America. The majority are songbirds, such as warblers, and many are species of conservation concern. The most common reasons for population declines are loss of suitable summer and winter habitat (e.g., La Sorte et al. 2017). Collaboration between wildlife biologists and silviculturists in active forest management can successfully create and maintain breeding habitat for these species (Corace et al. 2009). Kirtland's warbler is a neotropical migrant that nests in upper Michigan. Its recent delisting is an example of highly successful conservation management (Federal Register 2018). This was done by promoting young jack pine (*Pinus banksiana*) forests and active management of brood parasitism by the brown-headed cowbird (*Molothrus ater*) across the landscape. Still, Kirtland's warbler is a conservation-reliant species where lack of continued effort to create habitat and minimize brood parasitism could lead to population declines in the future (Corace et al. 2009).

Active forest management provides opportunities for creating and maintaining elements of forest structural characteristic and disturbance regimes that can provide critical summer habitat for many migratory bird species. For example, in Appalachian mature oak-dominated forests, retaining 40–90 ft^2/ac of basal area in 25 ac harvest units creates breeding habitat for Cerulean warblers (*Setophaga cerulea*, Wood et al. 2013). Golden-winged warblers (*Vermivora chrysoptera*) depend on early successional patches in a larger matrix of mature forest (Bakermans et al. 2011). Because forest structures are ephemeral, maintenance of breeding habitat for both warblers requires active management across the mature forest landscape. Sustainable silviculture is not only compatible with but is necessary for meeting goals for the creation and maintenance of breeding habitat for a number of neotropical migrants (Bakermans et al. 2011). These two examples from different regions within the United States provide an opportunity to highlight collaborative management which has been observed for other species and other regions (e.g., McComb 2007).

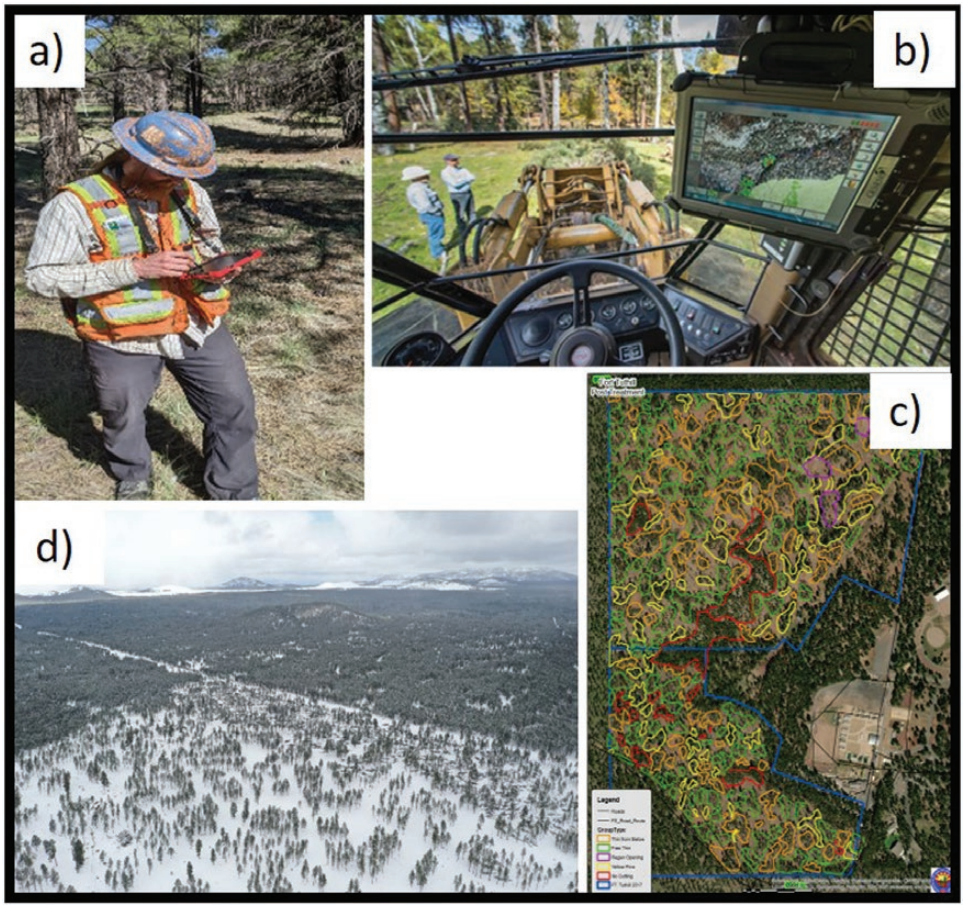

Figure 1 (A) Tablet marking performed by Coconino National Forest timber marker Daniel Conley (photo credit: Mark Nabel). (B) Tablet mounted in the cab of a feller buncher to facilitate logging operations (photo credit: Neil Chapman). (C) Digital prescription guide created during tablet marking (photo credit: Mark Brehl). (D) Highly variable residual stand conditions created through tablet marking (photo credit: Roses Lockwood).

bringing together knowledge and experiences from other disciplines, resources, tribal nationals, and society at large in the application of management on the ground.

Looking forward, it will continue to be difficult to practice silviculture. Silviculture requires life-long learning and mentorship, and continual learning is part of the profession. Although silviculture is science-based, its implementation comes without the constraints associated with the scientific process, which will arguably not keep pace with rapid forest change. In this way, our understanding of site and stand history, silvics, autecology, forest ecology, and disturbance ecology still represents the best available science when developing prescriptions. Yes, these factors may be changing with climate change; however, this only highlights the importance of mentoring, continuing education, and creativity in contemporary silviculture. We should not lose sight of the very important relationships that we develop over our careers while mentoring and being mentored; it is the openness that both can happen (mentoring and being mentored) during conversations, meetings, and emails that can allow our disciplines to span boundaries. Despite our desire to search for simple solutions, correct answers, or least-cost-based solutions to silvicultural questions, we need to be careful, and "we must reject formulaic approaches to our profession because forests represent a broad portfolio of ecosystem services from which to choose" (Don Bragg in Jain 2019, 423). Being able to successfully navigate relationships with colleagues and stakeholders may well be one of the most challenging and critical components of being a successful silviculturist. The ability to respond to changing objectives has been and will continue to be an important part of what it means to be a silviculturist. Silviculturists will also need to bravely embrace uncertainty, potentially by accepting a range of desirable conditions, openly sharing failures, and adapting prescriptions frequently.

Not surprisingly, it will continue to be the responsibility of the silviculturist to interpret the science and provide alternatives for meeting goals associated with forest management: "The silvicultural systems of today are generally more complex than anticipated 30 years ago. The technology of plantation forestry has advanced, and the range of structures for management on many other lands has greatly expanded to include numerous variations on mixed-species or multi-aged stands. As a result, the demands for silviculture and the demands on silviculturists have never been greater" (D'Amato et al. 2017, 63). To meet these demands, the silviculturist must, of course, have a mastery of the foundational science and emerging technology associated with silviculture. Silviculturists are also required to have a deeper understanding of basic forest sciences for insight into the likely effects of management on future stand trajectories. Although the science needs to be understood and interpreted, it is changing rapidly, may be hard to follow in practice, and will sometimes even change by the time a practitioner has crafted their

prescription! However, it is equally important that silviculturists are mindful of the art in the application of silviculture. Palik et al. (2020, 29) observed that "silviculture as a discipline has always called for the **artful** application of … classical tools to meet new objectives and adapt to new ecological and economic conditions." We argue that, particularly in the context of increasingly complex conditions, including changing climate and objectives, silviculturists must be especially creative when conceptualizing and applying innovative silvicultural systems and approaches (Box 1 and Box 2).

As silviculture evolves, the word art might be better understood as leniency in creativity, the opposite of a cookbook approach to management. Future silviculturists will take their understanding of natural processes, species silvics, and stand development and then prescribe not one but a suite of possible actions consistent with anticipated forest development. The silviculturist must be humble in the face of complex forest ecosystems while attempting to achieve a set of dynamic objectives and conditions and visualizing (simulate) a range of alternative futures based on the proposed actions. For example, long-term climatic patterns, localized weather events, and individual microsites all influence forest ecosystems across multiple scales; as other biotic and abiotic (wildfire, wildlife, fungi, insects, site), economic (income), and social (perceptions, goals, objectives) considerations are overlaid, the ability to quantify and identify interactions will be daunting.

In conclusion, being a silviculturist means being engaged in the art of balancing activities that are based in science but that include a whole host of other skills. Technology cannot supplant the expertise of the silviculturist but rather should complement it, by offering additional tools for the silviculturist to consider when developing management options. And for this reason, balancing art and science will always be at the center of the silviculturist's universe. Striking the balance of understanding between scientific interpretation of changing ecosystems in the context of changing societal goals, and anticipating the changing future is not something that can be optimized in any technical way. As such, the silviculturist remains the honest broker in the linkages between planning and execution. That means evaluating the possible outcomes in light of the science and the application and informing the other disciplines and society whether the chosen approach is likely to steer us closer to the desired objectives or not (hint: oftentimes it is not possible). Regardless, silviculturists do not have a crystal ball to identify all the potential events over decades or centuries. The shifting conception of what a silviculturist must consider while planning includes the undercurrent of constantly changing forest management goals and the rapidly changing environment in response to climate change. Both of these are changing much faster than the typical lifespan of the species that are being managed. If the previous literature of "changing silviculture" over the past 30–40 years is any indication, silviculturists of the future will live out the tired trope that "they will be tasked to do more than they ever have before" except that it will again be true. Fortunately, as Kabrick and Pile (in Jain 2019) observed, most silviculturists view these as intriguing challenges and embrace the opportunity to be active stewards in the forests of tomorrow. Silviculture prescriptions have been and will continue to be objectives-based and sustainable, and art will continue to play a prominent role in the future of silviculture

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