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silviculture

The Stand: Revisiting a Central Concept in Forestry

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The stand concept is in question because of a trend toward more complex structures and broad-scale management of many forests. The stand was traditionally a uniform operational unit designed to make management efficient. Stand-level objectives on some ownerships have recently shifted toward increasing within-stand variability through the use of various treatments including multiaged systems, variable retention regeneration methods, or variable-density thinning. The result may be greater heterogeneity within rather than between stands, thus leading to this discussion of the relevance of the stand concept in contemporary forestry. We recognize stands as being the logical operational unit for forestry, but with the flexibility to change in boundary over time due to stand dynamics, through management intent, or to include a variety of different stand structures. As a result, stands may be managed to enhance within-stand variability. A new terminology is not needed nor do stands need to be endlessly split into smaller and smaller units as management creates more and more stand variability. The stand remains the logical operational unit of ecosystem-based forestry on a variety of land ownerships, within the context of multiple scale management.

Keywords: silviculture, ecosystem management, landscape delineation, forest management, forest regulation

"The stand" is a foundational concept in forestry. Forest management typically operates at the spatial scale of the stand, a concept that has been a cornerstone to how silvicultural prescriptions are conceived, written, and implemented. Indeed, all of forestry has a stand-level underpinning. Since the profession developed in the United States, forestry has experienced a variety of paradigm shifts (see O'Hara et al. 1994, Seymour 2004, Puettmann et al. 2009), with concepts such as ecosystem management and ecological forestry shifting the way natural resource professionals think about ecosystem function, landowner objectives, and development of management strategies for forested ecosystems. Terminology in forest management, particularly in the realm of silviculture, is often confusing and inconsistently used. In this article, we review the concept of the stand, trace some of its historical and current usage, and discuss whether the stand remains the appropriate spatial unit for multiobjective forest planning and implementation.

Definitions

The Society of American Foresters (SAF) *Dictionary of Forestry* (Helms 1998) provides three definitions for *stand,* one each for ecology, silviculture, and wildlife: *ecology*—a contiguous group of similar plants; *silviculture*—a contiguous group of trees sufficiently uniform in age-class distribution, composition, and structure and growing on a site of sufficiently uniform quality, to be a distinguishable unit; and *wildlife*—a place from which game is shot (at) and past which game is generally driven. The term *forest* also has multiple meanings (Helms 1998): an ecosystem characterized by a more or less dense and extensive tree cover, often consisting of stands varying in characteristics such as species composition, structure, age class, and associated processes and commonly including meadows, streams, fish, and wildlife. Smith et al. (1997) defined a forest within the specific context of forest management: a collection of stands administered as an integrated unit, usually under one ownership (see also Helms 2002). Another related term is *patch* which is defined as both a small part of a stand or forest and an ecosystem element, e.g., an area of vegetation, that is relatively homogeneous internally and differs from surrounding elements (Helms 1998). A patch is therefore either a subunit of a stand or possibly a synonymous term.

Two other spatial terms germane to this discussion are *ecosystem* and *landscape,* each defined by SAF (Helms 1998): ecosystem—a spatially explicit, relatively homogeneous unit of the earth that includes all interacting organisms and components of the abiotic environment within its boundaries; and landscape—a spatial mosaic of several ecosystems, landforms, and plant communities across a defined area irrespective of ownership or other artificial boundaries and repeated in similar form throughout. The concept of landscape often holds aesthetic or

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Figure 1. Picture of a recently clearcut stand in western Washington. This stand was burned after harvest and awaits planting.

sentimental value (see Andrews 1999), and there are myriad other definitions; we have chosen to focus on definitions provided by Helms (1998) in the specific context of silviculture/forestry.

Stand Concepts

The stand concept served forestry well when even-aged systems were promoted to enhance uniformity and encourage sustained growth and yield, thereby maintaining consistent stand boundaries for efficiency (Figure 1). Spatially explicit boundaries made pragmatic sense for inventory and analysis, forest planning, and modeling projections of stand growth and development. Stands were the building blocks of sustainable, regulated forests. This system was most elegant and predictable when simple stand structures were arrayed in equal numbers across the forest. These approaches also tended to create forest- or landscape-level variability, thereby potentially satisfying multiple objectives at a variety of spatial scales. However, as Puettmann et al. (2009, p. 19) noted, the evolution of the stand concept emerged out of very practical reasons and not necessarily because it was ecologically based.

There is an ecological basis for stands in that disturbances may form discrete stand structures or a uniform group of contiguous trees. These areas would be variable in size and in some cases disturbances may have affected very large areas (Seymour et al. 2002). In other cases, disturbances may occur at the gap level, increasing within-stand heterogeneity (Franklin et al. 2002). Disturbances may also overlap, spatially creating diverse spatial patterns at fine or broad scales (Figure 2). The formation of stands in forest management has not attempted to emulate the highly variable spatial pattern or extent of disturbances. Instead, management seemingly promoted stands by first delineating them and then implementing treatments that lead to further distinguishing that stand from surrounding stands. These stands were either homogeneous structures or a uniform stand with a heterogeneous structure. The result is that, historically, we have often fragmented forests at large scales and homogenized them at small scales.

An ecological versus operational dichotomy now exists in how stands are defined. The *ecological stand* is a unit resulting from stochastic events such as disturbances or the lack of disturbances and may be further defined by climatic, edaphic, or geomorphologic qualities of a given site. The *operational stand* is a unit designed to achieve or help achieve some objective through management treatments or to make management more efficient such as with a viable size for timber harvesting efficiency. The primary motivation for the operational stand has been to achieve management efficiency. Either type of stand may be the appropriate unit for silvicultural practice. An additional constraint exists in the form of forest practice regulations that limit stand size. For example, USDA Forest Service policy after the 1976 National Forest Management Act limits clearcut stands to 16–32 ha (40–80 acres) and the California Forest Practice Rules generally limit clearcut size to 8–12 ha.

The forested landscape has been segmented into three categories: production forests, multiple-benefit forests, and preservation forests (Salwasser 1990, Seymour and Hunter 1992). The stand concept has limited utility on preservation forests where stands can be defined but where they are rarely managed. For production forests, stands are integral building blocks to regulated forests. However, emerging concepts related to managing forest landscapes encourage an evaluation of the utility of the stand-level unit on multiple-benefit forests that include public lands and other lands where timber production is not the primary objective. On these multiple-benefit forests there are often both ecological and operational issues that guide stand delineation.

The aim of many contemporary approaches to forest management is to enhance variability at the stand level, thus reducing variability at larger scales. There are several objectives and motivations for increasing stand-level variability or complexity, including creating stands that meet a variety of habitat requirements, restoring critical ecological processes or promoting stands that may be more resistant and resilient in an uncertain future climate, just to name a few.

Management and Policy Implications

One of the outcomes of recent paradigm shifts in forestry is the movement to enhance within-stand structural variation on many ownerships. Stands are deliberately managed to have a variety of different structures or highly complex structures so that within-stand variation may exceed between-stand variation. As a result, there is a tendency to subdivide stands into smaller units to maintain within-stand homogeneity. There may also be a tendency to rename stands or sections of stands to accommodate these new directions in forest management. We believe the stand is still the logical operational unit in today's forestry. Managing to enhance within-stand variation can still fit within the stand concept as forestry moves toward meeting expanding land management objectives.

Figure 2. Picture of the heterogeneous landscape in the Black Hills of South Dakota. Landscape shows areas of mountain pine beetle (*Dendroctonus ponderosae*) mortality, different forest types, various landforms, and a variety of stands.

Evolving Forest Land Management and the Stand

The Evolving Stand

In an operational sense, the stand is generally regarded as a semipermanent feature on the landscape that moves through rotations or cutting cycles as a distinguishable unit. This is a traditional and central concept to both silviculture and forest management, in which the boundaries of managed stands and therefore the compartments of regulated forests remain constant over time. In reality, stands shift due to changing management objectives or because of disturbances. Stands are also more dynamic than is probably recognized. Oliver and Larson's seminal book *Forest Stand Dynamics* (1990) described various ways that stands change as they develop. Many of these processes affect the uniformity that defines the stand. For example, differences in density, species composition, or site quality can lead to distinct variations in stand structure within a single stand. Oliver and Larson (1990, Chapter 14) also described how stand boundaries change over time as adjoining stands influence each other and create ecotones of unique conditions that lead to unique stand structures. Hence, within-stand variation can lead to separation of stands into substands, and stand edges may meander or simply change into different structures.

Much of this evolution in defining stand boundaries relates to our tolerance for what is "uniform" and "distinguishable" in separating stands, which, in turn, depends on our objectives: Do we delineate stands because of operational efficiencies or because of ecological characteristics? Ideally, basic stand delineations should probably correspond to broad ecological features whether they are stand features, geologic features, water courses, or others. However, political constraints such as property boundaries, road networks, or forest practice regulations will generally override ecological features. Other management objectives serve to refine boundaries by making stands efficient for intended management. A division between two stands may be artificial in any ecological sense but may create a lasting boundary that, in turn, becomes an ecological boundary. There is probably little disagreement in terms of the geologic or political boundaries that define stands. Our tolerance is largely determined by the operational constraints that might delineate two stands based on management efficiencies related to treatments or production. These delineations may therefore be different from one management organization to another. For example, an organization might split a stand into two because of a site quality gradation that increases wood production in one area, whereas another organization might focus on wildlife habitat and leave the original stand intact because they do not view the site gradation as an important factor. Hence two organizations may delineate different suites of stands on a landscape and may value the importance of ecological features in different ways. Their tolerance will be different and may change with time.

Alternative Management Approaches

Many current silvicultural approaches are providing new twists on the stand concept. On some ownerships, forms of *multiaged* silviculture are being implemented, which can create similar stands over large areas (O'Hara 1998). Multiaged treatments range from those that create larger group openings to those that remove individual trees, leaving only small gaps; their commonality is retention of two or more age classes (Helms 1998). In all cases, the operational effect is to subdivide the stand in different ways at each cutting cycle. In adjacent stands under the same management regime, the only difference may be the timing of cutting cycles. When practiced over large areas, stands become indistinguishable structures, and the stand concept only serves as an inventory and operational unit, but not a meaningful ecological unit. Forms of multiaged silviculture have, of course, been practiced for centuries, and their effects on stands and stand structures are not new. We might question whether the ecological or operational criteria for delineating stands are important in this multiaged landscape context or perhaps the stand may become an obsolete unit with little operational or ecological significance in these situations.

Other emerging treatments that encourage a reexamination of the stand concept are variable retention harvests and variable-density thinning. Both purposely attempt to increase stand heterogeneity, thereby taking a management unit defined for uniformity and directing it toward irregular structures and patterns. Variable retention is a regeneration method that leaves residual structure, either in aggregated or dispersed patterns, that improves esthetics, provides wildlife habitat, or provides water course protection (Mitchell and Beese 2002, Beese et al. 2003). Retention trees are presumably left through the entire next rotation therefore providing a structural element not

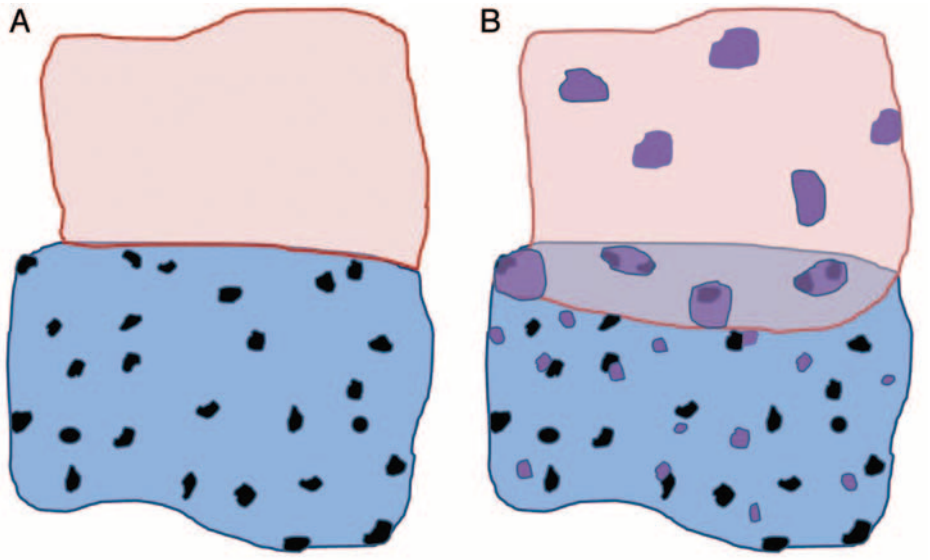

Figure 3. (A) Diagram of two stands with a single-tree selection in lower stand. (B) Diagram shows a later depiction with the upper stand managed with group selection and the lower with single-tree selection. The upper stand has been expanded to encompass part of lower stand and expanded small gaps.

present in conventional clearcutting. Variable retention is often viewed as a means to ameliorate some of the effects of clearcutting (Kohm and Franklin 1997, Aubry et al. 1999, Mitchell and Beese 2002).

Whereas variable retention harvests are an alternative to clearcutting that leaves residual stand structure, variable-density thinning is simply a means to enhance stand structural variability. These two treatments differ in intent. Variable retention harvests intend to secure a new age class, whereas variable retention thinning is generally an intermediate treatment in which a new age class is not an objective. Variable-density thinning deliberately thins a stand to different densities, including potentially leaving some areas unthinned (Carey 2003, O'Hara et al. 2012). Variable-density thinning is often applied in young stands and is commonly viewed as a restoration treatment that enhances wildlife habitat in the developing stand or sends the stand on a trajectory toward a desired structure. However, the primary intent of variable-density thinning is to increase, if not maximize, within-stand heterogeneity. The stand where variable-density thinning is implemented is a collection of areas of stand structural diversity. These areas may occupy any of Oliver's (1981) stand development stages as they develop posttreatment.

In what is perhaps the most fundamental change in the way stands are viewed and managed, variable retention harvests and variable-density thinning question the traditional stand concept. Rather than trying to maintain stand autonomy through management, these treatments attempt to eliminate the uniformity that defines stands and to blur stand boundaries. Stands that experience variable disturbances spatially or temporally, whether natural or as deliberate management, may therefore be in multiple stages of stand development at a given point in time. Multiaged treatments do largely the same thing. For example, stand boundaries may not need to be constant in many forests such as multiaged forests managed with a group selection system where treatments are concentrated in a revolving series of small gaps (Figure 3). The groups form the operational units, and, in any given year, groups from many different stands could be treated or perhaps the group is really functioning as a stand in these cases. In forests managed with single-tree selection where a broader homogeneous structure is the goal, the stand may be of little ecological importance other than to organize operational areas managed on simple cutting cycles. Over landscapes of stands managed with multiaged treatments, there may be little if any distinction of individual stands. Instead, landscapes will be homogeneous units where some stands resemble others, but heterogeneity occurs at various scales, particularly within stands. The regulated forest may produce even flows of ecosystem services or affect similar amounts of forest over time, but the view from afar may discern few treatments or stands.

Landscape-Level Perspectives

Stands are not only the building blocks of regulated forests but also the amorphous, dynamic puzzle pieces for building functioning landscapes. The classic regulated forest is a collection of stands formed for a sustained yield forest of similarly managed units. The natural landscape is a collection of stands formed by natural disturbances interacting with site factors and driven by stand- and landscape-level dynamics. This natural landscape would have stands in various sizes and in different stages of development. Whereas the regulated forest might ideally have equal-sized stands uniformly spread across the forest within a desired range of stand development, the natural landscape would have stands in different sizes, in seemingly haphazard patterns across an assortment of structural stages. To manage the natural landscape we need to know about these patterns and how our artificial landscape patterns might affect the multiple objectives we are trying to meet. However, for either regulated forests or natural landscapes, stands are the operational unit.

Highly artificial landscapes are sometimes created through single-species habitat management, resulting in complex management dilemmas at various spatial scales. These often test the limits of the stand concept. The extensive plantation-style approach to managing jack pine (*Pinus banksiana*) specifically to create habitat for the federally endangered Kirtland's warbler (*Dendroica kirtlandii*) in the northern Great Lakes is an example. Pine barren habitat was historically maintained through large, stand-replacing fires that created dense jack pine-dominated mosaics containing scattered small openings. Kirtland's warbler requires small stature, young, dense, and relatively large-scale "stands" of jack pine within a dynamic and shifting landscape. These specific habitat requirements have driven management in northern lower Michigan, creating large, simplistic, and homogeneous forested structures that are not necessarily compatible with other management objectives and exceed the typical stand size. Other examples of large landscape-scale habitat requirements include the home range of Canada lynx (*Lynx canadensis*) consisting of 1,700–20,000 ha of mosaic young- and old-forest conditions in mixed and coniferous forest with continuous horizontal cover for

their prey, the snowshoe hare (*Lepus americanus*) (Koehler and Brittell 1990, Ruggiero et al. 1999). The northern goshawk (*Accipiter gentilis*) requires a minimum stand size of 10–100 ha of mixed conifer, mature forest to old-forest characteristics within larger heterogeneous territories of ~2,400 ha (Reynolds et al. 1992, Greenwald et al. 2005). Where very specific species habitat requirements either drive or are dependent on forest management within highly fragmented landscapes, the stand-level approach to silvicultural planning and implementation is challenged but remains the means to achieve these landscape-level objectives.

Modern Mapping Technologies

The capability of modern mapping to characterize, inventory, and even project changes in forest structure has seemingly advanced faster than our on-the-ground ability to delineate stands. For decades, stands have been delineated with aerial photos, but modern technology provides opportunities for remote sensing from satellites and geographic information systems to delineate and map stands over time. These *polygons* are representations of ground-level stand delineations that may have a high level of coincidence. However, the delineation of a polygon at one point in time may not coincide with ground-level delineations. If we recognize that the uniformity and boundaries of stands are dynamic, then do we have the capability to recognize these distinctions from imagery and recognize the distinctions that are important to management? Or do the technological advances simply provide another variable that masks the heterogeneity that is important to most properly delineate stand boundaries?

The Future of Stands

Historical Success of the Term *Stand*

The conceptual and practical application of the term *stand* has served forestry very well. However, the utility of the term is highest when we try to use even-aged systems to enhance uniformity and thereby maintain the integrity of individual stands through rotations. These even-aged approaches to forest management are probably the clearest means to visualize and achieve a regulated forest. The stand concept was integral to these approaches. Regulated forests of even-aged stands also tended to create forest- or landscape-level variability. However, many new management approaches, such as multiaged silviculture, variable retention harvests, or variable-density thinning, move in a different direction by enhancing heterogeneity at the stand level while reducing it at broader, landscape scales.

Operable Management Units Are Essential

Contemporary stand management on multiple benefit lands does not come without some pitfalls. One is the tendency to follow enhancements of stand-level heterogeneity by subdividing the stand into increasingly smaller units or what Smith (1962, p. 467) referred to as a "chaos of little stands." This approach serves to maintain a unit of relatively constant structure for forecasting stand-level changes but reduces overall management efficiency. A second is that greater heterogeneity makes sampling much more difficult (Murphy and Farrar 1981), providing a disincentive for creating complex stand structures. A third is the use of stand-level averages to characterize stand conditions (North 2012). If we attempt to enhance stand heterogeneity, then the average becomes a poor representation of the stand. New stand metrics are needed to characterize stand heterogeneity in these more complex systems (e.g., Pommerening 2002). However, an operational unit is still required to organize treatments within forests or landscapes.

Going Forward

One way to view the current state of forestry is to consider it as a dichotomy of management approaches that on many areas minimize stand-level variation and on other areas attempt to maximize it. The stand is a critical concept in the former but almost abstract in the latter. If we embrace ecological models to guide management, the stand, or the stand by any other name, is still useful on multiple benefit lands. An operational unit is necessary to implement stand-level or landscape-level forestry, but should it be a stand? Our response is a resounding "yes." There is nothing wrong with the stand concept and renaming it only creates a new term, not a new concept.

Going forward, we conclude the following:

1. The stand is the logical landscape unit for forestry for both ecological and operational usage;
2. We find no justification to replace it with patches or some other term that does not have a significantly different meaning; and
3. The term *stand* needs to be flexible for different usages, even if that means a stand is defined differently in the same space.

Stands may not be the sacred entities of the past in either their role as operational units or as building blocks for regulated forests. However, a management unit is still a logical vehicle for implementing forestry for any objective. There is no question that the stand concept is sound for traditional even-aged forestry on production forests. For multiple-benefit forests, a more flexible model should also work with new emphases on multiaged silviculture, variable retention, variable-density thinning, or whatever management approaches are used. We need to recognize that stand boundaries may change over time due to natural stand dynamics and that we should accept this as part of fluctuations in treatment boundaries. Nature does not work in discrete units that stay constant over time, and we should not create artificial constraints that hinder our ability to emulate processes that result in dynamic forests or dynamic forest boundaries. Treatments that deliberately attempt to increase small-scale heterogeneity provide opportunities to move boundaries and combine units. On the other hand, we also need to avoid micromanagement that creates a chaos of small units that hampers management efficiency. Within these constraints, the stand remains a logical concept and an effective approach. The old idiom, "if it ain't broke, don't fix it" applies here: we do not need a new term and the term does not need renaming.

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