Turk J Agric For
24 (2000) 443–451

Exploring the Concept of a Forest Landscape Management Paradigm

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Received: 01.12.1997

Abstract: The concept of forest management planning has rapidly progressed towards a more holistic approach in the last decade. Considering the whole landscape of ecosystems is the focus of landscape management. This paper examines the evolutionary process of forest management and compares and contrasts the landscape management planning concept to its predecessor, the conventional forest resource management approach. It explains the conceptual framework, provides the principles and the improvements over the conventional management planning, and discusses different approaches towards the landscape management concept. However, the paper stresses the fact that the evolutionary process of forest management provides the basis for what has long been desired, sustainable healthy forest ecosystems. In conclusion, smarter use of information technology such as geographic information systems (GIS) and remote sensing (RS), understanding spatial forest ecosystems dynamics, and effective public involvement could make this new approach on the ground happen.

Orman Ekosistem Amenajmanı Kavramının İrdelenmesi

Özet: Orman amenajmanı planlama sürecinin seyri son on yıldır çok değişkenli ve bütünleşik bir yaklaşım tarzına doğru hızla gelişmektedir. Orman ekosistemini bütün yönleriyle ele alan bu yeni yaklaşım ekosistem veya doğa amenajmanı olarak anılmaktadır. Bu makale, öncelikle orman amemajmanındaki bu değişim sürecini ortaya koymakta ve ekosistem amenajmanını bütün yönleriyle bir önceki yani orman kaynakları amenajmanı yaklaşımı ile karşılaştırmaktadır. Bu makalede, daha sonra ekosistem amenajmanı kavramının çerçevesi çizilmekte, temel prensipleri ortaya konmakta, geleneksel amenajman yaklaşımına göre üstünlükleri tartışılmakta ve ekosistem amenajmanının şekillenmesine yön veren farklı bilimsel yaklaşım tarzları da sergilenmektedir. Ancak, orman amenajmanı planlamasında uzun zamandan beri arzu edilen sürdürülebilir sağlıklı orman ekosistemlerinin konu edildiği bu değişim süreci üzerinde durulmaktadır. Sonuç olarak, sosyal katılımın sağlanması, konumsal orman dinamiğinin anlaşılması ve coğrafi bilgi sistemleri, uzaktan algılama gibi çağdaş bilgi sistemleri ve teknolojilerin ormancılıkta akıllı kullanımı ekosistem amenajmanının uygulamaya başarıyla aktarılmasını sağlayacaktır.

Introduction

Over the last 300 years world population has increased almost elevenfold, nearing six billion. This rapid development brings increased, widened and varied demands for timber and non-timber products such as recreation, clear water, health of society, wildlife habitat and biodiversity. In order to satisfy these diverse needs, the forest management planning concept has changed progressively by evolving from timber management through integrated resource management to landscape management (1–6).

In the past, forest managers focused on extraction of maximum timber production, thus this practice was called timber management. Specifically, the management objective was the maximization of timber production rather than the definition and control of the kinds and distribution of forest conditions or resources needed to achieve multiple benefits. Now, different integrated resource management approaches are being tested. Approaches include methods for protecting endangered species and preserving some critical natural sites such as habitats, recreational areas, historical sites and ecologically sensitive zones. The management focus is still the sustainability of specific resources –mainly timber– with the other concerns accommodated with constraints. Specific concerns, like maintenance of critical habitats for specific wildlife species, setting aside sites for parks and ecological reserves, and protection of riparian zones, are addressed ad hoc in current management planning by merely constraining the timber harvest schedule in the belief that other values will be maintained. This is sometimes called integrated resource management, although it does not truly manage values other than timber.

The state of the forest landscape has declined as the contemporary management approach has been implemented for years. Around 13.7 million hectares of forest are disappearing every year (0.7 million ha was compensated by plantation) as a result of current management practice according to FAO records (7). Furthermore, slightly more than half of the tropical forest has been degraded or almost deforested; 40% of the dense tropical forest has been converted to other uses such as agriculture, animal breeding, 10% has been partially cleared or fragmented. All these are undoubtedly major causes of deterioration and threats to forest health. Coupled with these, the bitter fact is the forecasted loss of 1 million plant and animal species during the next 15-20 years. As a result, the current management approach fails to maintain and sustain the forest landscape for future generations.

There are a number of other shortcomings of current management approaches (5–9). Among others, the most prevailing one is the scale or the focus of management. For example, there are so many values involved in management planning that it becomes very cumbersome to integrate their management. Besides, favoring one value over others may, however, eliminate a very crucial landscape process and have far reaching consequences (10). In addition to this, unconscious design and implementation of harvesting and silviculture interventions in the past has resulted in various degrees of what is frequently called forest fragmentation (i.e., breaking large contiguous forest conditions into many small, isolated patches). Many scientists feel that it will adversely affect biodiversity and ecological processes in the future (11–13).

Given these and other shortcomings, management has now been evolving toward a more robust, holistic, and ecosystem–based landscape management (1, 2, 14, 5, 15, 6). This new management philosophy, loosely named 'new forestry' (16), has become known as forest ecosystems management or simply forest landscape management. Forest landscape management is an approach to manage forested landscapes for both commodity production and ecological values by controlling spatial structure and its dynamics (5).

Forest Landscape Management

Landscape management (LM) is an overall concept that influences the way of forest management at large. The economic, ecological, technologic and the social aspect are recognized and reflected in forest management decision making to provide the best stewardship and to sustain ecosystem functions while providing goods and services for people. These four crucial and necessary dimensions are described below.

Social aspect: The land, subject to management, belongs to people. The decision maker of all the landscape under management is the people. Consequently, the public want to be more involved in deciding how these lands are used and managed. Citizens also have a right and responsibility to be involved in public land management. Since any interventions to forests influence the community living particularly in or near the forest then public involvement becomes essential in forest landscape management.

Today, the public, organized in different special groups, is debating and criticizing how the land should be used. These debates and conflicts are revealed in questions on harvesting old-growth forest, preserving species of plants and animals, protecting the environment, and the importance of forests in regulating changes in the global climate. These groups are primarily polarizing into two alternative land use categories: *cut it down* or *lock it up*. In these polarized environments, the concept of ecosystem management is appealing as it seems to embrace ecological values without rejecting commodity production (3). Regardless of this controversial environment, the tendency is towards seeking an active role in the process of forest management planning. It is the public involvement that has initiated and will help shape the concept of forest ecosystem management in the future.

The economic aspect: Almost every activity needs to be justified by its economic merits. Forest landscape management is no exception. Considering other non-timber values in management planning will have an effect on the economic return. For example, many areas would have to be allocated for various forest uses such as biodiversity, natural conservation and recreation other than fiber production. Furthermore, increased management activities under landscape management will generally cost more than just managing for timber (i.e., reduce economic returns). However, the total cost of producing timber, wildlife habitat, biodiversity, and other ecological values **together** will generally be lower than producing them separately. Each individual value production means that many hectares set aside will be in reserves and will not produce any timber market values, thus forcing a shift to less efficient, more costly sources of wood and substitutes elsewhere (17). Managing to support more diverse habitats while harvesting timber to help pay for operations can reduce the cost of producing both outputs.

The ecological aspect: The primary goal of forest management appears to be to maintain and sustain healthy and productive ecosystems. An ecosystems perspective for management recognizes the need to design alternative management strategies sensitive to the balance among various components of the forests (3). These components or specifically organisms in the forest ecosystems are hierarchically organized into functional groups and linked through complex processes to their physical environment and to each other as well. Thus ecosystems have three primary attributes: composition, structure/pattern and function/process (1, 5). Composition refers to the identity and the variety of elements in a collection, and includes faunal and floral species richness. Structure is the physical organization of the system. In particular, it refers to the relative spatial arrangement of patches and interconnections among them. Function involves ecological and evolutionary processes including gene flow, disturbances and nutrient cycling. In other words, ecological functions are recognized by capture, production, cycling, storage and output of resources (18). The other important element of ecosystems that blends them in a harmonious matter is the relationships or interactions among these characteristics of ecosystems that make a system dynamic. For example, functions are dependent on the structure that performs them. Thus, here exists the human influences on all these characteristics of the ecosystems that should be the concern of management planning.

Given the general description of ecosystems, management to sustain them becomes very crucial and complex. Management has to recognize the complexity, and provide quantitative measurements of those characteristics and offer a design procedure to maintain the system's dynamics over time without jeopardizing the natural balance of the ecosystems while satisfying the various needs of the society. This is where the landscape management paradigm enters into the ecosystem formulation.

It is very important to note that landscape management does not concentrate on a species–based approach where such an approach will fail as it quickly exhausts (i) time availability, (ii) financial resources and (iii) societal patience and scientific knowledge. (4, 5). Since forest landscapes are considered a complex web of interactions whose thread represents air, water, soil, vegetation, wildlife, insects, and microorganisms, it becomes extremely hard to focus on every specific individual. Besides, according to the hierarchy theory, where lower-level units interact to generate higher-level behaviors and higher -level behaviors control those at lower levels, planning must occur on a larger scale (19). Therefore, a large scale approach -landscape level- is the only way to manage the biodiversity. The forest landscape structure, a mosaic of patches of forest conditions varying in content and scale, altered by natural events (geomorphologic and ecological processes) and by human interventions, thus becomes the focus of landscape management.

Science and technology aspect: The accumulating pool of knowledge in forestry at large has a significant effect on the management in forest ecosystems. With the changes in management objectives, philosophy and processes, a fundamental change is taking place in the forestry scene. New forestry disciplines such as landscape ecology, spatial forest modeling, environmental ethics, conservation biology are burgeoning to help mature the idea of landscape management. Added to this is the rapid improvement in computer-based technology suitable for handling forest resource problems over large areas and long time periods. To ensure sustainability of forest values, managers must have better decision making tools and a comprehensive spatial database.

Advances in geographic information systems (GIS) have dramatically increased the ability of resource managers and researchers to gather, store, maintain, manipulate, model and monitor a mosaic of landscapes with the digital forest inventory in place. Forests now can be monitored with high resolution based remote sensing, global positioning systems (GPS) and the resulting data organized in a GIS. The enabling effect of advances in these fields has changed the scope of forestry problems and the questions that can be asked. It is now relatively easy to spatially reclassify, analyze, model and monitor changes in large areas of forests with various attributes and examine associated timber and other non-timber values. GISs have specifically helped clear away several stumbling blocks that limited forest management endeavors in the past (20, 21); (i) establishing and maintaining an up-to-date digital inventory of the present forest, (ii) developing a spatial data handling and analysis capability, and (iii) providing on-the-ground management planning. Furthermore, GISs have enabled foresters and researchers to develop management design with spatial objectives in mind, i.e., a target spatial pattern that enables both conservation and the timber management. Now it is possible to develop alternative spatial management strategies with operational research techniques such as optimization, simulation to manipulate spatial pattern by forecasting it over time towards the achievement of a target landscape pattern. By examining the changes in the landscape pattern as the planned or anthropogenic activities and natural disturbances are applied, understanding forest landscape dynamics or landscape processes becomes much simpler than it used to be. GISs coupled with other computer-based techniques such as artificial intelligence and image analysis of remotely sensed data, and maintenance of a huge digital forest inventory will become easy and more importantly the qualitative management decision-making process will be improved. This leads to what has been desired, landscape management to become a reality on the ground.

Approaches to Landscape Management

Spatial forest modeling has accelerated with the proliferation of GISs and landscape ecology opened the ecosystems based management planning – landscape management. There are two basic approaches to the design and planning of landscape management. The first approach is known as models of forestry (2) later renamed as the TRIAD approach (22). According to this approach the forest under management is permanently allocated for three basic uses or models of forestry. The first model aims to produce as much fiber as possible, thus it is called tree-crop forestry or high-yield forestry. It tends towards an agricultural mode of management. The model focuses on the most productive sites with the best access to the markets. The second model is the multiple-benefit forestry or new forestry. It looks for a long-term balance in the sustainable production of various values or benefits of forests. The model is practiced with many smooth silvicultural actions on the areas left after allocating the stands to the first model. The natural processes of the ecosystems are maintained in those allocated areas. The last model of forestry is conservation or protection forestry. It emphasizes the least alteration of natural forest by human beings in the remaining areas. No yields or resources drive the management of protection forestry. For example, the national parks, wilderness areas, research natural areas such as ecologically critical areas like gene pool reserve areas and other areas intended to be protected are characterized under the preservation model of forestry.

This approach may seem appropriate for the implementation of landscape management. However, one should bear in mind that forest landscape is not like a pie to be physically divided and statutory allocate to different land uses or model forests. The notion of the statutory landscape allocation is invalid as many resource values are pervasive and widely spatially distributed over the whole landscape (5, 6). For example, watershed values essential for the maintenance of water quality or aquatic ecosystems in general can not be set aside and isolated to one part of a watershed or selected part. As the effects of timber harvesting on riparian zones and of road construction and maintenance on water quality transcend the divided boundaries or land uses those effects have to be considered throughout the drainage system. Statutory allocation cannot provide a workable or logical landscape for wildlife management either, for at least two very crucial reasons. (i) most wildlife species require large tracts of undisturbed landscape, in other words, they do not recognize the boundaries between land allocations even between jurisdictional boundaries like provincial or national boundaries. (ii) it is impossible to provide for sufficient populations of many species in completely natural habitats. Lands allocated for timber will intensively be managed for timber production and that will eliminate populations of faunal and floral species reducing their genetic diversity and putting their existence at risk.

The other approach to landscape management is the holistic approach at landscape level. Unlike the TRIAD approach, this holistic approach does not physically and permanently divide the land base for certain uses, however, it aims to manage the forest ecosystems in harmony (23, 14, 24). Also known as the proactive approach, it would recognize the importance of restructuring forest landscapes carefully in a calculated and knowing fashion so as to maintain their key functions (e.g., production of values) and the resilience of the natural landscape structure (e.g., maintenance of biodiversity). This approach would involve interventions designed to control the landscape structure explicitly. Forest landscape would be measured quantitatively and appropriate actions would be applied in strategic geographic locations to bring a landscape to a target structure capable of both maintaining biodiversity and serving all the functions and values dependent upon it.

Principles of Landscape Management

Given the different approaches to landscape management it is clear that consensus does not exist.

Generally, issues in forest management in fact have been identified by the variety of opinions represented. A number of significant guiding principles underlying most of these management issues can be listed as follows (3):

• Forest management decisions must be based on an ecosystems perspective. This perspective views forests as composed of organisms hierarchically organized into functional groups and linked through complex processes to their physical environment and each other. Thus landscape management recognizes the need to balance the sensitive management design practices among the various components.

• The effect of forest management activities should be evaluated over a range of spatial scales. Ecological processes occur at different spatial scales (micro sites, stands, watersheds, landscapes and regions) and the effects become quite different from each other. Landscape management considers the effects of human activities or natural disturbances.

• The effect of forest management decisions must be evaluated over longer time periods. Like spatial scale, expanding the time scale causes new issues to emerge. Long term site productivity, ecosystem resilience, ecosystem health and the long term viability of biodiversity necessitates thinking across a range of ecosystem time scales.

• Forest management strategies must leave future options open. Long and unresolved discussions about the uses of forestry, uncertainty about the future natural events coupled with a lack of understanding of the basic principles of ecosystem functions force the management design process to avoid foreclosing on future management options. Sustainability becomes a central issue in landscape planning.

• Equal participation should be involved among the full range of forest users in forest landscape planning decisions. The clear direction can be taken by multiple participation in a workable environment. Commercial interests, environmentalists, recreationists and scientists should create constructive and sincere partnerships for management decisions.

• Forest landscape management should be based on the integration of ecological, economic and social relationships. No longer should timber production always have priority over other forest uses, though the commodity production is still necessary for the livelihood.

• Landscape management has three dimensions: the physical structure defined the by topographic and geological structure, biologic composition represented by the fauna and the flora, and human dimension represented by the social, economic, spiritual, historical and cultural values. The landscape management endeavor tries to balance these three dimensions for the well being of future generations by providing future management options.

Forest Landscape Modeling Concept

A key challenge for landscape management is to develop a comprehensive set of alternative management designs that are functionally linked to an available action set and to perform landscape analysis to find the desirable combination of production of resources and ecological values. In general, forest management seeks control of the forest inventory by designing, implementing and assessing a set of activities: harvesting, silviculture, protection and allocation. For management planning, a manager must be able to characterize the initial landscape structure, design alternative spatial management strategies, and forecast and interpret forest landscape responses. A very large number of alternative intervention strategies create a difficult and complex decision making environment. To implement landscape design, the contemporary approach to modeling the design process must change to embody the spatial structure in each stage.

A landscape management model would differ from conventional models in five important aspects (5). First, a spatial structure objective would be established. Second, a landscape model would characterize the initial spatial structure. Third, a landscape model would use structural measurements to add geographical intervention queuing rules based upon locational attributes of forest stands, for example core area or shape. Fourth, a landscape model would introduce alternative intervention patterns whereby the geographical format of interventions could be varied. The spatial harvesting pattern dictates how a planned set of harvesting actions is going to be applied to the landscape –size, shape, proximity, spatial direction and location. Together these would constitute a spatial management strategy capability. Last, a landscape model would provide measures of forest performance using landscape level structural measurements. In short, a landscape management design model would enhance contemporary management design by reorganizing and incorporating the spatial structure into each stage of the modeling process. While structural measurements are a basis for establishing structural objectives, characterizing the initial forest landscape structure and calculating performance indicators, and development of spatial management strategies require additional effort to build a workable forest landscape design process.

Landscape Management Versus Contemporary Forest Resource Management

Forest management has been evaluated in terms of its evolutionary process, goals, modeling concepts, approaches, data, coverage, different aspects and other general principles (Table 1). The goal of forest management has changed from sustaining individual forest resources for the people, as in forest resource management, to sustaining ecosystem health with active public involvement as in landscape management. Forest resource management keeps the traditional concept of regulating timber harvesting to an amount equivalent to annual growth to stabilize wood supplies and associated economic activity at the community level. Landscape management states that its goal first is to sustain ecosystems that yield natural resources and second to sustain the renewable natural resources themselves, considering the order or the priority of management goals (6). In short, landscape management considers ecosystem sustainability explicitly whereas forest resource management considers it implicitly.

Conceptually, forest landscape management is designed to manage forests proactively whereas forest resource management aims to manage forest resources reactively. Within the contemporary forest management design process, timber harvesting is scheduled by seeking out certain forest conditions across a forest over time. Forest structure always determines where management actions will take place and all actions focus on restructuring the forest as a timber producer. Harvesting and silvicultural interventions are prescribed in the form of levels and rules, often to extract maximum wood from a forest landscape in a predictable, economic and timely fashion and to control the forest age-class structure. The age-class structure is not controlled explicitly since emphasis is not so much on structure of the forest but rather on finding a schedule or a strategy that maximizes sustainable wood supply subject to constraints. Harvesting is controlled through the implementation of scheduled interventions on appropriate stands. For example, generally an overmature stand or a stand with high yield has precedence in the harvest queue wherever and whenever it appears. Alternatively, volume concentration or the economics of harvesting will dictate which stands can be harvested in certain geographic locations. In both situations, stands are harvested and appropriate silvicultural treatments are applied with little or no consideration of the effects on landscape structure and future scheduling opportunities. Since landscape structure is not modeled, the spatial performance (forest response) over time cannot be measured for analysis of landscape dynamics. Therefore, the design approach is *reactive* where landscape considerations tend to be debated, if at all, only after the harvest schedule is actually implemented and structural changes in the landscape emerge. This reactive approach arises from the economic incentive to maximize sustainable timber volume and thus achieve economic efficiency. Thus, this process results in an indeterminate landscape structure where the ability to produce or maintain ecological and other values or functions is unknown. It is increasingly clear that dramatic alteration of the natural landscape structure may result in unacceptable effects on wildlife habitat and ecosystems.

Unlike the reactive approach, a *proactive* approach (landscape management approach) would recognize the importance of restructuring forest landscapes carefully in a calculated and knowing fashion so as to maintain their key functions (e.g., production of ecosystems values) and resilience[3] (e.g., maintenance of biodiversity). This approach would involve interventions designed to control the landscape structure explicitly. Forest landscape would be measured quantitatively and appropriate actions would be applied in strategic geographic locations to bring a landscape to a target structure capable of both maintaining biodiversity and serving all the functions and values dependent upon it. This proactive approach arises from the ecosystem incentive to harmonize sustainable management of ecological values and thus achieve ecological efficiency or ecoefficiency.

Furthermore, contemporary forest resource management fails either to take into account the cumulative effects of forest management activities on other noncommodity forest values or to include risk in evaluating management alternatives. The management actions are implemented through equal considerations of timber and nontimber values, if ever considered, by a simple line-staff, functionally organized agency. Individual forest value is primarily focused and the others are accommodated as constraints to management to an entext that they do not conflict. Landscape management, however, considers all the values embedded in forest landscape in an integrated fashion with the involvement of multidisciplinary management teams or social

[1] An ability to absorb stress or change without significant loss of function.

Table 1. Comparison of landscape management with contemporary forest management.

	LANDSCAPE MANAGEMENT	CONTEMPORARY MANAGEMENT
Goals	• manage forest landscape or ecosystems explicitly with the people	• manage forest landscape or forests implicity for the people
Concept	• sustainability of ecological values-proactive	• optimal production of forest resources-reavtive
Approach	• holistic approach-integration of land uses	• statutory allocation of land uses-equal consideration of forest resources
Data	• spatial data • spatial landscape structure • structural forest landscape performance indicators	• attribute data with limited graphic data • numeric forest structure • resource outputs and inventories used as performance indicators
Coverage	• landscape perspective	• management unit, watershed or site specific perspective
Aspects	• social, economic, ecologic, and science and technology aspects	• economic and limited consideration of ecologic, social, and science and technology aspects
Principles	• biological diversity • ecosystems health & function • integrated management • public and private partnerships involvement in ecosystems decision making • risk minimization or a version • ecologic or ecoefficiency • environmentally more sound • not implemented, yet technically unflawed • multidiscriplinary management teams	• –– • –– • segregated management • ad hoc public involvement in natural resource management decision making • –– • economic (cost-benefit) efficiency • environmentally less sound • implemented, relatively successful for a specific region or management unit • functional and line-staff organizational structure

responsiveness. Thus, it becomes relatively easy to evaluate the cumulative and interactive effects of management actions on the environment and on the level of goal achievement-ability to understand structural forest landscape dynamics.

Lastly, landscape management extends over social, political and jurisdictional boundaries exploring ecosystems and landscape level spatial information (graphic and attribute type information). Technical understanding of the important effects of larger spatial structure on ecological values, spatial landscape dynamics or cause-effect relationships, are only explored with the help of operational research, remote sensing (RS), geographic information systems (GIS) and advanced computer technology. Thus the understanding of the complexities of spatial forest landscape structure, ecosystem processes and the functional relationships between them provides necessary and crucial background information for the successful design and implementation of landscape management. The effects of forest fragmentation are better quantified, understood and even controlled by the use of structural forest landscape performance indicators such as core area, percolation, spatial autocorelation and dispersion indices (25, 15).

Conclusions

The landscape management design process focuses on spatially re-engineering a forest landscape for production of both timber and non-timber values. This represents a new approach and fundamental shift in focus from resource-based to forest-centered or holistic management planning where the importance of spatial structure in determining value flows could be accounted for. The requirements for a successful forest landscape management call for: (i) active public involvement in management and policy making; (ii) an ability to quantitatively characterize spatial forest structure; (iii) access to spatial management strategies; and (iv) spatial measurements of forest response. Landscape management design accounts for spatial structure driven from ecosystems functions at all management design stages and thus takes advantages of new emerging technology like RS and GIS, and encourages the public to be involved in management and decision making. Thus landscape management is evolutionary not revolutionary in the sense that it does not mark a radical shift in the way the forests are managed but instead a logical step in the progression of the practice of forestry. Landscape management is a dynamic program involving concepts and principles that evolve and adapt along with changes in science, technology and demographics.

In order to implement the landscape management concepts on the ground, (i) a common understanding must arise among the various users, (ii) managers must have better decision making tools and a comprehensive spatial database, (iii) forest values must be managed on the basis of sustainability, and (iv) alternative future management options should be evaluated with the spatial forest dynamics in mind.

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