THE STAND CONCEPT IN TODAY'S FOREST RESOURCE MANAGEMENT

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ABSTRACT

The stand as the inescapable management unit is commonly defined for certain characteristics such as cover type, ecological site type (or its components), and proposed use. Examples thereof are given in this paper. Confusion arises, however, when people use one characteristic, and then they themselves or others assume that different or additional characteristics apply. This also happens when the same land parcel is part of several stands because divergent criteria are used, for example in a tropical environment, logging suitability versus species composition. The stand must therefor be viewed as dynamic, whereby change may occur in the temporal as well as in the spatial domain, incorporating new, or integrating a series of previously competing management objectives. Better resource management will also result when stands are delineated according to inherent physical properties, intrinsic biological potential, and current vegetation status (species, age, etc.). Some difficulties preventing this at present are described.

1. INTRODUCTION

When forests are managed for multiple uses, with a range of interlinked management goals and a variety of individuals with staff responsibility for achieving these goals, misunderstandings and conflicts can often occur. At least part of these misunderstandings may be due to lack of communication associated with different definitions for the same term. We suggest that problems exist with the definition of the most basic management unit, the "forest stand".

The forest stand is obviously a human concept. Although primary forests inherently encompass significant variation, they cannot be simplistically described as stand mosaics. The units formed by the naturally occurring diversification often do not meet the criteria that drive the human management objectives. Moreover, the succession in primary forests is characterized by continuously changing spatial units, ranging from small irregular groups to rather extensive homogeneous areas when maturity is reached.

Forest managers converse in terms of "forests" as general entities, but deal with "forest stands" as specific entities; they plant stands, thin stands, inventory stands, harvest stands, and perform a number of other management activities within them. A common definition of what constitutes a stand is essential for integrated forest management. In the following discussion we would like to clarify the concept of the areal management unit, or the "stand", and demonstrate how a variety of definitions for that unit can exist.

2. BACKGROUND

Forest land managers have always needed and will always need to predicate management on areal units defined according to criteria that make them relevant to specific management aspects. However, as the objectives and goals of forest management have evolved over time, so have the criteria used to define the areal management unit. Another reason to pay closer attention to what the forest stand concept represents today is the fact that the stand is often referred to in non-forestry sciences either without a clear definition, or perhaps even under an obviously erroneous categorization. A typical example occurs in the field of remote sensing, where stand is commonly substituted for cover type without further clarifications, although what is really meant by it is a group of stands (not necessarily contiguous) similar in their dominant tree species and crown closure.

We are also beginning to see the emergence in forest ecosystem management of such spatial analysis tools as geographical information system (GIS) and global positioning system (GPS) technologies. These not only allow us to conceptualize entirely new ways of investigating spatial dependencies in natural environments, but they also greatly facilitate the incorporation of new approaches to connect stands as spatial entities to management-driven (human) objectives. This by no means implies that defining the boundaries of such areal units is going to get any easier. But we are now at least beginning to realize the fuzzy and temporally inconsistent nature of stand boundaries.

However, technological advances are not the only factors that contribute to the growing confusion in the interpretation of the term "stand". New accents, or even completely new visions on the overall goals of forest management will clearly impact the practice of stand definition and delineation. The 1992 UNCED conference in Rio de Janeiro (Anon., 1992) mainly stressed two aspects of natural resource management; sustainability and biodiversity. These principles were further developed at the Helsinki Ministerial Conference in 1993 (anon. 1993). As a consequence, it is expected that the scale factor in forest management will be reduced, not only in already intensively managed forests, but also and probably especially in forest areas up to now characterized by large-scale exploitation only.

3. THE STAND AS THE SPATIAL UNIT

Forest stands have traditionally been defined as "aggregations of trees or other growth occupying a specific area and sufficiently uniform in composition (species), age arrangement, and condition as to be distinguishable from the forest or other growth on adjoining areas" (Davis, 1966). This basic designation originates from the classical Swiss forestry school of thought. It has, however, been reinvigorated and reinforced by other Central European forest scientists in recent years. In addition, Bonneman and Röhrig (1971) claim a minimal stand size as part of the definition, in this case the 0.5 hectare prescribed by local forest management practices. Schütz (1990) agrees with the fundamental meaning of the management unit but amplifies the concept with two remarkable notions. First, he states that the stand concept is valid exclusively in maturing and mature forests, not in the early development stages, e.g., establishment and sapling stages. Indeed, during these phases the naturally occurring variation in forest canopy and structure is still very noticeable requiring specific management interventions at a very small scale (small spatial units). Second, although he does not prescribe a maximum size for the stand, he states that for practical reasons stand size should not exceed that of a standard cut (five to ten hectares in central Europe).

Other language denotations are very similar. In French, "peuplement forestier" is described as "l' ensemble des arbres (ou végétaux arborescents, par ex. bambous) ayant une uniformité jugée suffisante quant à sa composition floristique, sa structure, son âge, sa répartition dans l'espace, sa condition sanitaire, etc., pour le distinguer des peuplement voisins, et pouvant ainsi former une unité élémentaire silvicole ou d'aménagement" (Association Française des Eaux et Forêts, 1975). In Spanish, "rodal" means "agrupación de arboles u otras plantas que, ocupando una superficie de terreno determinado, es suficientemente uniforme in su especie, edad, calidad o estado, para poder distinguirla del monte o arbolado que la rodea" (Meira and Mata, 1968). Although these definitions are only some of the many formulated so far (Chapman, 1931, and Toumey, 1958), their common keywords "specific area", "uniform", "condition", and "distinguishable" are universally present in some form or another in virtually all other forest stand definitions that were found documented in the literature.

The major characteristic that must be present for stand definition is that the stand exhibits some significant difference from the adjoining land parcels so that it becomes visually identifiable as a single areal unit. In other words, the stand is a relatively homogeneous forest subunit or arbitrarily defined forest situation that can be recognized as such in the field. There remains some confusion within the forestry profession with respect to the homogeneity characteristic of the stand. The situation is quite clear and evident in plantation forests where uniformity is often strived for via even-aged (re)afforestations. The circumstances are totally different, however, when forests originate from natural regeneration with a variety of species, ages, and structural characteristics. It is indeed true that such forest ecosystems require more time to arrive at a stage where unique spatial units of a minimum size are identifiable. Either Schützes first notion is accepted,

saying that the stand concept is not valid in young natural forest, or a spatial and structural variability must be accepted within the young stand. The latter perspective is nowadays generally accepted in Central Europe when naturally regenerated and intensively managed mixed forests are concerned. In this case, however, further subunits are distinguished, e.g., "horsts", "groups", and "troups", respectively ranging in size from three to five larger trees, over 0.03 - 0.1 hectares, to 0.1 - 0.5 hectares (Röhrig and Bartsch, 1992).

Stand is not synonymous with cover type, or ecological forest type. In the U.S., the term cover type, or forest cover type, is often interchangeably used with forest type. It is a designation primarily based on upper-canopy species composition, sometimes modified to include age, density, and/or structure information. Many spatially distant and/or distinct stands may exist within a given cover type. Ecological forest types (sometimes also referred to as forest site types), on the other hand, represent groups of stands similar in their composition, development (successional trend), and site conditions. In all stands belonging to a particular ecological forest type, we expect from similar treatments similar responses. This is most often not the case with stands belonging to the same cover type. The stand thus embodies a set of particular conditions that make it unique with respect to multiple-use considerations such as tree harvesting, recreation, wildlife conservation and enhancement, watershed management, aesthetics, etc.

Since forest management became an explicit professional discipline in the early 18th century, a variety of parameters have been proposed to differentiate stands. The majority of these are actual condition descriptors such as species composition, age, site productivity, canopy closure, canopy architecture (layers), and tree density. Stands have traditionally been defined according to the value of these parameters in relation to the specific management objective, e.g., timber production for forestry, habitat creation for wildlife, etc. However, objectives change or may combine over time, and the physical and biological condition descriptors are equally subject to change. Such changes are not necessarily specific to the existing spatial extent of the stand, implying that they may not be limited to the single stand, and/or they may not be evenly applicable to the entirety of the stand. Consequently, the stand is, or should be, considered a dynamic concept, susceptible to change over time and space. If one looks at classical forest maps, one may repeatedly observe that the occurrence of stands is frequently highly irregular in relation to topographic, environmental, and multiple-use features (Coppin et al., 1986). It is very probable that the existence, number, and spatial distribution of stands initially present in a forest map may bear little resemblance to what is ultimately desired in terms of integrated management units.

Apart from biophysical characteristics and management goals, silvicultural systems also strongly affect the definition of the stand. Clearcutting and stripcutting lead to well identifiable stands, where the size depends on the local management practices but is usually relatively large. Shelterwood systems generally also apply to larger areas, but variation remains noticeable and sometimes even considerable, especially in the young

development stages. Among the different silvicultural systems, it is the group selection approach, widely applied in Central Europe and often referred to as "Femelschlag", that best reveals the stand concept. This silvicultural system is founded in such principles as adaptation to local site, sustainability, and diversity. Its intensive management style is necessarily based on small spatial units. Consequently, variation and complexity are maximized among, and minimized within, stands, and stand delineation is clearly evident in the spatial domain. Finally, there remains the selection forest silvicultural system (Plenterwald), in which stands are not anymore identifiable because the management approach has come down to the tree level. Nevertheless, management units are distinguished, mainly with a focus on exploitation.

The question of a biological foundation for the stand concept not only arises in connection with these selection forest systems, but also with larger homogeneous forest plantations, e.g. poplar, pine, and eucalypt populations. Unlike the former more-natural forests, which feature diversity on a large scale, such plantations are species-homogeneous and may be submitted over the totality of their area to the same management goals. However, diversification in age, density of plantation, and exploitation parameters (e.g., slope) then often constitutes the motive for stand delineation. As such, even from a purely silvicultural perspective, it is evident that any definition of stand must respect silvicultural parameters, and thus be considered a non-static concept.

When classifying forest lands, one always has a purpose in mind. So the classification scheme can be considered successful only if the objective is adequately met. The entire concept of stand definition can therefor be seen as the last phase of a management-oriented forest classification scheme, whereby the stand is the final inescapable management application unit. From this perspective, an alternative definition can be phrased as follows : the stand is the lowest level of any forest resources classification approach where the forest is subdivided into areal units on the basis of spatial patterns that affect resource use and natural processes (after Baily et al., 1978). This formulation rests on two important assumptions, that the stand has multiple resource values, and that forest resources, physical features, and total environment are closely interrelated.

Although general agreement can easily be reached on a basic stand definition, the size of the stand remains inherently variable. For some silviculturalists, this is a natural result of the dynamic character of the stand, for others it remains a topic of contention. Opinions diverge with the priority given to either ecological and silvicultural aspects, or technical and financial factors. In Central Europe with its limited and intensively managed natural resources, it is common practice to aim for stands no larger than five hectares. On the other hand, in the humid tropical forest, a single stand may comprise several tens of hectares (Coppin, 1986). However, where circumstances (especially budget) allow for it, small-scale forestry with relatively small stands and the appropriate management practices expedites the forest management objectives of sustainability and biodiversity much more efficiently. The small-scale approach guarantees a series of additional benefits :

- It promotes mixed forests.
- It reduces the risk of external disturbances.
- It corresponds better to the natural state of affairs and to natural phenomena.
- It permits the consideration of local site variations.
- It creates more favorable microclimates.
- It favors and promotes natural regeneration.
- It results in structural enrichment of the ecosystem.

In Europe, it has also proven to stimulate employment in the forestry sector, to lengthen the rotation periods, and to cut overall energy consumption in forest operations (Lust, 1981).

4. STAND AND SITE

Although one may dwell much longer on the exact formulation of the definition of a stand, it is of more direct relevance to the present-day forest manager to determine how the keywords "condition", "resource use", and "natural processes" should be interpreted. One line of thought is to link these principles to the concept of productivity, which is of universal concern in forest management. Productivity is a feature of the vegetation that integrates many site factors and invariably touches on the confusion in forestry and related disciplines between the stand and site notions.

Site is usually defined as "an area considered in terms of its environment, particularly as this determines the type and quality of the vegetation the area can carry" (Davis, 1966). Other definitions of site such as "an area which appears, for all practical purposes, to provide throughout its extent similar conditions as to climate, physiography, geology, soils, and edaphic factors in general, and is commonly between 0.1 and 2 hectares in size" (Valentine, 1986), and "the physical location and environmental features of a forest ecosystem" (Barnes, 1982), demonstrate that site as an assessment of land capability is a rather static concept.

Areal units have been qualitatively classified into ecological site types using the descriptors of land form geology, climate, soil properties, topography, and potential or existing vegetation. Alternatively, site can be quantitatively assessed via a site-class scheme, where site class is a measure of the fiber production of a particular species. While such a (often vertical) growth classification or productivity appraisal of a site can be used to determine its silvicultural potential. it cannot, for example, be considered the sole criterion for choosing a harvesting technology. In this case the forest resource manager requires information on soil load bearing capacity, current soil moisture content, and so on. In addition, technical requirements often impact spatially static concepts. The irregular shape of the site units that is typical in nature invariably contributes to the complexity of forest structures and the ensuing degree of difficulty with respect to, for example, timber exploitation. It is obvious that stands, while respecting natural site boundary conditions, must also take into account other considerations. As a consequence, forest managers have traditionally made stand boundaries more uniform by also adhering to other geographic and/or artificial fringes in order to facilitate management interventions.

Today, forest management objectives are typically centered on providing for several goods and services, keeping in mind the need to sustain or increase long-term productivity. It is clear that the ecological site type as a global indicator of land characteristics and capabilities is one of the most important, if not the most important descriptor in stand delineation. However, since the forest stand is the basic land unit in integrated forest resources management, it cannot be delineated from ecological site types only. Although extremely valuable, site cannot be the exclusive condition for stand definition. It is furthermore evident that there is no direct spatial coincidence between forest site and forest stand, the latter encompassing additional conditions defined by the management goals.

Practical experience suggests that the distinction between site and stand is not always maintained in forestry, and particularly in related disciplines. Examples abound in the literature. It has been, and probably still is, very common among photo interpreters, map makers, and image analysts, to produce forest stand maps exclusively from observed site parameters without even having any knowledge of the management objectives that apply to the forest in question. This is especially so when management objectives are multiple and/or integrated (Coppin et al., 1983). And average tree height as an indicator of site productivity is still the sole criterion for stand delineation in many northern U.S. coniferous forests and softwood plantations. What is more, classifications based on productivity alone are usually too broad for practical use in forest land management, because dissimilar environments may have similar productivities. It can be said that the stand-site muddle has been, and is, the cause of a lot of confusion among professionals that deal with forest ecosystems.

Different "schools of thought" have tried to solve the problem from different angles. The intensive silvicultural management in southwestern Germany (Baden-Wurttemberg) has been grounded in site science since the early 1950's. Under this approach, the site represents the basis for determining silvicultural and forest management practice, whereby a strong interrelationship between physiography, soils, and vegetation is assumed. It should be noted, however, that the concept of site must be seen in a much broader context than presented in the preceding paragraphs, and that under this approach the management units are called ecosystem units rather than forest stands. They, moreover, focus intensively on site-species interrelationships. These ecosystem units are by definition composed of individual sites of similar growth and yield for the major species. The different ecosystem units thus have polymorphic growth curves and markedly different productivities. It follows from this summary description that the ecosystem unit in and of itself is basically another term for the forest stand in its dynamic context. Site conditions that are directly related to the overall productivity of the unit form the backbone of the classification, while all multi-user aspects of the management practices are adequately encompassed.

Over the years, various methods have been developed to categorize the site as the medium for forest growth (Leak, 1992). Some of these definitions are very application-oriented and are commonly single-factor approaches with a limited generic value. Examples are manifold and include, among others :

1. Site classification by direct measurement of tree or stand growth. Here the average height growth of dominant trees is the most common measure taken, because it tends to be independent of stand density in most forest types. Diameter, volume, and weight, on the other hand, are strongly influenced by stand dynamics.

2. Site classification by measures of environmental factors. These include soil characteristics and climatic variables.

3. Site classification by understory plant indicators or habitat types, where the potential climax vegetation and successional development phases are considered.

Other approaches are basically variations of the multi-factor ecological site classification of which the previously described German system is a prime example. These alternatives usually provide the framework for intensive multiple-use management; managerial recommendations are by necessity unit-specific. It follows that it is rather irrelevant if the unit is then referred to as an ecosystem unit or a forest stand. Probably one of the promising systems to delineate management units or forest stands is based on landforms which integrate the larger geomorphological entities and the climate into the definition (Hills and Pierpont, 1960). The approach entails the matching of local climate regimes to the geomorphology of the landscape units; the latter being concretely understood as spatial and volumetric ecosystems (as defined earlier) in a regional context.

5. THE DYNAMIC STAND CONCEPT

As societies' demands for wildlife (game and non-game) renewal begin having an impact on the traditional forestry practices via the requirement for open areas, for diversity and connectivity in the spatial arrangement of the forest stands, and for non-linear boundaries, forest stand delineations will have to change, and these changes may transcend the static nature of some of the more commonly used stand descriptors. For example, when the edge effect is very important, there may be a need for different and new stand criteria such as, e.g., perimeter-to-area ratios.

The same applies to the market forces where the production of raw material is one of the major management objectives. To attract customers, sales must comply with certain thresholds of areal extent and volumetric content. In many cases, sale boundaries in, for example, Minnesota, northern U.S.A, at present do not coincide with the actual mapped stand boundaries (Coppin and Queen, 1995), but since the sale of standing timber is effectively a management intervention, it will impact the future spatial distribution of the stands in the area of interest.

Increasing human population densities and increasing human population mobility will equally impose further constraints on the forest stand as the management unit. Even marginal considerations such as the visual aesthetic impressions left upon the public after management interventions such as restricted clearcuts, creation of open islands for wildlife, etc., will help shape the forest stand of the future. So, without doubt, will recreation and watershed conservation requirements.

6. CONCLUSIONS

The forest stand remains without question the appropriate unit for integrated forest management. The resource manager and the interested observer should never lose sight, however, of its dynamic character which is momentarily defined by the direct link to the current management objectives. Site, as an indicator of sustainable productivity is one of the more important criteria in the process of stand identification, especially if assessed within the multi-factor approach.

A note of caution must be added as to the applicability of the forest stand concept as presented here to other parts of the world. Forestry as a professional activity has evolved to a science-based discipline in the industrialized countries, and we now know the luxury of being able to apply multi-factor approaches in the management of our renewable natural resources. While this should ideally be the case everywhere, lack of knowledge, unavailability of hard data, and political realities many times exert considerable pressure on the people trying to shape resource management policies in third world areas. While the concept of the management unit still is valid, the keywords might have a different information content according to the local management level. For example, in selective logging of tropical virgin forest, the management unit results directly from a land stratification procedure with physical accessibility for logging equipment as the sole criterion (Coppin, 1986 and 1987). The definition of "forest stand" still holds, although western foresters will be rather unfamiliar with its spatial dimensions (commonly one km^2) and the single, narrowly focused management objective (exploitation of an average of about two trees per hectare). Also "sufficiently uniform" must here be viewed from a different perspective (terrain conditions).

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