PETE BETTINGER
KEVIN BOSTON
JACEK P. SIRY
DONALD L. GREBNER

Forest Management and Planning

Academic Press is an imprint of Elsevier
30 Corporate Drive, Suite 400, Burlington, MA 01803, USA
525 B Street, Suite 1900, San Diego, California 92101-4495, USA
84 Theobald's Road, London WC1X 8RR, UK

Library of Congress Cataloging-in-Publication Data
Application Submitted

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library.

ISBN: 978-0-12-374304-6

For information on all Academic Press publications
visit our Web site at www.elsevierdirect.com

Printed in the United States of America
08 09 10 9 8 7 6 5 4 3 2 1

Contents

Chapter 3. Geographic Information and Land Classification in Support of Forest Planning

Chapter 4. Estimation and Projection of Stand and Forest Conditions

Chapter 5. Optimization of Tree- and Stand-Level Objectives

Chapter 6. Graphical Solution Techniques for Two-Variable Linear Problems

Chapter 7. Linear Programming

Chapter 8. Advanced Planning Techniques

Chapter 9. Forest and Natural Resource Sustainability

Chapter 10. Models of Desired Forest Structure

Chapter 11. Control Techniques for Commodity Production and Wildlife Objectives

Chapter 12. Spatial Restrictions and Considerations in Forest Planning

Chapter 13. Hierarchical System for Planning and Scheduling Management Activities

Preface

Forest Management and Planning arose from our desire to provide students in natural resource management programs a focused treatment of the topics that are important for upper-level forest management courses. This book presents an extensive overview of the methodology one might use to develop forest and natural resource management plans. A portion of the book is devoted to the development of information to support stand-level and forest-level management planning processes. In this regard, we discuss commonly used economic and ecological criteria for assessing the value and relative differences between plans of action at both the stand and forest levels. At the forest level, we emphasize the development of traditional commodity production forest plans as well as the development of forest plans containing wildlife goals. We also present alternative methods for developing forest-level plans, such as those that involve discrete yes or no management decisions.

Many of the topics included in upper-level university natural resource management courses have remained stable over the past 25 years. These topics generally include economic and physiological assessments of forest structure to determine whether proposed courses of action can meet a landowner's needs. However, quantitative forest planning has broadened and now includes complex wildlife goals, spatial restrictions on forest management plans, and other advanced issues. In addition, forest sustainability and forest certification have become central issues for land management organizations in the last decade. We also anticipate that wood supply chain-of-custody certification and management and carbon certification will become important issues in forest management planning in the near future. Therefore, although this book begins with a discussion of methods for assessing and valuing fine-scale decisions (a single project, for example), it builds up to discussions of how we might use them to address broader-scale issues for the management of natural resources.

Our various experiences in forest management over the last 25 years have helped us to craft this book. Each of the authors has taken and taught forest management courses, and we also have acquired valuable practical experience throughout North and Central America, New Zealand, Asia, and Europe. Although we currently work in academia, we have worked for the forest industry, forestry consultants, as well as state, federal, and international organizations. In addition, our extensive travels have allowed us to experience and understand forest management challenges in other parts of the world. Our goal was to develop a book that avoided taking an advocacy position on important topics such as sustainability and forest certification, since many of these alternative management paradigms are valid in today's natural resource management environment. In addition, we attempted to provide impartial treatment of these types of topics, since many are value-laden. As a result, the book provides an overview of the issues and discusses many of the challenges and opportunities related to managing forests under alternative philosophies.

The first part of *Forest Management and Planning* describes the management planning process (Chapter 1) and the development of information necessary for valuing and characterizing forest conditions (Chapter 2). Included in Chapter 2 are physical, economic, and ecological methods for valuing and characterizing forest conditions. The first part of the book also provides an overview of geographic databases (Chapter 3) and the methods used to estimate and project conditions into the future (Chapter 4). We then turn our attention to tree- and stand-level optimization techniques (Chapter 5), graphical techniques for envisioning linear planning problems (Chapter 6), and linear programming (Chapter 7), a commonly used mathematical problem-solving technique. Chapter 8 focuses on advanced forest planning techniques such as mixed-integer programming, goal programming,

and binary search, and heuristics. Forest-level planning generally utilizes linear programming or these advanced techniques, thus an understanding of their similarities and differences is important for natural resource managers. Starting with Chapter 9 (forest and natural resource sustainability), we begin to tie the planning techniques to broader issues prevalent within the field of natural resource management. Chapter 10 describes a number of models of desired forest structure, and Chapter 11 discusses a number of control techniques that one might use to move forests to a desired structure. Here one will find the classical concepts of area and volume control. Spatial restrictions increasingly are being incorporated into forest plans, therefore we provide a discussion of several of these in Chapter 12. The remaining chapters of the book cover broader issues in forest management and planning, including the hierarchy of planning processes typically found in organizations (Chapter 13), the wood supply chain and its management (Chapter 14), and forest certification and carbon trading (Chapter 15).

Three appendices are provided in this book to enhance the learning process. Appendix A provides data that is used throughout the book in a number of examples. One set of data involves a 100-year projection of a single western North American conifer stand, using five-year time period increments. The development of the stand in each time period is described with a stand table and several summary statistics. Two forests, composed of 80 or more stands, are described in the Appendix as well. The actual geographic information systems databases related to these forests can be acquired from the authors. Appendix B provides a description of the Simplex Method, which is a process used within linear programming to locate optimal solutions to linear planning problems. Appendix C provides a discussion and helpful hints for writing memorandums and reports.

Although the book contains a number of graphics to help students visualize management problems, we incorporated several photographs as well to tie the concepts described back to the management of the land. Most of the photographs provided in the book were captured by Kelly A. Bettinger, a wildlife biologist, through her extensive travels. The exception is the photograph of Hurricane Katrina storm damage in Chapter 6, which was taken by Andrew J. Londo, an associate professor at Mississippi State University.

We hope that readers of this book will find it both a useful learning tool as well as a valuable reference in their future careers in natural resource management. Our goal is to provide you with the tools to become a confident and competent natural resource manager.

PB
KB
JPS
DLG

CHAPTER

1

Management of Forests and Other Natural Resources

Quantitative and qualitative methods are necessary for helping land managers and landowners understand the choices they must make from among many competing alternatives. The results of planning processes help guide the activities of land managers, and allow land managers and landowners to understand how various alternatives may meet their objectives. This book concerns the theory, methods, and issues related to forest management and planning, and presents to its readers numerous methods for both assessing the current and future state of the resources, and for determining the best management alternatives available. Some traditional quantitative planning methods are presented, such as linear programming, that are still in use today by both public and private organizations. An overview of other more advanced methods are provided as well. This book also provides coverage of conventional and contemporary issues in natural resource management that influence planning processes, such as forest sustainability, forest certification, and wood supply chain management. In this introductory chapter, we present an overview of forest planning, one of the most extensively studied and most complex issues in natural resource management. In describing the forest planning environment, the basic types of group decision-making processes are presented along with a discussion of a few of the challenges facing forest management and planning.

OBJECTIVES

As we enter the twenty-first century, and as the human population expands in North America and other parts of the world, the management of natural resources is becoming one of maintaining the consumptive needs of society while also caring for the integrity and function of ecological systems. A large number of natural resource managers today continue to manage for wood production objectives, which in itself is a noble endeavor. A large number of natural resource managers also research and advise on the management of forests as it relates to wildlife, fisheries, recreational, and other environmental and social services. On many lands in North America a balance must be struck between commodity production and ecosystem goals. This balance is explored through planning processes performed at the national, regional, and local levels. This introductory chapter covers issues related to forest management and planning and the decision-making environment within which we must operate. To be successful land and resource managers, we must understand the system within which we work, as well as the social system within which we live and participate as professionals. Upon completion of this introductory chapter, you should be able to:

1. Understand the basic forms of decision-making processes, as viewed by the management sciences.
2. Understand the steps in a general planning process, and how they might vary from one natural resource management organization to the next.
3. Understand the hierarchy of planning common to natural resource management organizations.
4. Understand the challenges related to natural resource planning.
5. Understand how information related to planning efforts flows within an organization.

I. MANAGEMENT OF FORESTS AND OTHER NATURAL RESOURCES

Forest management involves the integration of silvicultural practices and business concepts (e.g., analyzing economic alternatives) in such a way as to best achieve a landowner's objectives. Management of forests requires a plan (however developed), and an assessment of the activities necessary to meet the objectives. In addition, a recognition of the important ecological and social concerns associated with a forest may influence the character and depth of a plan. In a more general way, forest management can involve the application of silvicultural practices so that a forest remains healthy and vigorous [1]. The range of forest management activities can include those focused on the economics of forest businesses, or on the ecology of the ecosystem. Activities can include tree planting, herbaceous weed control, fertilization, precommercial thinning, commercial thinning, final harvests, harvests for habitat improvement, preservation, road construction, road obliteration, and prescribed fire, among others. Each may have a cost and a benefit, depending on the objectives of the landowner. Choosing the timing and placement of activities is the main task of forest planning.

Later in this book we discuss concepts related to forest and natural resource sustainability. In Chapter 9 we discuss the sustainability of timber production, multiple uses, and ecological systems. The term *sustainable forest management* tends to favor the latter two approaches, because those who use it suggest that it involves management actions that are ecologically sound, economically viable, and socially acceptable. This approach to forest management is similar to, if not consistent with, ecosystem-based forest management approaches, where management plans are developed within a larger framework, take a big-picture perspective, and involve a number of values derived in and around the area being managed [2]. We attempt to stay neutral when it comes to favoring any approach, since each form of sustainability is used today (depending on the landowner and the landowner's objectives). Thus our goal is to describe the approaches used in practice, and provide some guidance for young professionals on the methods that might be used within each for developing a forest plan.

II. CHALLENGES RELATED TO THE MANAGEMENT OF FORESTS

Forest management is a rewarding experience for those who are drawn to the profession, yet it faces challenges from a number of areas. As you may expect, there are numerous economic challenges. For example, there may be the need to make a profit, the need to break even, the need to operate within a budget (perhaps at the activity level), the need to generate income, or the need to generate competitive financial returns when compared to other investments. These economic challenges usually are expressed in dollars and cents, and involve discounting or compounding monetary values if the need arises. There are a number of environmental challenges as well, including those related to wildlife habitat maintenance and development (Figure 1.1), water quality, soil quality, air quality, biological diversity, and fish habitat conditions. A number of these concerns are embedded in laws and regulations, others are simply the desire of landowners to protect or maintain certain values. There are also a number of social challenges facing forest management. For example, the use of prescribed fire is becoming a severe social challenge, because as people move out into the rural landscape, air quality becomes more of an issue. However, prescribed fire may be needed to restore and maintain native ecosystems, which is an important social and environmental concern.

Convincing the public that land is being managed responsibly is another social issue that we address in Chapter 15, with a discussion of forest certification. Policy instruments (laws and regulations) guide the management of public lands and influence the management of private lands. The development of additional policies to guide the management of private forests is a contentious issue. Janota and Broussard [3] found that absentee landowners and landowners who view their forests as long-term investments are more supportive of policies that encourage sustainable management, whereas landowners who

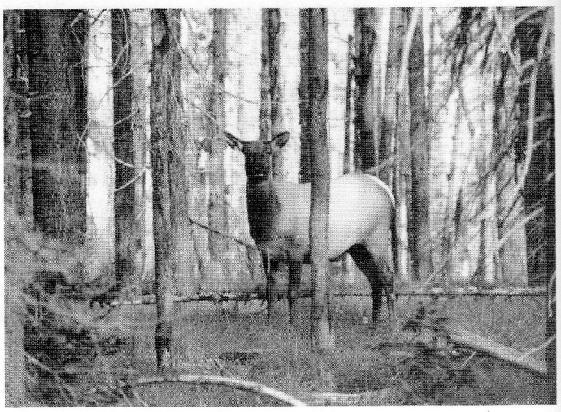

FIGURE 1.1 Management of natural resources may involve a balance between commodity production goals and goals related to wildlife habitat maintenance and development.

view the effects of their management actions as isolated from the broader landscape were less favorable toward these types of policies. In addition to these challenges to the management of forests, there is also the social need to provide jobs to local communities, and the need to pay these employees a reasonable wage.

There are a number of technological challenges related to forest management as well, and we will allude to some of these as we discuss the various planning processes. Other forest management challenges, such as those related to silvicultural systems or operational methods (harvesting, fuel reduction, etc.), are perhaps best left to be described in other texts. The long production period associated with the growing of forests sets this type of management apart from that incurred in agricultural operations, and as a result the outcomes of management are subject to many more potential environmental and human-caused risks. However, the development of management plans for forested areas must be accomplished in light of these uncertainties, which can be numerous for plans of action that cover large areas and long periods of time.

III. PLANNING FOR THE MANAGEMENT OF NATURAL RESOURCES

Forest plans are specific descriptions of the activities that should be used to best meet the objectives a landowner has for their property. Managing a forest without a plan in mind may be guided by short-term operational considerations, but this may in turn have long-term, undesirable or unforeseen consequences for the landowner [4]. As a result, the planning process is an important aspect of forest management. If a forest plan is not carefully and thoughtfully prepared, the activities that are implemented may not yield the result that is desired by the landowner. Most of the larger natural resource management organizations in North America have developed a plan of action for the land that they manage. More broadly speaking, Siry *et al.* [5] indicate that management plans have been developed for 43 percent of the world's forests. Whether planning occurs through a traditional process that uses linear programming to allocate activities to forest strata, a more elaborate process that uses a heuristic to develop a spatially explicit harvest schedule, or a seat-of-the-pants (back of the envelope, scratch of the head) method to determine what to do next, some form of planning is generally used. In many cases, quantitative relationships are employed to sort out the better plans from the mediocre or poor plans.

Why do people develop natural resource management plans? Organizations that undergo forest planning generally are interested in plans that will provide them guidance for (1) implementing activities, (2) predicting future harvest levels, (3) optimizing the use of limited resources, and (4) maintaining or developing habitat areas, perhaps while simultaneously balancing several other concerns (budgets, personnel, etc.). Today's natural resource management environment in the United States places as much, if not more, emphasis on ecological and social concerns than it does on economic or commodity production interests. It is imperative that natural resource managers efficiently use the resources at their disposal to meet the goals they consider important. To the displeasure of many college students, quantitative methods typically are used to justify or support decisions. These include economic, biometric, and operations research techniques. To be an effective natural resource manager, and to be able to consider multiple objectives and constraints simultaneously, it is necessary to use contemporary simulation and optimization techniques. Therefore, although students may not become an expert in these fields, they must understand how to apply these methods and interpret the results.

Periodically, we see natural resource management issues make headlines in the news media, which underscores one important responsibility entrusted to us as natural resource managers. That is, if we claim to manage land scientifically, and if our intent is to meet our landowner's objectives, then we need to be able to confidently and competently assess the conditions and outcomes of current and future forests, range, and wildlife habitat. If this is not possible, and if we cannot communicate well the trade-offs, then it will be difficult for us to convince our clients (the landowner, supervisor, stockholder, or the general public) that their goals are (or will be) met. It will also be difficult to convince the general public that we (natural resource managers) know what we are doing. To develop trust amongst various groups interested in the management of natural resources, land managers need to demonstrate that economic, ecological, and social goals are all being considered in the development of management plans. Planning processes that proceed in a systematic, organized, and quantitative fashion may help ensure that the resulting plans can withstand rigorous scrutiny. The content of this text should help you develop some of these tools, or at the very least understand the concepts that you might encounter in your career as natural resource managers.

Forest plans come in all shapes and sizes, from the extensive, voluminous plans developed for United States National Forests, to the shorter, briefer plans developed by consultants for private landowners. Some plans are even less formal, and are based on what some may call "back of the envelope" or "scratch of the head" processes. We will leave these latter approaches for others to describe. In this book, we present a number of measures that can be used to quantitatively describe natural resource conditions, and present methods and procedures we can use to evaluate alternatives for a stand or a forest.

A forest plan begins with a statement of the goals and objectives of the landowner. These must be ascertained through an understanding of the landowner's desires. Effective communication with a landowner is essential. Small, private landowners may require one-on-one meetings and tours of their property. Other larger landowners may require numerous meetings with stakeholders and managers to effectively gauge the goals and objectives. Next, maps, tables, and photographs of the property should be compiled to provide context and data for the management plan. Maps and tables that demonstrate how ecological, economic, and social goals will be achieved over time help people understand that these goals are being taken into consideration. An understanding of the most current state of the resource being managed is essential for building a plan of action. If maps or photographs are several years old, then they may need to be updated prior to the development of a plan, especially if activities have been implemented since their development (in the case of maps) or capture (in the case of photographs).

Inventories of the resources that are under the control of the landowner, and that may be affected by the actions described in a management plan, must then be collected or compiled. These inventories may include forest conditions, water conditions, soil conditions, wildlife populations or habitat conditions, and recreational area and trail conditions. In addition to understanding the current condition of a forest, projections for all alternatives to be considered are needed to understand where the resources are headed under different management regimes. Economic, ecological, and social outcomes, where appropriate, then need to be assessed to determine the value associated with each alternative management regime. In addition, natural resources may be functionally connected, and actions applied to one resource (e.g., the trees), may affect another (e.g., wildlife habitat). Understanding these functional relationships is essential in assessing alternative plans of action.

Ultimately, a forest plan will provide a management recommendation that describes how a plan of action (as set of activities over time) will contribute to the goals and objectives of the landowner, and how these activities may affect other natural resources of interest. In addition, the forest plan should provide a comparison of how the management recommendation differs from some set of alternative management scenarios. This comparison allows landowners to understand the "what if" questions that they might have contemplated. Finally, a timeline describing the implementation of the activities should be provided, suggesting how the activities will interact economically, ecologically, and socially, and how they will contribute to the overall goals and objectives of the landowner (Table 1.1). Timelines are helpful to landowners, particularly for budgeting purposes. Notice in Table 1.1, for example, that the revenues generated in 2010 and 2011 are less than the costs associated with the scheduled activities. Management plans should be designed to help landowners understand the options available, and although they provide guidance, it is ultimately up to the landowner to determine the course of action to take.

TABLE 1.1 A Summary of Activities Related to the Management of a Small Forest (several stands)

Year	Activity	Revenue	Cost
2009	Site preparation		$10,000
	Final harvest	$100,000	
	Commercial thinning	20,000	
	Fertilization		15,000
	Road maintenance		4,000
2010	Site preparation		15,000
	Planting		5,000
	Commercial thinning	15,000	
	Prescribed burning	2,000	
2011	Herbaceous weed control		5,000
	Habitat improvement		3,000
2012	Final harvest	75,000	
	Road maintenance		4,000
2013	Site preparation		12,000
	Commercial thinning	18,000	

IV. CHARACTERIZING DECISION-MAKING PROCESSES

Decisions regarding management plans are made in natural resource management organizations usually by a team of people with various educational and

cultural backgrounds, and various lengths of experience in professional settings. One main characteristic of planning efforts is that the time frame for the tasks performed by the team members usually is limited. In addition, the tasks the team members must perform may require a high degree of knowledge, judgment, and expertise [6]. More often than not, people on these teams have developed individualized sets of behaviors and decision-making styles based on previous experiences, which makes group decision-making an interesting and sometimes controversial event.

A. The View from the Management Sciences

The work that has been performed to explore how groups make decisions is vast, and a number of theories regarding how and why decisions are made have been put forward [7, 8]. Generally speaking, in the management sciences, there are three types of decision-making processes: rational, irrational, and something in-between called the "garbage can" process. These models are more thoroughly discussed in the management sciences literature, and our objective here is simply to provide a brief description of each. In the *rational model*, a decision-making team gathers all the data needed, analyzes all the possible scenarios, and reaches the best solution based on this complete set of information. Of course, this process is used only when there is a sufficient amount of time and resources [9], and may involve decisions that are easily resolved by means of mathematical formulas [10]. However, this is rarely the case in natural resource management. In fact, some may argue that there never are enough resources available (such as time, funding, or people) for this model to be used in forest or natural resource planning. Further, the rational model assumes that the planning team is sufficiently involved to provide the appropriate amount of attention to the attributes of the plan for which they have expertise. Given the multiple demands on a natural resource manager's time, this assumption may not hold true. And it will eventually become obvious that decisions concerning the development of a plan are inherently value-laden, even though we may believe that we are objectively assessing the management of a landscape. It is for these and other reasons that the *best solution* to a problem may not be the plan chosen by the land manager or the landowner.

The *irrational model* of decision-making is the opposite of the rational model: decisions are made based on limited (or no) data, and few (or no) alternatives are assessed. In this model of decision-making, decisions are based on limited information. Although we would hope that important natural resource management decisions are made using a more conscientious effort, we acknowledge that these types of decisions often do occur. More commonly, a decision model similar to this is used, one called the *semi-rational model* (or bounded rationality) [11]. With this model, decisions are based on the best available information that can be collected during a limited time period, thus planners recognize the uncertainties and shortcomings of the databases and models. When using this decision-making model, we assume that incomplete information is the *status quo*, that a subset of alternatives are considered due to a lack of information or time, and that decision-makers will select a management alternative that is *good enough*.

A third alternative model often used (but rarely recognized) in decision-making efforts is known as the *garbage can model*, which was coined by Cohen *et al.* [12]. This model differs from the others in at least one of these aspects: (1) the goals and objectives are unclear, they may be problematic, or may be a loose collection of ideas; (2) the technology for achieving the goals and objectives is unclear, or the processes required to develop results may be misunderstood by the team members, or (3) team member involvement in the decision-making effort varies, depending on the amount of time and effort each member can devote to the tasks in the decision-making process. Cohen *et al.* [12] noted that these conditions are particularly conspicuous in public and educational group decision-making efforts. This alternative model was designed to explain situations where teams are confronted with unclear criteria for decision-making, and where goals are subjective and conflicting [10]. Without being formally introduced or recognized, this model may be more prevalent in natural resource management decision-making situations than the rational or semi-rational approaches.

Decision-making is the process of identifying and selecting management alternatives, and is based on the values and preferences of the decision-makers. In making a decision, we usually assume that several alternatives were considered, and the one selected best fits our goals and objectives. However, this is not universally the case. Risk is inherent in almost every decision we make, and very few decisions are made with absolute certainty about the outcomes and impacts, because a complete understanding of all the alternatives is almost impossible to obtain. In situations where time constraints pressure the planning process, the alternatives assessed may be limited due to the effort necessary to gather information. Plan developers must also guard against the use of selective information. That is, in some cases

planners choose to use a set of information containing only those facts that support their preconceived position. Consideration of alternative management scenarios or management pathways may help reduce the risk of making poor decisions.

Throughout this book we emphasize the need to optimize the use of a set of resources. Optimization involves strategies for choosing the best possible solution to the problem given a limit on one or more resources or given limits imposed by policies. Along the way, the optimization process hopefully evaluates as many alternatives as possible and suggests the choice of the very best option given the problem at hand. Many natural resource managers cringe at the thought of implementing an optimal plan because the human element largely has been ignored, and a number of economic, ecological, and social concerns may have not been incorporated into the problem-solving process. One of the main features of decisions related to the management of natural resources is that they may have politically relevant side effects, and as a result, decisions made using strict optimality criteria might be viewed by some as inadequate [13]. In reality, as plans are implemented, some form of satisficing occurs. In satisficing, plans are adjusted marginally to take into account those factors that were not recognized in the development of the plan. However, throughout this book we suggest the need to develop optimal decisions for managing natural resources. Beginning with the most efficient decision related to the management of resources allows you to understand the trade-offs involved when satisficing is necessary.

B. A Broad View on Planning within Natural Resource Management Organizations

Our description of a planning model is very general in nature, since the actual process used within each natural resource management organization will vary. Most decision-making processes, particularly those that involve the public or public land, include the following steps:

1. Allow public participation and comment on the management of an area.
2. Determine the goals for a management area.
3. Inventory the conditions necessary to evaluate the goals.
4. Analyze trends in land use changes and vegetative growth.
5. Formulate alternatives for the area.
6. Assess the alternatives for the area.
7. Select an alternative and develop a management plan.
8. Implement the management plan.
9. Monitor the management plan.
10. Update the management plan.

The steps may be rearranged, depending on the planning model used by various natural resource management organization. For example, the public participation step may occur later in the process, as alternatives are being formulated for the landscape. Alternatively, some steps may be omitted from planning models. In this case, planning processes associated with private landowners may forgo or minimize the use of the public participation step. However, there are a number of decision-making process consistencies among natural resource management organizations, such the statement of goals, the assessment of alternatives, and the selection and implementation of the plan.

One major difference in the planning processes for public and private land is that planning processes may be mandated for public land, and only suggested for private land. For example, United States National Forest planning efforts are required by the Forest and Rangeland Renewable Resources Planning Act of 1974. Several themes permeate the National Forest planning process and differentiate it from private land planning processes. First, it should take an interdisciplinary approach, and a team composed of professionals from several disciplines is used to integrate their knowledge and experience into the planning process. Second, the public is encouraged to participate throughout the planning process. Third, the plan being developed must be coordinated with other planning efforts of other federal, state, or local governments as well as Indian tribes. And finally, the public has the ability to appeal the decision made regarding the final forest plan. These themes make the National Forest planning process distinctly different than, say, the process used by a timber company, where public participation, coordination, and appeals may be limited. As overarching guidelines for United States National Forest planning processes, the National Forest Management Act [14], Part 219.1(a) states that:

> The resulting plans shall provide for multiple use and sustained yield of goods and services from the National Forest System in a way that maximizes long term net public benefits in an environmentally sound manner.

The importance of planning is emphasized as well, as Part 219.1(b) states that:

Plans guide all natural resource management activities and establish management standards and guidelines for the National Forest System. They determine resource management practices, levels of resource production and management, and the availability and suitability of lands for resource management.

As an example of a specific United States National Forest planning process, the Humboldt-Toiyabe National Forest (Nevada) recently embarked on a planning process for a portion of the forest (Middle Kyle Canyon). The process began with the development of data from which all future work would be based. A number of maps were generated, and presented at various scales, to help people understand the issues that affect the analysis area. The National Forest then held meetings with community and government representatives in an effort to understand their needs, their expectations, and any other relevant information regarding the planning effort. The information obtained from the meetings was then synthesized, and a set of goals for the analysis area were developed. Three management options for the analysis area were proposed, each in an effort to address, in different ways, the goals. The options represented different approaches to public use, facility development, vegetation management, and so on. The options then were analyzed to determine the impacts on economic, ecological, and social objectives, and subsequently a second round of public participation was employed. One of the options will eventually be chosen by the planning team [15].

State forest planning processes are similar to federal forest planning processes. For example, in developing the recent Elliott State Forest plan (Oregon), a core team of interdisciplinary professionals was organized, and while guided by a steering committee, they were directly responsible for managing all technical elements of the planning process [16]. The technical elements included developing current and future descriptions of the resources, developing the goals of the plan, developing strategies for reaching each goal, and finding a way to balance the competing goals through a modeling process that examined multiple alternatives. The public was involved in the process as well, through meetings, field tours, and newsletters.

Example

The managers of the Brule River State Forest (Wisconsin) developed broad goals for the forest with an emphasis on restoring, enhancing, or maintaining ecosystems. In addition, the managers of the forest constructed objectives for providing angling, hunting, canoeing, kayaking, camping, and cross-country skiing opportunities [17]. The steps that the forest used in the planning process included:

- Conduct research and gather data on the property (step 3 earlier)
- Identify key issues (step 2 earlier)
- Draft vision statement and property goals (step 2 earlier)
- Develop and evaluate a range of reasonable alternatives (steps 5 and 6 earlier)
- Develop and evaluate a preferred alternative (step 7 earlier)
- Develop the draft plan and Environmental Impact Statement (EIS)
- Distribute the draft plan and EIS for public and governing body review (step 1 earlier)
- Receive written comment
- Hold public hearings (step 1 earlier)
- Submit the draft plan, EIS, and comments to the Natural Resources Board for review
- Receive decision from Natural Resources Board
- Implement the plan (step 8 earlier)

In addition to broad vision and goal statements, the Brule River State Forest plan includes specific forestwide goals for recreation use (in the form of visitor days), watersheds (protect and maintain stream conditions), and land management (annual targets for thinning, clearcutting, prescribed burning), as well as specific objectives for areas within the forest.

Some counties and cities in the United States also have developed plans for the management of their natural resources. For example, Erie County (New York) developed a plan that has the intent of creating educational and economic opportunities, utilizing an educational center, conducting research, reducing taxes through timber sales, providing clean water, enhancing wildlife habitat, and encouraging recreational use [18]. The county developed "guiding principles" to ensure that the forest management practices suggested will build public confidence and ensure acceptance of the plan. Their strategy for achieving success is to frequently communicate the benefits of the plan to the residents of the county.

What distinguishes public land management from private land management is that usually Step 1 is limited when developing a plan for private land, and used extensively when developing a plan for public land. In addition, whereas the goals for private landowners may focus on economic values or commodity production, the goals on public land are generally broader (recreation, wildlife, water, timber, etc.). Finally, the planning process, particularly when

performed by industrial landowners, is repeated every year or two, whereas on public land the process may be repeated at much longer intervals (5 or 10 years).

Example

Molpus Timberlands Management, LLC, based in Hattiesburg, Mississippi, is a private timberland investment organization that is active in acquiring and managing forested properties. For each of their properties they implement a planning process to determine the management approach given the goals and objectives of their investors. The steps that they use in their planning process include:

- Collect pre-planning data about the forested property (step 3 earlier)
- Develop the forest planning team
- Assess local conditions, markets, and other limitations (step 3 earlier)
- Get field foresters to take ownership in developing the management plan (step 1 earlier)
- Identify the main objective and all relevant constraints for the forested property (step 2 earlier)
- Conduct stratification of inventory (step 4 earlier)
- Develop management regimes (step 5 earlier)
- Calibrate and test growth and yield models and expected silvicultural responses to allow for the development and evaluation of alternatives
- Select harvest scheduling tools and methods
- Formulate a plan (step 5 earlier)
- Initialize and solve unconstrained planning model (step 5 earlier)
- Review and provide feedback of the forest plan by the forest planning team (step 6 earlier)
- Improve models and conduct subsequent opportunities for review and feedback as deemed necessary (step 6 earlier)
- Select final planning model (step 7 earlier)
- Report results to the forest planning team for evaluation of strategic and tactical concerns
- Construct "what if" scenarios and track results (step 6 earlier)
- Implement the plan (step 8 earlier)
- Update and improve the plan over time (steps 9 and 10 earlier)

One distinct feature of this process is that it incorporates constant feedback and exchange between the field staff and the planning office. In general, Timber Investment Management Organizations (TIMOs) commonly try to maximize the net present value of their clients' timberland investments through commodity production activities. Some common constraints that they face involve the state of the ending inventory (standing volume at the end of the time horizon associated with the plan) and involve the product and harvest volume stipulations contained within wood supply agreements.

C. A Hierarchy of Planning within Natural Resource Management Organizations

Planning, at a small or large scale, can be viewed as a hierarchy (Figure 1.2). At the highest level in the hierarchy are strategic planning processes, which focus on the long-term achievement of management goals. Here, goals such as the development of wildlife habitat or the production of timber harvest volume usually are modeled over long time frames and large areas and are general in nature. Spatial aspects of management plans generally are ignored here, although with recent advances in computer technology and software, there are fewer reasons to avoid these issues in strategic planning. At lower levels of the planning hierarchy spatial relationships usually are recognized. For example, in tactical planning processes, issues such as the location of management activities over space and time are acknowledged. Plans that involve spatial habitat models are tactical plans, because the locational relationships between habitat units (usually timber stands) are recognized. This level of planning identifies site-specific actions that contribute to the larger purpose of the plan, but the technical details of implementing the actions are limited.

At the lowest level in the hierarchy is operational planning. This is the day-to-day, weekly, monthly, or annual planning that is required to actually

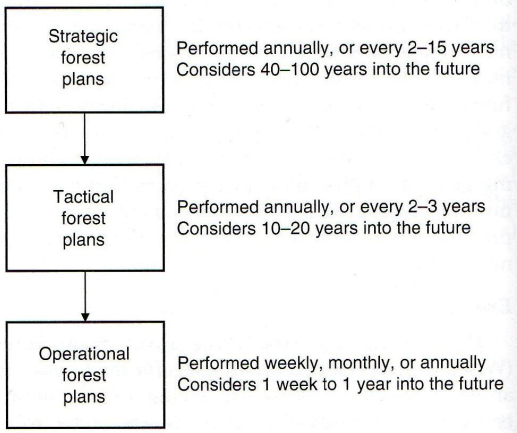

FIGURE 1.2 A hierarchy of natural resource planning processes.

implement a management action. Some examples of this type of planning include scheduling seedlings for the planting season, loggers for harvest areas, equipment for stream improvement projects, or fire crews for prescribed burning efforts. Operational plans (weekly, monthly, annually) are guided by tactical plans (annually, biannually), which are guided by strategic plans (longer term). The level of detail increases as we move from strategic to operational planning. Conversely, the number of people involved increases from operational to strategic planning. Although many natural resource management organizations develop and use management plans, they may not use all three types. Most, in fact, have developed a strategic plan and use various forms of operational plans. Each level of planning has been enhanced with the expanded use of geographic information systems, which give us the ability to view resource conditions and management scenarios quickly, and let us recognize spatial relationships among resources at lower levels of planning.

As a recreation or range manager, forester, wildlife biologist, soils scientist, or hydrologist, sometime in your career (perhaps immediately) you will be involved in decision-making and planning processes. At a minimum, you may be placed in a position to manage summer students or interns, and subsequently manage the budget required to pay their salaries. It is not uncommon, however, for an entry-level forester to be placed in charge of a planting or site preparation program, or for a biologist to manage a budget related to habitat improvements. How you decide to allocate the budget to the alternatives at your disposal requires quantitative analysis and decision-making techniques. Further, at some point in your career, you will likely be asked to provide input to one or more of the three general types of planning processes. This description of the different types of planning processes was admittedly brief, however Chapter 13 is devoted to a more extensive treatment of the hierarchical system.

D. Community or Cooperative Planning of Forests

Collaborative forest management, or community forestry, is a system where communities and governmental agencies work together to collectively develop a plan for managing natural resources, and each share responsibilities associated with the plan. The idea of a community-driven forest management and planning process is not new. Brown [19] discussed the concept over seventy years ago, and noted some requirements for community forests in North America:

> To initiate a community forest, one would require cheap land, large areas of forests near towns or cities, markets that are nearby.

Improvements in forest protection and ecological values often are noted as some of the benefits of these types of forest management programs. However, in developing countries, community interest in these programs generally is based on basic needs for fuel, timber, food, and other nontimber forest products, and when these are marginally available the interest in collaborative planning and management may wane [20]. Aspects of successful collaborative planning programs include measurable benefits (financial and others) from which the community can gain, local organizational control over the natural resources, and an absence of governmental control [21]. These types of management and planning systems require that groups reach consensus on contentious forest-related issues, and find agreement on the use of communal forest resources. The planning process may be lengthy and challenging, particularly when environmental and economic objectives are both important [22].

Admittedly, much of the discussion and analysis within this book assumes that planning processes occur within a single property and involve a single landowner. However, cross-ownership planning, or cooperative management, has been suggested as a way in which the effects of forest fragmentation can be mitigated, and as a way to improve the economics associated with small-scale decisions. Stevens *et al.* [23] suggested from a survey of nonindustrial landowners in the northeastern United States that over half would either be interested in sharing the costs associated with recreation projects, or be interested in adjusting the timing of management activities such that they are concurrent with those of other landowners. There may be a spatial context associated with this form of collaborative planning, since it may be feasible only for landowners within some proximity to others. In addition, some landowners may require observation of such collaboration before choosing to enter into agreements with their neighbors [24].

E. Adaptive Management and Planning of Forests

Adaptive management and planning involves many of the same planning processes as we have described in this chapter, with one exception. When utilizing this approach, a monitoring phase is specifically employed to provide feedback to the planning stages, which could allow the management plan of a property to better recognize some of the uncertainties related to

management activities. With this approach, the success or failure of management actions to produce the desired effects are evaluated both quantitatively and qualitatively. The conditions under which management activities fail to produce the desired outcomes are considered, and revised management prescriptions, constraints, or objectives are developed. An updated plan is then developed using the adjusted, and perhaps improved, management prescriptions, goals, and objectives. Grumbine [25] suggests that adaptive management is a learning process, where the outcomes from previous management experiences are evaluated and allow land managers to adapt to uncertain situations. Adaptive management and planning has been closely associated with *ecosystem management* on some public lands in North America; however, we could extend the notion of adaptive management to the short-term tactical plans developed by many timber companies as well. Here, updated information is collected annually in many cases, and plans are adjusted given the changing circumstances of the landscape, markets, and landowner objectives.

V. CHALLENGES RELATED TO FOREST PLANNING

Planning and decision-making processes often are hampered by a number of challenges internal to an organization. These include technological limitations (obsolete computer systems, inadequate software programs, and so on), personnel issues, lack of data, and limited support from an organization's management team. For example, the state of the technology used within natural resource organizations comes as a mildly disappointing surprise, sometimes, to newly hired young professionals. Technology may be so obsolete that it becomes the bottleneck in the planning process (e.g., an alternative may take hours to generate and report). Overcoming this challenge to forest planning may require planning itself. To correct this situation, for example, we may need to develop an estimate of the budget that would be required to purchase new equipment (i.e., gather information), then assess the alternatives (purchase system X or system Y), and finally, make a decision.

In many forest planning processes, the development of data can account for nearly half (or more) of the time spent in the planning process. What we are referring to here include geographic information system (GIS) databases, growth and yield data for each management prescription, prices, costs, measures of potential habitat quality, and levels of constraints that will be applied. Collecting, managing, correcting, and formatting this data generally is performed by several people in a natural resource organization, and is, unfortunately, one of the most underappreciated tasks by upper-level management. People's motivation to assist with the planning process is also a challenge, perhaps hinting that the semi-rational or garbage can approach is being used. One of the frequent reasons for this attitude among people is the perception that the success of an organization does not depend on the timely development of a new plan. We have mentioned only a few of the challenges, but the suite of setbacks that could occur is broad, and few planning processes can avoid them entirely. However, many of the challenges to planning that are internal to a natural resource management organization can be overcome, if they are recognized and acknowledged.

VI. INFORMATION MOVEMENT WITHIN A TYPICAL NATURAL RESOURCES MANAGEMENT ORGANIZATION

During a typical planning cycle of a medium-sized natural resource management organization, field-level managers are implementing natural resource management plans and collecting data about the resources to the best of their ability. Within this period of time, numerous treatments may be prescribed, natural disasters may occur, and land may change owners. Near the end of the cycle, data related to changes in the resources are compiled by the field managers and sent to a central office, where the "corporate" databases are updated and new plans are designed and selected (Figure 1.3). The cycle occurs on a yearly basis in some industrial forestry organizations, and occurs over a longer period of time in some public land management agencies. However, what should be of interest to young natural resource professionals beginning their careers as field managers are three thoughts: (1) the quality of the resulting management plan depends on the data provided to the planners by yourself and your colleagues, (2) the plan itself is developed through a process that you should understand, because you will be implementing the plan, and you should know how it was developed (the general quantitative methods used to generate outcomes for each alternative) and how it was selected (the type of planning process that was used), and (3) the operational details of your daily activities are related to both the tactical and the strategic goals of the organization.

With the movement to field-level use of geographic information systems and the notion that recent graduates should be more computer literate than their

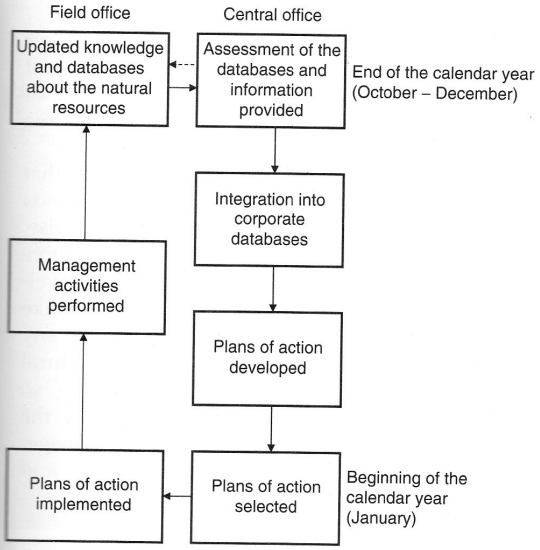

FIGURE 1.3 Movement of information during a planning cycle.

predecessors, more responsibility on data quality and data development is being placed on field-level land managers. Although central offices may still monitor and control the data standards, young professionals are being asked to enter jobs with these skills already in hand. Hopefully, you will gain some of these important skills as you work through this book.

VII. SUMMARY

Quantitative and qualitative planning methods are meant to assist the human mind in determining objectively rational courses of action. Planning methods are employed to help us sort through and understand the complexities inherent in our management alternatives. As economic and ecological conditions change, and as society's impression of how the landscape should be managed change, we need to address how our management of natural resources should change. This requires a planning process, which is facilitated by information, such as field data, potential management prescriptions, and forest plan alternatives. To be able to use quantitative methods, we may make simplifying assumptions so that problems are tractable (useable). Therefore, the most we should expect from the results is "guidance" for how natural resources should be managed. As a natural resource manager, you will also need to rely on your judgement in making decisions.

This book covers some concepts that will be important to your careers in natural resource management. These concepts include an overview of measures of forest structure, forest growth dynamics, economic evaluation methods, and planning techniques. Although these subjects may seem daunting or displeasurable, rest assured that there are few positions in natural resource management that avoid them entirely. Economics commonly is used to help us objectively sort through the various management choices available. Planning helps us organize the alternatives for the land we manage, and provides a framework for comparing and choosing among these alternatives. Thus at some point in your career you will be involved, for better or worse, in forest and natural resource planning. The concepts we cover in this book should not only be of value in your career, but should also be of value in your personal lives, particularly the subject of the "time value of money."

QUESTIONS

1. *Assessment of a forest plan.* Either through a search of the Internet, or through an investigation of the forest plans contained in your college's library, locate a federal, state, or county forest plan. From the official documentation of the plan, report the following two features:
   a) What goals or objectives guided the development of the plan?
   b) What were the steps used in the planning process?
2. *Forest planning process.* Assume you are employed by a small natural resource consulting firm (three people), and you needed to develop a management plan for a private landowner in central Pennsylvania. What types of internal (to your consulting firm) organizational challenges related to the development of the management plan should you consider?
3. *Types of forest planning processes.* Assume you are employed by a small forest products company in northern Minnesota, and the owner of the company wants your team (several foresters, a biologist, an engineer and a few technical staff

managing the inventory and geographic information system) to develop a strategic forest plan for the property that you manage. The owner has suggested that they want a rational plan to be developed, one that explores several alternatives. Develop a one-page memorandum to the landowner describing the three general types of planning processes, and the advantages and disadvantages of each.

4. *Cooperative planning and adaptive management.* Assume that you are a natural resource management consultant in a small town in central New York. As part of your nonprofessional life, you serve on your town's land planning committee. The committee is actively involved in the management of a small public forest within the town's limits, yet none of the other committee members have your natural resource background. They have mentioned at various points in time over the last year the need for adaptive management and cooperative planning. Develop a short memorandum for the committee that describes the two approaches.
5. *Public and private forest planning.* Assume that you are having dinner with some of your friends and during the various conversations that arise, you learn that one of them has a very negative opinion of how management plans are developed for public lands. Further, they dislike how private landowners seem to not do any planning at all for the management of natural resources. These are generalities, of course, so to help clarify the matter, describe briefly the similarities and differences between management plans developed for public land and private land.

References

1. Heiligmann, R.B. (2002). "Forest Management, Developing a Plan to Care for Your Forest." School of Natural Resources, Ohio State University, Columbus, OH. Extension Fact Sheet F-34-02.
2. Palmer, B. (2000). "Forest Management for Missouri Landowners." Missouri Department of Conservation, Jefferson City, MO. 108 p.
3. Janota, J.J. and Broussard, S.R. (2008). Examining private forest policy preferences. *Forest Policy and Economics.* **10**(3), 89–97.
4. Demers, C., Long, A., and Clausen, R. (2001). "What is in a Natural Resource Management Plan?" School of Forest Resources and Conservation, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL. Extension Report SS-FOR-14.
5. Siry, J.P., Cubbage, F.W., and Ahmed, M.R. (2005). Sustainable forest management: Global trends and opportunities. *Forest Policy and Economics.* **7**(4), 551–561.
6. Cohen, S.G. and Bailey, D.E. (1997). What makes teams work: Group effectiveness research from the shop floor to the executive suite. *J. Management.* **23**(3), 239–290.
7. Bettenhausen, K. (1991). Five years of group research: What we have learned and what needs to be addressed. *J. Management.* **17**(2), 345–381.
8. Salas, E. (1995). Military team research: Ten years of progress. *Military Psychology.* **7**(2), 55–75.
9. Smith, C.L., Sr. (1998). *Computer-Supported Decision-Making: Meeting the Decision Demands of Modern Organizations.* Ablex Publishing Corp., Greenwich, Connecticut. 172 p.
10. Mian, S.A. and Dal, C.X. (1999). Decision-making over the project life cycle: An analytical hierarchy approach. *Project Management Journal.* **30**(1), 40–52.
11. Simon, H. (1972). Theories on bounded rationality. In *Method and Appraisal* (C. Radnor and R. Radnor, Eds.), 161–176. North-Holland, Cambridge, U.K.
12. Cohen, M.D., March, J.G., and Olsen, J.P. (1972). A garbage can model of organizational choice. *Administrative Science Quarterly.* **17**(1), 1–25.
13. Gezelius, S.S. and Refsgaard, K. (2007). Barriers to rational decision-making in environmental planning. *Land Use Policy.* **24**(2), 338–348.
14. United States Congress. (1990). "National Forest Management Act Regulations. Title 36 — Parks, Forests, and Public Property, Chapter II — Forest Service, Department of Agriculture, Part 219 — Planning, Subpart A — National Forest System Land and Resource Management Planning."
15. U.S. Department of Agriculture, Forest Service. (2005). "Middle Kyle Complex." U.S. Department of Agriculture, Forest Service, Humboldt — Toiyabe National Forest, Sparks, NV. http://www.fs.fed.us/r4/htnf/projects/smnra/middle_kyle_complex/home.shtml. (Accessed 3/15/08).
16. Oregon Department of Forestry. (2004)."Elliott State Forest Management Plan, Draft." Oregon Department of Forestry, Salem, OR.
17. Van Horn, K., Brokaw, K., and Petersen, S. (2003). "Brule River State Forest Master Plan and Environmental Impact Statement." Wisconsin Department of Natural Resources, Madison, WI. PUB-FR-225. 261 p.
18. Grassia, B. and Miklasz, C. (2003). "Erie County Forest Management Plan (Draft): Creating Sustainable Forests in Erie County for the 21st Century." Erie County Department of Parks, Recreation and Forestry, Buffalo, NY. 277 p. http://www.erie.gov/parks/forestry_management_plan.asp. (Accessed 3/15/08).
19. Brown, N.C. (1938). Community forestry: A neglected phase of the American forestry system. *J. Forestry.* **36**(7), 687–694.
20. Matta, J. and Kerr, J. (2006). Can environmental services payments sustain collaborative forest management? *J. Sustainable Forestry.* **23**(2), 63–79.
21. Crook, B.J. and Decker, E. (2006). Factors affecting community-based natural resource use programs in southern Africa. *J. Sustainable Forestry.* **22**(3/4), 111–133.

22. Konstant, T.L., Newton, A.C., Taylor, J.H., and Tipper, R. (1999). The potential for community-based forest management in Chiapas, Mexico: A comparison of two case studies. *J. Sustainable Forestry*. **9**(3/4), 169–191.
23. Stevens, T.H., Dennis, D., Kittredge, D., and Richenbach, M. (1999). Attitudes and preferences toward co-operative agreements for management of private forestlands in the Northeastern United States. *J. Environmental Management*. **55**(2), 81–90.
24. Brunson, M.W., Yarrow, D.T., Roberts, S.D., Guynn, Jr., D.C., and Kuhns, M.R. (1996). Nonindustrial private forest owners and ecosystem management: Can they work together? *J. Forestry*. **94**(6), 14–21.
25. Grumbine, R.E. (1994). What is ecosystem management? *Conservation Biology*. **8**(1), 27–38.