Forestry and Biodiversity

Edited by Fred L. Bunnell and
Glen B. Dunsworth

Forestry and Biodiversity
Learning How to Sustain Biodiversity in Managed Forests

UBCPress · Vancouver · Toronto

20 19 18 17 16 15 14 13 12 11 10 09 5 4 3 2 1

Printed in Canada with vegetable-based inks on FSC-certified ancient-forest-free paper (100 percent post-consumer recycled) that is processed chlorine- and acid-free.

Library and Archives Canada Cataloguing in Publication

Forestry and biodiversity : learning how to sustain biodiversity in managed forests / edited by Fred L. Bunnell and Glen B. Dunsworth.

Includes bibliographical references and index.
ISBN 978-0-7748-1529-1

1. Biodiversity conservation – Case studies. 2. Forest management – Case studies. 3. Adaptive natural resource management – Case studies. 4. Sustainable forestry – Case studies. 5. Forest ecology. 6. Conservation biology. 7. Coastal forests – Management. 8. Rain forests – Management. I. Bunnell, Fred L., 1942- II. Dunsworth, Glen B., 1952-

QH75.F67 2009 333.95’16 C2008-906491-7

Canada

UBC Press gratefully acknowledges the financial support for our publishing program of the Government of Canada through the Book Publishing Industry Development Program (BPIDP), and of the Canada Council for the Arts, and the British Columbia Arts Council.

This book has been published with the help of Cascadia Forest Products and the K.D. Srivastava Fund.

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The University of British Columbia
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Vancouver, BC V6T 1Z2
604-822-5959 / Fax: 604-822-6083
www.ubcpress.ca

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Preface

This book arose from an attempt to solve a complex, real-world problem – how do we sustain biological diversity in managed forests? MacMillan Bloedel harvested natural forests in coastal temperate rainforest, largely on public land. It had the largest forest holdings in coastal British Columbia and faced effective market campaigns to stop clear-cutting of old growth and reduce its harvest. In 1998, the company adopted a completely new form of forestry that it believed could be shown to sustain native species richness in coastal temperate rainforests. Shortly after making this commitment, MacMillan Bloedel was acquired by Weyerhaeuser Company. Weyerhaeuser maintained the commitment to evaluating ecological consequences of forest practices, so efforts to learn how to sustain biodiversity in managed forests also continued. The forest planning and practices introduced (zoning and variable retention) were novel, as was the large-scale effort to evaluate the effectiveness of these practices within an adaptive management program.

As part of its quality control in developing and implementing its adaptive management program, Weyerhaeuser hosted meetings of an International Scientific Advisory Panel. Panel members were recognized experts drawn from Australia, Europe, Canada, and the United States. These members praised the efforts and accomplishments of the adaptive management program and were instrumental in Weyerhaeuser receiving the Ecological Society of America's Corporate Award in 2001. The panel also urged the authors to publish the approach, yielding this book.

The book is divided into three parts. Part 1, "Introduction," introduces the generic nature of the problem, including elements of wicked problems and complex challenges faced by forest managers, plus a potential solution to the problem, an effective adaptive management program. Part 2, "The Indicators," treats the major indicators of success in sustaining biological diversity and learning acquired from evaluating these indicators. Part 3, "Summary," summarizes the monitoring design for the adaptive management program, noting elements that must be considered and summarizing lessons learned.

To present this process of learning how to sustain biodiversity in managed forests, we draw on literature from six continents but present it in the context of a real-world case study. Employing a specific case study has the benefit of linking abstract concepts to the real world of unyielding topography, nature's frequent caprice, and economic constraints. It does this for a coastal temperate rainforest – historically the most controversial forest type in the northern hemisphere. Conflicts between the extraction of wood and other forest values in this region are often magnified, frequently to national and international levels. The area is also uncommonly rich in species among northern temperate regions, thus presenting a significant challenge to efforts to sustain biological diversity.

Material summarized in this book is the product of a great many individuals – both researchers and practitioners of forestry. The authors are those who had responsibility for distilling those contributions into an accessible story.

Bill Beese chaired the Variable Retention Working Group that developed guidelines for implementation of retention systems and conducted implementation monitoring. He is trained as a forest ecologist and silviculturist and worked in ecological classification, reclamation, prescribed fire, and silvicultural systems research for twenty-five years with MacMillan Bloedel and Weyerhaeuser. He has great respect for the foresters and loggers who put the theory of retention into practice and managed to improve safety performance at the same time.

Fred Bunnell held the senior forest renewal chair in conservation biology at the University of British Columbia for fifteen years, where he is now professor emeritus. During that period, he was for ten years director of the Centre for Applied Conservation Biology. He was trained as a forester and received six provincial, national, and international awards for applied research. He has also served on more than eighty resource management committees and panels, many of which have dealt with contentious issues. He admits that the problem addressed in this book is the most complex and most frustrating one on which he has worked.

Glen Dunsworth chaired the Adaptive Management Working Group that conducted the field studies and helped to design the program. He was trained as a genecologist and worked in regeneration research, genetics, and modelling and conservation biology for twenty-five years with MacMillan Bloedel and Weyerhaeuser. He believes that this case study reflects the realities of design and implementation of adaptive management in an industrial setting, a truly challenging learning experience.

Dave Huggard is a research associate at the University of British Columbia and an independent consultant in forest ecology. He has an MSc in animal ecology and a PhD in forestry. He is a lapsed naturalist and field biologist, an aspiring statistician, and currently most interested in how we can obtain and use reliable knowledge in natural sciences. These interests have led him to roles in a variety of integrated forest ecology projects, including as a member of the Adaptive Management Working Group.

Laurie Kremsater is a research associate at the University of British Columbia and a consultant in forest wildlife ecology. Trained in forestry and wildlife ecology, she has worked in conservation biology and forestry for twenty years, primarily with vertebrates and their forest habitats. She has served on a number of land use planning teams, including the Clayoquot Scientific Panel, she has co-ordinated a variety of integrated forest ecology projects, and she has been a member of the Adaptive Management Working Group that addressed the challenges described in this book.

Acknowledgments

This book and the journey of the Forest Project comprise an example of corporate leadership responding to concerns of social licence – social expectations beyond the law that a corporation must meet. The project would not have been possible without the determination and vision of CEO Tom Stephens, Chief Forester Bill Cafferata, and the MacMillan Bloedel Board of Directors. The corporate critical thinking and Forest Project strategy were the product of intense and focused teamwork facilitated by Dennis Fitzgerald and led by Glen Dunsworth and Fred Bunnell (ecology); Bill Beese, Ken Zielke, and Bryce Bancroft (silviculture); Nick Smith and Steven Northway (growth and yield); Tom Holmes, Lorne High, Walt Cowlard, Marv Clark, Ray Krag, and Lorne Pelto (Harvesting); Robert Prins, Bill Stanbury, Ian Vertinsky, and Casey Van Kooten (economics); and Linda Coady, David McPhee, Bill Shireman, Terry Morely (social aspects).

Heightened awareness of social licence and partnership in applying the science behind the project was provided by ENGOs including the Natural Resources Defense Council, Greenpeace Canada, Western Canada Wilderness Committee, Sierra Legal Defence Fund, Ecotrust Canada, World Wildlife Fund, and Sierra Club of British Columbia. We are specifically grateful for the advice and intellectual support provided by Jody Holmes, Rachel Holt, and Matt Price.

Putting the project on the ground could not have happened without the dedicated work of MacMillan Bloedel and Weyerhaeuser field foresters and engineers and the members of the Variable Retention Working Group, including the assistance and guidance of Ken Zielke and Bryce Bancroft.

The adaptive management framework was the product of the collaborative efforts of the scientists in the Adaptive Management Working Group (which the authors helped coordinate). We thank Lynn Baldwin, Mark Boyland, Wayne Campbell, Emina Krcmar, Ann Chan-McLeod, Renata Outerbridge, Kristiina Ovaska, Isobel Pearsall, Mike Preston, Kella Sadler, Lennart Sopuck, Nick Stanger, Tony Trofymow, Pierre Vernier, and Elke Wind. We are especially indebted to Jeff Sandford for his intrepid work and gentle hand in coordinating this disparate group, providing for their field needs and safety, and carefully integrating all their data into a geo-referenced database.

The annual review and advice of the science panel were two of the most helpful aspects of the project. The panel reviews provided a third-party validation of the work and an opportunity to share in the development of the science and aid in its implementation. More importantly, given the stature of the scientists chosen, the panel provided global recognition of the novelty of the work. The support and leadership of Jerry Franklin, David Lindenmayer, Bruce Marcot, Reed Noss, and M.A. Sanjayan were instrumental in sustaining the effort and guiding the science.

We appreciate the corporate and government funding without which much of the science could not have been developed. We received corporate funding from MacMillan Bloedel, Weyerhaeuser, and Cascadia Forest Products and grants from the BC Enhanced Forest Management Pilot Project, BC Forest Science Program, BC Forest Investment Account, Canadian Forest Service, Forest Renewal BC, National Science and Engineering Research Council, and Social Sciences and Humanities Research Council.

Comments of anonymous reviewers improved the manuscript.

Finally, we thank our partners and families for their love, patience and sacrifice for those innumerable times when we were away from home and in front of the computer late at night. Without their support, the project and this book would not have been possible.

Part 1: Introduction

Part 1 provides the context for much of this book and the book's focus on learning how to sustain biological diversity in managed forests. It describes the problem, the major case study, and the general approach employed. It also reviews the implementation-monitoring program that was necessary because a new approach to forestry had been undertaken.

As noted in Chapter 1, the problem addressed is that of managing to sustain biodiversity in managed forests. It is a wicked problem with interrelated, interdependent parts encompassing diverse values. We cannot maximize our efforts to produce wood products or to sustain biodiversity without harming the other major objective. The single objective of sustaining biodiversity in forested systems confronts special difficulties. Among them are international agreements that have encouraged policies and practices well ahead of direct experience, thus placing forest practitioners in a situation of playing "catch-up" and having to learn as quickly as possible. The most effective way of learning while implementing new planning and practices is adaptive management. The broad goal of this book is to illustrate an approach to learning how to sustain biodiversity in managed forests. It describes a process for learning, not a tidy recipe for success.

Chapter 2 presents the case study used to illustrate the process. The area is about 1.1 million hectares in rugged terrain, primarily within the coastal temperate rainforest, hosts some of the largest, longest-lived trees in North America, and has attracted market campaigns to limit forest practices. The turbulent social environment led the forest company to adopt novel approaches to forest planning and practice. Although these approaches were well reasoned, their consequences were unknown. The company implemented an adaptive management program to evaluate the effectiveness of practices, new structures to help the program work, and an extensive monitoring program to provide feedback on its actions to practitioners and policy makers. This book draws on experiences from six continents but expresses much of it around a single, complex case study. Among the advantages of employing a case study is linking abstract concepts to the real world.

Chapter 3 describes the approach taken to the problem in terms of four questions that managers confront when addressing any complex problem. Where do we want to go? How do we get there? Are we going in the right direction? How do we change if the direction is wrong? These four questions reflect the four steps critical to creating an effective adaptive management program: (1) clearly defined objectives, (2) planning and practices to attain those objectives, (3) ways to assess proximity to those objectives, and (4) ways to modify practices if those objectives are not attained (links to management action). In Chapter 3, we provide an overview of how these steps were pursued in the major case study from coastal British Columbia.

The bulk of this book is devoted to the rationale, implementation, and interpretation of the indicators used to assess success and the overall design and implementation of the adaptive management program. That is, much of the book is about effectiveness monitoring. However, the approach to both forest planning and practice is novel. The company also had to employ implementation monitoring that recorded the rate at which it was attaining corporate goals for the implementation of new practices and the degree to which the practices were adhering to principles outlined by the company. Chapter 4 describes the implementation-monitoring program.

1
The Problem

Fred L. Bunnell, Glen B. Dunsworth, David J. Huggard, and Laurie L. Kremsater

1.1 "Wicked" Problems

When the term "ecosystem" was coined, the "system" part was invoked to represent the remarkable number of interactions that occur among components of any chunk of nature (Tansley 1935). The practice of forestry modifies ecosystems and changes the nature of interactions within an ecosystem and its ability to provide different values that we desire. Society desires a variety of values from the forest, some of them competing. Management of forests becomes a challenge of dealing with organized complexity and directing clusters of interrelated parts toward specific ends. Problems that cannot be resolved by treating these clusters in relative isolation Ackoff (1974) termed "messes." He argued that we fail more often because we solve the wrong problem than because we get the wrong solution to the right problem. Ackoff (1974), King (1993), and others[1] noted that using techniques of systems analysis, we could solve many seemingly intractable problems by examining interactions among parts rather than breaking problems into separate parts and fixing individual components. Others argue that some problems defy any form of analysis and are insoluble in terms of a simple "yes" or "no" answer. They term such problems "wicked."[2] There is no moral sense to this use of the word but a recognition that some problems defy tidy solutions no matter the efforts and good intentions directed toward them.

Wicked problems arise when the boundaries of messes expand to include sociopolitical and moral-spiritual issues (King 1993). They have been defined as a "class of social systems problems which are ill-formulated, where the information is confusing, where there are many clients and decision-makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing" (Buchanan 1992, 15).

Many of the challenges facing natural resource management fit the definition of wicked problems (Allen and Gould 1986; Barrie, McCool, and Stankey 1988; Shindler and Cramer 1999; Wang 2002). That is certainly true of efforts to design an approach to sustaining biological diversity in managed forests. When designing an approach to management, we typically engage in a kind of linear thinking that entails two major phases: problem definition and problem solution. In the problem definition phase, all elements of the problem are systematically analyzed, while in the solution phase, these elements are synthesized into a solution. We use this approach believing that it offers the best hope of a logical solution to a problem. That is especially true in many optimizing models used to create harvest schedules in a managed forest. With wicked problems, it is not possible to clearly define the problem, let alone the solution.

We illustrate more completely in the following sections why sustaining biodiversity in managed forests is a wicked problem. Here we consider generic elements of such problems and their implications. Among their features are that

- they can be described in different ways that have different solutions – there is no one way to formulate the problem;
- the problem is unique;
- there is always more than one plausible explanation for outcomes;
- there is no single right or true test for a solution; and
- the solutions cannot be true or false, although they can be more or less effective (see Rittel 1972 and Rittel and Webber 1973, 1984).

Few argue that they have found *the* approach to sustaining biological diversity in managed forests. The first feature of wicked problems indicates that we should not become wedded to any single approach. It appears equally true that every specific example of the generic problem is unique. Over the past decade, we have addressed sustaining biodiversity in managed forests in several regions. Factors ensuring that each case was unique included the social and economic environment, the size of the area, tree species present, other organisms present, typography, harvest methods, and the disturbance history. This feature of wicked problems implies that what we offer in this book is an approach to learning to solve the problem in ways that can be no more than broadly effective – details will vary among areas. The third feature (more than one plausible explanation or mechanism for observed outcomes) clearly applies to the problem of sustaining biological diversity, in part because interconnections in nature encourage alternative mechanisms and because many spatial, temporal, and cumulative effects are poorly understood. That is why we have subtitled this book *Learning How to Sustain Biodiversity in Managed Forests*. It is the process of learning that we describe, not a tidy solution. The absence of a single best test of approaches is frustrating to a researcher and severely challenges some practitioners, policy makers, and other decision makers. We can take heart from the last feature noted –

providing that we focus on what we can agree is more or less effective rather than what is right or wrong. Combined, the features suggest that we are likely to agree only on a direction rather than a prescription. That argues for the use of adaptive management and suggests that we generally learn more from comparisons among alternative practices than from comparisons of specific targets (§5.3).

1.2 Expanding and Competing Values

The values that we ascribe to biodiversity or economic returns are often strongly held and frequently in conflict. They help to make the problem we address a wicked one. In some instances, these values have deep historical roots but have evolved in ways that make the practitioner's life more complex and confused. In his classic silvicultural textbook, D.M. Smith (1962, 369) wrote that "there is hardly any objective more ancient and honorable ... [than sustainable yield]." Indeed, foresters have pursued sustainable yield since the late Middle Ages, when coppice forests were managed to guarantee a perpetual supply of fuel (Knuchel 1953). Only one tradition in forestry is older.[3] Joint management of forests and wildlife began at least 500 years before the first efforts at sustainable yield in coppice systems. Our word *forest* (*forestis*) first appears in 556 CE to describe a tree-covered area in which hunting and fishing rights were preserved for King Childebert I (Glacken 1967, 325). The concept of sustainability for more than one resource is well entrenched in forest practices. What has expanded rapidly is the number of values to be sustained.

Values desired from forests have continually changed but never so rapidly as in the past three decades. Rapid expansion began with the environmental movements of the 1970s and gained momentum in 1987 when the Brundtland Commission introduced the concept of "sustainable development." That concept considered *all* resources and came to mean not just the uninterrupted flow of a particular product but also retaining resources for *future alternative* uses. These uses were unknown and thus unspecified. Biodiversity was mentioned only twice in the commission's report (Brundtland 1987, 148, 157). Just five years later, the Earth Summit in Rio de Janeiro produced three international documents directly addressing biological diversity in forests.[4] The scope of responsibility for land managers, particularly forest managers, had broadened enormously to include things that had not yet been named or identified. We often fail to appreciate the relatively slow rates at which some forests change. At the time of the Earth Summit in 1992, not all consequences of forest practices initiated fifty years earlier were evident. Compared to the common pace of events in forestry, or to common progress surrounding international agreements, the pace was extremely rapid. For some newly emphasized values, there was almost no experience in developing forest planning and practices to sustain them. Sustaining biological diversity has proven to be the greatest challenge, and "policy created to sustain biological diversity is well ahead of research and understanding" (Bunnell and Chan-McLeod 1998, 7). The fact that enacting policy has preceded research or experience on how to enact it is a serious challenge. The challenge is amplified because some desired values are competing.

Competition is most evident between biological diversity and wood products. In both temperate and tropical regions, species richness is greater in tall, well-stratified forests than in vegetation of lower stature (Bunnell and Kremsater 1990; Wilson 1988). In many areas, forests also contribute significantly to regional economies and help to support amenities. Managers thus confront two potentially competing goals: (1) to extract renewable wood products from the richest terrestrial ecosystems on Earth, and (2) to maintain biological diversity.

While addressing this competition, we should be mindful that wood is a renewable resource and that the creation of wood products is more environmentally friendly than that of many substitute products. Lumber, for example, is highly energy efficient compared with other construction products, requiring only 580 kilowatts per tonne to produce. In contrast, aluminum requires about 73,000 kilowatts per tonne, plastics 3,480, and cement 2,900.[5] In most instances, the production of forest products produces a smaller "ecological footprint" than does the production of alternatives. Likewise, there is little evidence suggesting that production of wood products and associated economic contributions cannot be sustained indefinitely when appropriately managed.[6] However, there is increasing evidence that some forest practices will not permit the long-term maintenance of forest-dwelling species (Angelstam 1997; Berg et al. 1994; Morrison and Raphael 1993; O'Hara et al. 1994; Spies, Franklin, and Thomas 1988). Because the major cause of species' decline appears to be habitat loss (Diamond 1984; Hayes 1991; Wilcove et al. 1998), it is important to understand how forest practices modify habitat and associated species. The challenge is to sustain biological diversity while extracting wood products.

Describing this challenge, Bunnell observed that "[foresters] are proceeding at great speed, over very difficult terrain, towards an unknown goal" (1998a, 822). We have acknowledged the speed. We next examine why the terrain is so difficult, and we present our efforts to clarify the goal in §3.2.1.

1.3 Special Difficulties in Forests

Of all terrestrial systems, forests contain the largest and most long-lived components. The long lives of many tree species, the spatial extent of forests, and the social perceptions of forests combine to create special difficulties in managing to sustain biological diversity. Bunnell and others noted five (Bunnell and Chan-McLeod 1998; Bunnell, Kremsater, and Wind 1999).

1 For historical and social reasons, forest practitioners bear an uncommon responsibility for sustaining biological diversity. In western North America, for example, both forestry and agriculture provide highly valued crops, but only forestry is consistently charged with sustaining biological diversity. This condition appears to result from history (some species evicted by agriculture have survived in forests: e.g., grizzly bears and wolves) and from greater social value being placed on food crops than on wood products. Both species richness and genetic richness are under greater threat from agriculture than from forest practices (Askins 1993; Dobson et al. 1997; Hamrick, Mitton, and Linhart 1979; McCracken 2005).

2 More species reside in forests than in other plant communities. Monitoring species richness in forests requires surrogates, such as habitat elements, that represent groups of species, including those difficult to census.

3 Forestry is usually planned over large areas. In any area large enough to permit sustainable harvest, both natural disturbances and forest practices create stands of different ages and structures. Moreover, large areas are rarely homogeneous and contain stands of varying species composition and distinctive communities. That variation encourages species richness but complicates setting objectives and planning.

4 Forestry must be planned over long periods. Other than for some broadleaved species, rotation lengths in Canadian forests are rarely less than sixty years. Natural disturbance frequencies in forests can be highly variable in extent, frequency, duration, location, and intensity (Agee 1993; Cumming, Burton, and Klinkenberg 1996). In any forest, especially unmanaged forests, there will be a diverse array of stands with a variety of structures that change over time. Long periods of time are required to account for all components contributing to biological diversity. Many would argue that sixty years is much too short (see, e.g., Goward 1994 and Norse 1990).

5 Public goals and perceptions change quickly, but practices are evaluated slowly. Only recently have concerns about forest-dwelling organisms expanded to include all species. Well-documented information is available for only a very small portion of species, even among vascular plants and vertebrates. Moreover, because trees can grow large (thereby inducing considerable environmental change), but grow slowly, there has been little time for practitioners to evaluate the reliability of newly developed tactics to sustain forest-dwelling species (Binkley 1992; Bunnell 1998c; Namkoong 1993).

These difficulties consistently challenge the larger public and forest managers. Difficulties are especially challenging when a commitment has been made to sustain both forest-dwelling biodiversity and economic production of wood fibre. They are sufficiently challenging to elude tidy solution and thus yield a wicked problem. Because practices to sustain biodiversity have preceded experience with those practices, land managers must play "catch-up." Fortunately, there is an effective way of learning while practices are being implemented – adaptive management.

1.4 Adaptive Management

Adaptive management[7] is a formal process for continually improving management practices by learning from the outcomes of operational and experimental approaches. Four elements of this definition are key to its utility. First, it is *adaptive* and intended to be self-improving. Second, it is a well-designed, *formal* approach that connects the power of science to the practicality of management. Third, it is an ongoing process for *continually improving management,* so the design must connect directly to the actions that it is intended to improve. Fourth, although experimental approaches can be incorporated into adaptive management effectively, *operational* approaches and scales are emphasized to permit direct connection to the efforts of managers.

There is nothing easy about implementing adaptive management well. The design itself is difficult to conceive and implement, particularly in forested systems (see Chapter 12). Two of the largest barriers have been effectively linking the somewhat different worlds of science and management and developing concepts and structures that permit feedback from findings to changes in action. At its best, adaptive management is a conscious choice to link science with management so that each responds to the needs and information of the other (Halbert 1993; Lee and Lawrence 1986; Marzluff, Raphael, and Sallabanks 2000; Meretsky, Wegner, and Stevens 2000; Salafsky et al. 2002). Neither science nor management is consistently subordinate; rather, the priorities of each are reconciled through the design of the process. Managers help to establish the program's direction so that it connects to management issues and commit to using the results of the monitoring. Researchers understand management issues well enough to design sampling and experiments that connect directly to management questions and help to interpret findings and their implications for management. Even when this ideal is attained, the process may fail and not be adaptive because institutional structures or philosophies become barriers to implementing changes (Lee 1993, 1999; Ludwig, Hilborn, and Walters 1993; Stankey and Shindler 1997).

Despite these barriers, efforts to attain and evaluate success proceed best through the framework of adaptive management. For adaptive management to attain its theoretical promise, it must contain four broad elements (see Figure 1.1):

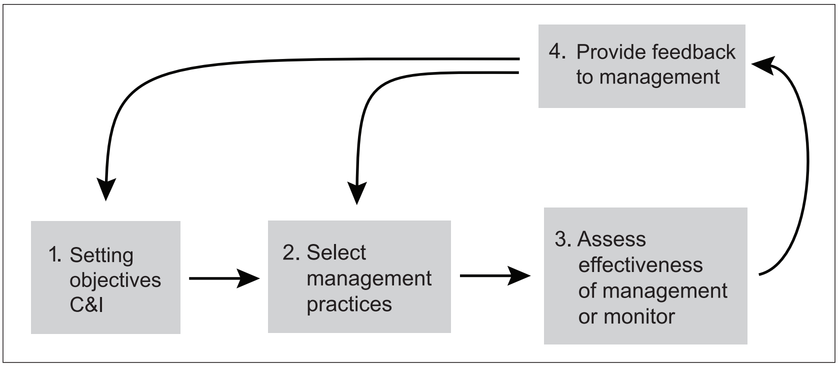

Figure 1.1 Major elements of a successful adaptive management process.
Note: C & I represent Criteria and Indicators used in some forest certification systems.

1 clearly defined objectives;
2 planning and practices to attain those objectives;
3 ways to assess proximity to the objectives; and
4 ways to modify practices if objectives are not attained or are changed (links to management action).

Specify clear objectives: Objectives must be sufficiently clear that means of assessing proximity to them are likewise clear. Objectives cannot be rigid and must respond to changes in both values and information. In sustainable forest management, major objectives are increasingly being described as criteria for success, while indicators are used to measure outcomes that should be evident when a criterion is successfully attained. Criteria and indicators for sustaining biodiversity in managed forests are described in §3.2.2.

Select planning and practices: Once objectives are clear, the planning and practices likely to attain those objectives can be chosen. In forests, effects of practices at the stand level both affect and are affected by forest planning over broader areas and vice versa. That is particularly true for effects on forest-dwelling biodiversity (Bunnell and Huggard 1999). Evaluation of success in sustaining biological diversity must occur at a variety of scales.

Assess proximity to objectives: The objective of sustaining biological diversity cannot apply to specific cutblocks but must be evaluated for broad areas (Bunnell and Chan-McLeod 1998; Bunnell, Kremsater, and Wind 1999). Assessments everywhere are too costly, so they must be designed in a fashion that can be "scaled up" to reflect larger areas. Scaling up often relies on computer projections of habitat and organisms' responses to habitat. We learn fastest, or reduce uncertainty fastest, when we organize our current information in a way that can be directly challenged by new information – that is, by making predictions and evaluating their accuracy. Some elements of the task of managing to sustain biodiversity are too ill known to permit prediction. A key element of assessing proximity to objectives is providing a structure for learning. Where prediction is difficult, comparisons remain useful (§5.2). It is important to recognize that monitoring, or a way of assessing proximity to objectives, is only one part of adaptive management. To make it work, the fourth broad element of the process must be present.

Ways to modify practices: The fourth element of effective adaptive management is a set of known ways to modify practices if objectives are not attained or if they change in response to changing values. New information is of little use to practitioners if it does not link to management practice. Linkage is provided by both the evaluation system developed for each indicator of success and descriptions of potential management actions that are expected to help correct any failures or strengthen areas of weakness. The evaluation system should assess the success of current management activities and track improvements in management over time. The ability to change may require a formal mechanism for accepting results and associated management or policy changes.

1.5 Bounding the Book: What It Is and Is Not

Of all objectives sought by sustainable forest management, sustaining biodiversity is the most challenging and fraught with uncertainty. This book addresses the problem of learning how to sustain biodiversity in managed forests in a scientifically credible and cost-effective fashion. The focus on learning emphasizes the importance of monitoring consequences of actions. Because this learning is occurring while management actions are occurring, the appropriate framework for the monitoring is adaptive management. That is, the findings of monitoring are intended to guide future management actions. The book *is* an illustration of how we can learn to sustain biological diversity in the midst of continuing management actions.

The book *is not* a review of the wide range of strategies and tactics that have been proposed or attempted to sustain biological diversity. The range in approaches reflects the complexity of the problem and the fact that there is no single correct solution to the problem (§1.1). The approach to sustaining biological diversity discussed in this book borrows heavily from other efforts but usually differs somewhat to meet local goals or conditions (see Aubry et al. 1999; Aubry, Halpern, and Maguire 2004; Hollstedt and Vyse 1997; Lovejoy 1985; Margules 1993; Schmiegelow, Machtans, and Hannon 1997; and Vyse, Hollstedt, and Huggard 1998). For example, designed experiments are included but only as one part of a broader program that includes many issues not amenable to simple experimental resolution. The design of experiments also incorporated a social decision to involve all the regional divisions of the company in the adaptive management effort, so the questions and geographic layout are more complicated than are those involved in more focused research efforts. Moreover, the variability in forest practices addressed is wider than that normally encountered in commercial forestry.

Principles of various regional approaches to zoning (Kneeshaw et al. 2000; Noss 1993; Oliver 1992) are incorporated into the management approach (§2.3), as are coarse filter approaches such as gap analysis and landscape trend analysis (see Chapter 6), but again, as one part of the overall monitoring approach. Nor was our approach focused on particular species of *a priori* interest. We did not set out to monitor particular species at risk or focal species, nor did we attempt to monitor entire communities. Our interest was species that could help to answer specific forest management questions. Elsewhere, initial emphasis on species has been driven primarily by regulations, such as the US Endangered Species Act or the survey and manage approach of the Northwest Forest Plan (Molina, Marcot, and Lesher 2006), or simply by relative ease of monitoring.[8] We also include, but do not emphasize, a broad assessment of trends in multiple species developed in programs such as the Alberta Biodiversity Monitoring Program (ABMP) and the Finnish Wildlife Triangles (ABMP 2005; Pellikka, Rita, and Lindén 2005). We focus on species that are sensitive to the forestry practices and management issues of interest.

Incorporating useful elements of a range of approaches reflects an effort to enact a cost-effective approach to effectiveness monitoring in an adaptive management framework. The emphasis is consistently focused on how we learn to do better rather than on championing a particular approach. A criteria and indicators approach was adopted because it is now so much a part of forest companies' efforts at certification globally.[9] We present a rationale for the broad indicators and specific measurements selected (§3.2).

The practice of forestry is complex. Developing the planning and practice of forestry to sustain biodiversity is still more complex. To cope with this complexity, applied researchers often invoke simplified concepts such as natural disturbance regime and range of natural variability (Haeussler and Kneeshaw 2003; Hessburg, Smith, and Salter 1999; Perera, Buse, and Weber 2004; Swanson et al. 1994). This book does not evaluate competing concepts invoked to guide management. The planning and practices evaluated here focus on consequences of the most dramatic departures from the natural disturbance regime rather than on mimicking the regime (see Chapter 2). The most dramatic departures are the reduction of old-forest elements and intact old-growth forests.

There are both general and specific reasons for not attempting to mimic the natural disturbance regime. Generally, the extremes of natural variation are simply unacceptable to the vast majority of the public, whether induced by logging or more naturally (neither the current mountain pine beetle outbreak nor a larger forest fire is considered desirable). The specific nature of the natural disturbance regime in the example area would create additional problems if logging attempted to mimic natural patterns. The case study is an area of 1.1 million hectares in coastal British Columbia (see Chapter 2). The driest portion of the area is now well populated by people who do not want a return to the frequent fires that occurred naturally. The small openings created by gap dynamics in the wetter portions of the study area are impractical to re-create widely from economic, safety, and ecological concerns (they would interject roads and their associated disadvantages throughout the region).

Once a social decision has been made to truncate natural disturbance regimes, the issue becomes one of examining consequences of various forms of truncation (Bergeron and Harvey 1997; Bergeron et al. 2001; Bergeron et al. 2002; Hansen et al. 1991; Hunter 1993). Such an examination is challenging. Natural disturbance regimes do not exist as simple, measurable, and fixed "things." Quantifying the abstraction of natural disturbance regimes for specific locations has proven very elusive and varies with the scale and period over which it is defined (Boychuck et al. 1997; Cumming, Burton, and Klinkenberg 1996; Wallenius 2002). Moreover, mimicking natural disturbance closely is simply not achievable because logging and natural disturbance are inherently different. Logging, for example, does not produce charcoal or create the upturned mounds of earth following from windthrow that help to perpetuate one forest type in the study area (McRae et al. 2001; Zackrisson, Nilsson, and Wardle 1996).[10]

The case study used for illustrative purposes differs from other forest types in features beyond the disturbance regime. For example, variable retention (VR) is employed. VR was invoked to mitigate the main detrimental effects of industrial logging when compared to the major regional disturbance regime – potential loss of large, long-lived trees and abundant coarse woody debris, creation of large openings. That is not the primary objective for management in many forest types, simply because they do not have trees nearly so large or long lived. Other elements of the physical and ecological setting had to be acknowledged in the approach to forest planning and practice. For example, there is a major variation in ecosystem types and elevation across the management area, which is not true of much of the boreal forest in North America and Europe. The history of logging is relatively short compared with those of most of Europe and elsewhere in North America, which means that the presence of unlogged, old-growth stands must be considered and can be exploited as opportunities for conservation. Features of the case study, such as rugged terrain and natural forests of exceptionally large, long-lived trees, must be accommodated in the approach to forestry and monitoring.

There are also features absent in the area that must be accommodated elsewhere. For example, forests and the practice of forestry dominate most of the landscape. Other land use practices such as agriculture, mining, or oil and gas development are uncommon, so there is less need for cumulative effects analysis (Davies 1995; Grant and Swanson 1991). Likewise, where the practice of forestry dominates the landscape, the potential negative impacts of fragmentation are less well expressed than where agricultural and urban areas are interspersed (Bayne and Hobson 1997; Bunnell 1999; Rudnicky and Hunter 1993). Although there is private land in the management area, there is nowhere near the interspersion of public and private land that complicates the practice and monitoring of forestry in the United States and parts of eastern Canada. The tree species potentially available for harvest are few relative to temperate Australia, eastern North America, and parts of eastern Canada, requiring less silvicultural attention to maintaining tree species diversity, particularly for hardwoods (Bergeron and Harvey 1997; Greene et al. 2002).

As always, there are the differences in the organisms' responses to forest practices that require localized approaches. The American marten (*Martes americana*), for example, is considered an indicator of old-forest conditions in some areas (Sturtevant, Bissonette, and Long 1996; Thompson and Curran 1995) but exploits young forests as well in British Columbia (Lofroth 1993; Poole et al. 2004). The inherent dangers in extrapolating findings from elsewhere require breadth in the monitoring system and are exacerbated by the relative lack of regional knowledge for some organism groups compared with other regions (e.g., lichens, bryophytes, and invertebrates in Fennoscandia).

Such ever-present differences in the ecological and physical setting, and thus the practice of forestry, ensure that specifics of the forest planning and practices and of the monitoring system described here are limited primarily to the Pacific Northwest of North America. This book necessarily addresses a specific area and asks questions about effects of specific management practices, but our purpose is to illustrate generic concepts that will help others to design adaptive management and monitoring programs in a variety of situations. More specifically, our purpose is to illustrate generic concepts applicable for forests anywhere by providing concrete examples of these concepts within a real corporate enterprise.

1.6 Summary

The problem that this book addresses is that of managing to sustain both biodiversity and production of wood products in managed forests. It is apparent that

1. sustaining biological diversity in managed forests is encumbered by difficulties, many specific to forest management;
2. sustaining biodiversity is a "wicked" problem with no single correct solution; and
3. adaptive management is well suited to exposing solutions that are most effective in a range of alternatives.

Our goal is to illustrate an approach for learning how to sustain biodiversity in managed forests. In this chapter, we introduced broad elements of the problem. In Chapter 2, we present the major example that we use to illustrate the process.