Operational Experiments for Sustainably Managing Forests

Grossflachige Feldversuche fiir die nachhaltige Waldnutzung

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Abstract

Historically,, applied manipulative studies of forests have tested the ability of specific silvicultural treatments to address wood production objectives. Changing societal values now demand expanded approaches to forest management that also integrate social, ecological, and economic goals. As a result, many recent (past decade) experimental manipulations have become multi-disciplinary in scope and approach and involve restorative treatments, novel silvicultural approaches or variants of more traditional approaches that are relevant to operational scales. We examine a wide range of manipulative forest ecological experiments that have addressed a variety of responses to changes in forest structure or function. The silvicultural treatments employed in these experiments were oftentimes designed by interdisciplinary teams (e.g., forest ecologists, sociologists, biologists, economists, and silviculturists) with wood production and additional ecological, social or economic objectives as joint outcomes. Individually and collectively these studies represent major investments by research and land management organizations to meet increasing public demands for forests that provide healthy environments for people (clean air and water), support biological diversity (e.g., habitat), and sustain economic productivity (wood or other forest products and jobs).

Zusammenfassung

Die klassischen forstlichen Feldversuche wurden angelegt, urn die Auswirkungen bestimmter forstlicher Nutzungseingriffe auf das Baumwachstum and die Holzertrage zu untersuchen. Die gesellschaftlichen Anspruche an die Waldnutzung haben sich mit der Zeit geandert; sie haben eine Erweiterung erfahren and umfassen heute soziale, okologische and okonomische Zielsetzungen. Infolge dieser Entwicklung sind Feldversuche heute in der Regel multi-disziplinar and oft auch grol3flachig konzipiert. Zahlreiche Wissenschaftler mit unterschiedlichen Erfahrungen beteiligen sich an der experimentellen Manipulation and Datenerfassung in Freilandstudien. Das Ziel ist die Untersuchung neuartiger Waldbauverfahren, oder Varianten herkommlicher Verfahren, unter moglichst operationalen Bedingungen, d.h. auf Flachen, die die Gro13e der traditionellen Versuchsanlagen zum Teil weit iibertreffen. Wir untersuchen in diesem Beitrag unterschiedliche waldokologische Feldstudien mit einer Vielzahl moglicher Reaktionen auf experimentelle Manipulationen, die eine Veranderung der Waldstruktur and -funktion bewirken. Die experimentellen Managementsysteme in den grossflachigen Feldstudien werden in der Regel durch interdisziplinare Teams konzipiert, unter Beteiligung der Natur-, Sozial- and Ingenieurwissenschaften. Die Auswertungen beziehen sich nicht nur auf Aspekte der Holzproduktion, sondem auch auf waldokologische and sozialokonomische Perspektiven der Waldnutzung. lm Einzelfall and in der Gesamtheit handelt es sich bei diesen Feldstudien urn gr8(3ere Investitionen von Forschungsorganisationen and anderen Geldgebern, die das Ziel verfolgen, nicht nur die Nutzfunktionen der Walder, sondem auch der zunehmenden Nachfrage nach deren Schutzfunktionen and nach dem Erhalt der biologischen Diversitat Genuge zu tun. In einem ersten IUFRO workshop in Davos/Schweiz (Szaro et al., 2004) and einer darauffolgenden zweiten Konferenz in Portland/Oregon (Peterson and Maguire, 2005) wurden vor allem Erfahrungen im Zusammenhang mit grossflachigen Feldversuchen ausgetauscht. Dieser Beitrag fasst die wichtigsten Ergebnisse der beiden Veranstaltungen zusammen.

INTRODUCTION

Forests represent a global resource and many issues dealing with their use and maintenance cannot be effectively dealt with in an insular fashion (Szaro, 2000). Global participation is desirable, and often considered even mandatory, if these resources are to be sustained and equitably utilized. This approach must ensure that forests will continue to exist at some acceptable level for the benefit of current and future generations. Attempts to meet this objective are often referred to as "sustainable forest management". Sustainability requires the integration of environmental, social and economic aspects • through compatible management and development strategies (Loskill, 2006). The German Council for Sustainable Development (Rat fiir Nachhaltige Entwicklung, 2004) highlighted the needed link between forestry and forest research in order to transfer the knowledge gained from centuries of management experience and recent developments in forest modeling to implement the differing facets of sustainability in novel societal approaches. This recognizes that managing a forest ecosystem is a complex and challenging task, because it is necessary to value the system as a whole. This involves treating all the functions simultaneously and often as equally important or at least finding a balance between them. This challenge is immense, but it also provides many opportunities for generating new knowledge and its delivery.

Historically, applied manipulative studies of forests have tested the ability of specific silvicultural treatments to address regeneration and wood production objectives. Moreover, these traditional replicated forest experiments normally occupy scales of 0.5 to 5.0 hectares (UK Forestry Commission, 2006). Examples of such studies are longterm growth and thinning trials providing data for yield tables (Pressler, 1865; Schwappach, 1890; Schober, 1972) and more recently for density-dependent growth models (Ek and Monserud, 1974; Burkhart, 1987; Gadow, 1987; Spellmann and Nagel, 1992; Pretzsch, 2001). Yet, current silvicultural questions are often focused at a wider array of issues that occur at broader landscape scales. Developing solutions to these questions requires an approach that links intensive study and operational trials. Both managers and researchers need to participate in the design of the work and the interpreting of the results and so gain from shared experience (UK Forestry Research Commission, 2006). Changing societal values now demand these expanded approaches to forest management that also integrate social, ecological and economic goals. The role of silviculture in altering trajectories of stand structure and composition is vital to that success (e.g., see DeBell and Curtis, 1993; O'Hara et al., 1994). In their broad review of large multi-disciplinary studies, Peterson and Monserud (2002) provided examples of manageable research questions that most experimental approaches strive to address:

- What do we need to know to determine the consequences of a change in the current mix of forest management values across the region?
- What are the relations of socioeconomic components to biophysical and management policies and practices as we move across different scales, from local (stand/watershed) to intermediate (province) to regional?
- What types of silviculture and conditions allow for the maintenance or improvement of the integrity of the riparian system while simultaneously managing for wood production?

Many recent (past decade) experimental manipulations have become multi-disciplinary in scope and approach and involve restorative treatments, novel silvicultural approaches or variants of more traditional approaches that are relevant to operational scales. Small-scale site based experiments play a useful role in the development of basic understanding but are unlikely to ascertain the full. range of system responses at operational scales. As a result, the ecological science used as a basis for much of our management is largely composed of theories that are oftentimes untested (Franklin 1999a). The long-term nature of much of the relevant ecological science needed to develop operational management strategies such as system responses to disturbances and patterns occur over many decades or even centuries and over large landscape scales make validation particularly challenging (Franklin, 2005).

Manipulative forest ecological experiments need to address a variety of responses to changes in forest structure or function. Some of the necessary data can be collected as a part of carefully designed monitoring programs but scientific experimentation also needs to be part of the validation process. Indeed, there are circumstances where monitoring can only be effectively accomplished by conducting a carefully designed experiment (Franklin et al. 1999a). The silvicultural treatments employed in these experiments are increasingly designed by interdisciplinary teams with wood production, ecological, social or economic objectives as joint outcomes (Franklin, 2005).

Individually and collectively these studies represent major investments by research and land management organizations to meet increasing public demands for forests that provide healthy environments for people, sustain biodiversity, and ensure economic productivity.

Workshops held in 2003 (Szaro et al., 2004) and in 2004 (Peterson and Maguire, 2005) represent a new effort sponsored by IUFRO Divisions 1 and 4 that has focused on large-scale experiments for sustainable forestry. This paper summarizes the lessons learned from those workshops in designing, implementing and maintaining studies at operational scales.

LESSONS LEARNED

Suite of common issues/problems/challenges

Large-scale and long-term silvicultural experiments are needed to evaluate the effects of alternative forest management strategies on biological diversity, yet they are rarely undertaken due to the substantial commitments of time and resources required (Aubry et al., 2004). Since large-scale management experiments are implemented at the scale at which management occurs these studies are typically longer term and include multiple objectives at multiple scales that cover a spectrum of natural resources topics (Ganio and Puettmann, 2005). As a result, designing studies that effectively incorporates these features can be challenging (Ganio and Puettmann, 2005). All long-term forestry research faces many of the same problems including continuity of financial support, longevity and persistence of researchers, data storage and access, the shifting of societal goals and values that were used in the original experimental design, etc (Franklin, 2005; Innes, 2005). Long-term observations are essential elements in the science and application of resource management yet there are not likely to be very many of these experiments because of the difficulty and expense associated with establishing and maintaining long-term experiments in forest responses (Franklin, 2005). Hence, such experiments need to focus on major paradigm shifts, such as fundamental changes in silvicultural practices. Another possibility is to work closely with resource managers in an adaptive management process to incorporate learning elements as part of many management activities.

Field experiments at the scale of management operations have several advantages but also some drawbacks (Brang et al., 2003). Among the advantages are: 1) the potential to assess processes and factors which are relevant for system dynamics, but not completely understand at the beginning and 2) a better knowledge of stand development and often even initial conditions and some causal relationships, in comparison to purely retrospective approaches. The drawbacks include 1) problems with extrapolating the results to other sites (although not as great with small plot studies), 2) a considerable investment of resources, and 3) the necessity of a long-term commitment.

The DEMO (Demonstration of Ecosystem Management Options) experiment established in the Pacific Northwest during the last decade is an example of a study with its focus on structural retention as a part of regeneration harvest practices (a fundamental change in silvicultural practice). The development of the DEMO experiment exemplifies the difficulties of dealing with these issues (Franklin et al., 1999b).

Common elements of design/approach

The objective of forest research is to reach a better understanding of biological and economic systems and to generate information that is useful for management. An important objective of forest management, on the other hand, is to utilize research information that is useful. These two objectives are not always easy to match in an increasingly fragmented scientific environment which rewards highly specialized investigation. Forests represent a remnant wilderness of high recreational value in the densely populated information societies, a natural resource threatened by elimination in impoverished regions and a renewable reservoir of essential raw materials for the wood processing industry. Thus, experimental design must account for both, specific local research objectives and interdisziplinarity.

One common element in many studies frying to develop new and innovative alternatives to traditional silvicultural practices particularly clear-cutting, focus on what is left behind, referred to as "retention" (Franklin, 1997). Possible approaches range from variable-retention (Aubry et al., 2004; Beese et al., 2005; Bunnell, 2005; Harrington et al., 2005; D. Maguire et al. 2005, Schwarz et al. 2005) alternative thinning regimes (Beggs et al. 2005; Marshall and Curtis, 2005), and even ways to provide connections between similarly managed areas (i.e. forest corridors or minimum distance between similar patches; see Baughman and Guynn, 2005). Taken collectively, most of these experiments address one or more thinning treatments (uniform and/or irregular), variable-sized openings and patches (or "leave" islands) that when implemented, retaining some arrangement of forest structure (often either uneven-aged or two-aged systems) and range of aggregation or dispersal of individual trees that can be managed towards some future desired condition. The fact that all these experiments together comprise a diverse portfolio of approaches and designs with multi-disciplinary evaluations is one that should be valued in the forestry community (Gadow and Klein, 2005).

Franklin (2004) gives some guiding principles in the development of large-scale and long-term forest experiments (Table 1).

Table 1. Developing and Designing Long-term Experiments (Modified from Franklin 2004)

Keep them simple
Keep them statistically credible
Devote the necessary resources to data management
Build the capacity for sustaining the long-term studies
Provide leadership continuity

The statistical concerns and needs for replications, power analyses, appropriate experimental designs, and so forth for these newer kinds of approaches have received renewed interest (e.g., see Bennett and Adams, 2004; Ganio and Puettmann, 2004; Gadow and Kleinn, 2005). In addition, the commitment of necessary resources, capacity and multi-disciplinary leadership (Inns, 2005) is a shared challenge globally.

Solutions at local/regional levels

Successful approaches to sustainable forest management are increasingly community-based and initiated by local people (Johnson et al., 1999; Torres and Magana, 2006). Rapid cultural changes caused by the in-migration of numerous new people into traditional resource-based communities and surrounding areas may be underlying causes to changes in social values. There is a growing realization that a long-run approach to land use and management is generally better (ecologically and economically) for developing harmonious and sustainable relationships between people and the land (Canadas, 2005).

Role of public acceptance/education

Successful approaches often include an educational element, which benefits both those who are actively engaged in ecologically-based assessment and decision-making processes, and others who may be affected by such processes (Johnson et al., 1999). A shared literacy and awareness about ecosystems, and about how humans rely on and affect them, can help to build receptivity and support for sustainably managing forests. This is especially important in the urban environment (Gadow, 2002). The educational process is often fostered by direct involvement in ecologically-based assessment and decision-making processes. The communication between managers, members of the public, scientists, and staff people involved in these processes leads to a broadening of their collective understanding of the ecosystems being addressed. It also increases the understanding of how human uses can act as vectors of change in ecosystems, and about ecosystem-compatible options for our use of them. The analysis and decision support models that are used in these processes facilitate learning about what variables are important, and what we know and don't know. Early and continuous involvement in these processes leads to a deepening understanding of sustainable forest management concepts and applications by all parties.

The educational process is also facilitated by the dissemination of ecological information between (and to) agencies, managers, scientists, and the public, especially when such information is communicated in language all parties can understand. It is also helped when the "lessons learned" through implementation are evaluated as to their transferability. However, the recent multi-disciplinary operational experiments in North America are incorporating more research components that use photos, visual simulations, and surveys to communicate and test public values for *visual* aesthetics of the new silvicultural treatments to be used by forest land managers (e.g., see Bradley, 2005; Ribe, 2005); these are primary (i.e., funded as part of the experiment) objectives in some studies (e..g, see Aubry et al., 2004; Reutebuch et al, 2004).

Information to Knowledge

Long-term experiments are invaluable to forestry, but it is critical that the information that is generated by them is transformed into knowledge that can be used to improve forest management practices. There are many barriers to this, and most managers of long-term forest experiments are devoting so much time to the maintenance of funding for their work that there is little opportunity to address such issues as extension and uptake. This is creating a "vicious circle", as the funding is dependent on the managers being able to demonstrate the value of their experiments (Iimes, 2005}.

The conversion of information to knowledge and the dissemination of that knowledge to those who can best use it is a critical stage of any long-term forest research project. There is a need to better plan for this and to ensure that it becomes as an integral a part of project planning as the experimental design. Whether this can be achieved in the short-term remains to be seen (Inner, 2005).

Successful integration of training programs, networking, technology transfer, information dissemination and improved linkages among policy-makers, stakeholders and scientific communities are essential (Szaro, 2000). Developing reasonable solutions is very difficult in part because the method of knowledge generation and its delivery is in a period of uncertainty and flux because of several important drivers of change including democratization, market economics, globalization, technological innovation and the roles of public/private engagement. The fact of globalization and wide spread access to information means that the bulk of the knowledge to which access is needed will have been produced elsewhere. Over 90% of the knowledge produced globally is not produced where its use is required. The challenge is how take and find knowledge that may have been produced anywhere in the world and synthesize and deliver it so that it can be used effectively in particular problem-solving contexts for local and regional applications.

On the right trajectory

All of the experiments shared at both workshops showed that alternatives to clearcutting were operationally feasible and can enhance biodiversity conservation as well as providing some timber resources (Vyse et al., 2005). Some trials also showed that the alternatives can have some negative effects on at least some components of the forest ecosystem. As a consequence, widespread application of a single practice is unlikely to be sustainable but rather a suite of alternatives should be considered (McClellan, 2004; Vyse et al., 2005; McClellan and Hennon, 2005).

It is assumed that there are numerous ecological benefits of uneven-aged, continuous cover forest management, but validated research results are lacking and predictions are largely conjectural (Gadow, 2004). Although data are available on the ecological characteristics of unmanaged forests and clearcuts in the Douglas-fir region of North America, there is little quantitative information on how forest ecosystems will respond along a gradient of retention levels. Better information on the ecological effects and public responses to variable-retention harvesting systems is needed if forest managers are to achieve the objectives of continuous cover forest management (European terminology) or ecosystem management (North American terminology; see Franklin et al., 1997).

Adaptive management

A managed forest ecosystem may be seen as an enterprise which produces a comprehensive set of goods and services and which constantly needs to adapt its production processes and its range of products in response to an evolving market. This objective can be achieved if research is made accessible at different levels, as is the case in most enterprises. Thus, it is often postulated that forest management should be sustainable, be based on validated research results, conform to acceptable environmental standards, and be transparent to the public. In an ideal world we would have enough information and be able to predict with sufficient certainty that we could just plan our management activities and be assured of the desired outcome (Szaro et al., 1999). Unfortunately, this is not the case because our understanding of ecosystems is not, and may never be, complete. There are inherent uncertainties within and among ecological, economic, and social systems. Surprises in the behavior of ecosystems are inevitable and management systems must be designed to adjust to the unexpected rather than act on the basis of a spurious belief in certainties (Gadgil, 1999; Gunderson, 1999). Therefore, an adaptive management approach (e.g., see Walters, 1986 and Borman et al, 1999) is essential for addressing uncertainty by structuring initiatives as experiments in which results are used to continually correct course (The Keystone National Policy Dialogue on Ecosystem Management, 1996). Figure 1 illustrates the basic interactions that help define the research context: social values influence institutional policy, which in turn affects managerial decisions and actions, resulting in a mix of outcomes. Those decisions and proposed actions are evaluated -often challenged -by society prior to being implemented, as a normal part of the planning process (Peterson and Monserud, 2002; Szaro and Peterson, 2004).

A formal process of adaptive management can be used to maximize the benefits of any option for land and natural resource management and to achieve long-term objectives through implementation of ecosystem management (Lessard, 1998). The process itself is straightforward and simple: new information is identified, evaluated, and a determination is made whether to adjust strategy or goals (Salafsky et al., 2001). It is a continuing process of action-based planning, monitoring, learning and adjusting with the objective of improving the implementation and achieving the desired goals and outcomes. In this process goals and objectives are clearly stated, an initial hypothesis of ecosystem behavior is described, and monitoring is conducted to provide feedback for redirection of management "experiments" or practices. While the concept of adaptive management is relatively straightforward, applying it to complex management strategies requires answers to several critical questions. What new information should compel an adjustment to the management strategy? What threshold should trigger this adjustment? Who decides when and how to make adjustments? What are the definitions and thresholds of acceptable results? Are thresholds is feasible to detect given the oftentimes latent effects of impacts? Adaptive ecosystem management depends on a continually evolving understanding of cause-and-effect relationships in both biological and social systems. Planning for and adapting to surprise will provide an actionary rather than a reactionary basis for more informed decisions.

This reiterative approach causes management execution and adaptation systems to make progress towards goals, even if the goals change with time (Baskerville, 1985). It promotes and information-rich environment and a rationale for routinely monitoring and evaluating social, political, and biological environments. Feedback loops for an adaptive management process already partially exist within many societies. These can be in the form of project scoping activities, participation in project design, analysis, and review, special public forums, and in worst case scenarios - litigation and legislation (Everett et al., 1993).

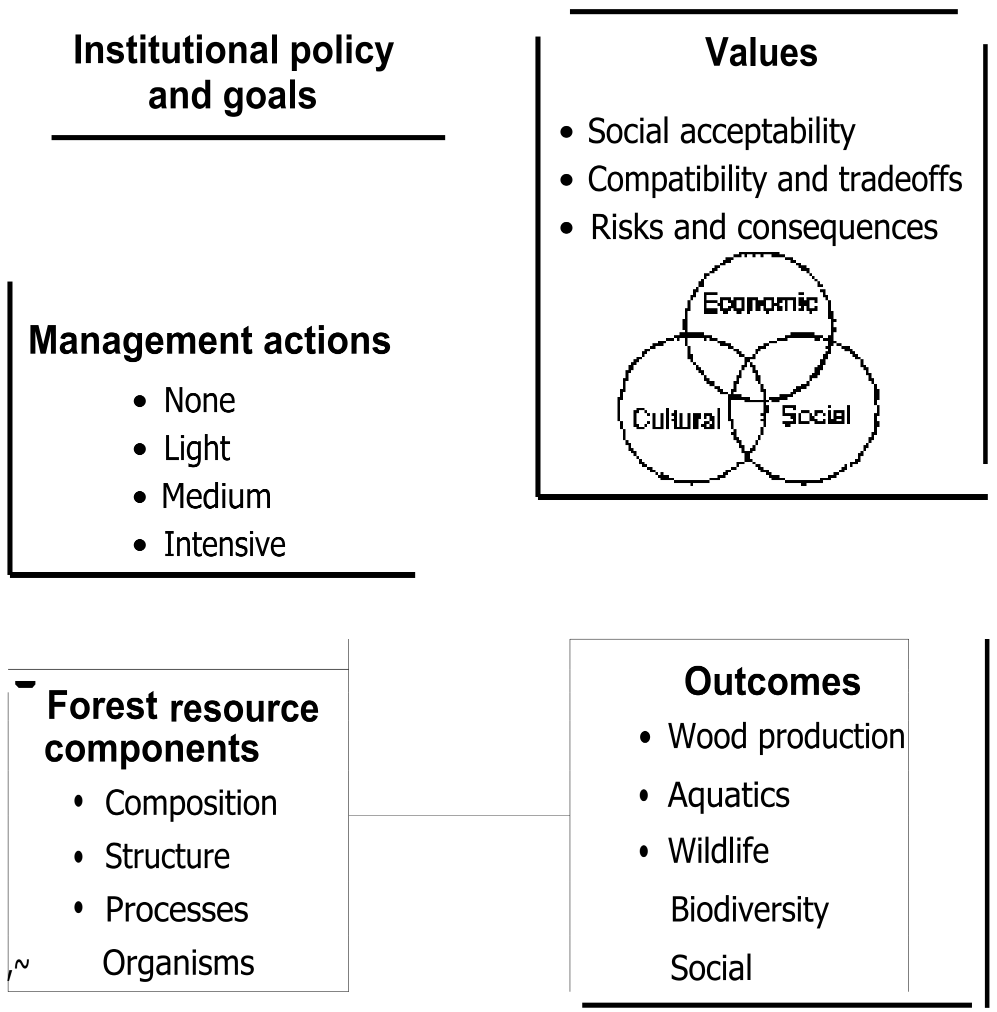

Figure 1. Conceptual model showing interactions among forest resource components, societal values, institutions, management, and outcomes (From Peterson and Monserud, 2002).

SUMMARY

The general public is getting more acquainted with forestry and demands a high level of sophistication of forest management (Gadow, 2004). Greater research involvement is called for and the ultimate objective of field experiments, which often represent major investments, is to meet increasing public demands for forests that provide a healthy environment for urban people, a biologically diverse and near-natural habitat and sustainable yields of forest products. There is no obvious right or wrong way to integrate science into the decision-making process but the differences between the development of scientific knowledge and its consideration need to be recognized. In science, the following of a relatively formal process is the norm leading to the acceptance of that information within the scientific community. However, the acceptance of scientific results by policy-makers, decision-makers and the public may differ markedly and be heavily influenced by personal perceptions and values.

The last two decades have witnessed a dramatic shift in perspective on how forest land should be managed (Peterson and Szaro, 2004). In response, forest research and development has added new integrative and large-scale experiments that can better evaluate joint outcomes and improve policy and management decision-making. These large-scale experiments help in adapting management actions to achieve desired outcomes by providing alternatives that integrate across sectors in real-time scenarios.

Given the uncertainties involved in making long-term management decisions in the face of incomplete knowledge, these large-scale experiments are a step in the direction of true adaptive management strategies. Adaptive management is an approach that need§ to be considered more broadly to ensure that desired outcomes can be achieved over time. Careful monitoring of outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. It is this link between iterative learning and associated iterative improvements to management that is the key to a sustainable future.

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