# PART V

# Management Options, Policies and Institutional Arrangements to Address New Challenges

Matti Nummelin

# 22 Managing Forested Landscapes for Socio-Ecological Resilience

*Convening lead authors: Brenda J. McAfee and Ronnie de Camino*

*Lead authors: Philip J. Burton, Brian Eddy, Lutz Fähser, Christian Messier, Maureen G. Reed, Tom Spies and Roberto Vides*

*Contributing authors: Carolina Baker, Milka Barriga, José Campos, Olga Corrales, Leonardo Espinoza, Sachi Gibson, Jonas Glatthorn, Catherine Martineau-Delisle, Cornelius Prins and Nancy-Anne Rose*

**Abstract:** Addressing sustainability in the face of profound global changes presents new challenges for forest managers. It has initiated a new cycle of development in approaches to management of forests for natural resources and other ecosystem services. Selected case studies from North America, Latin America, and Europe are used to illustrate advances in forest management in response to local impacts of global changes, and to identify options for addressing current challenges and elements of an emerging management paradigm based on the integration and resilience of ecological and socio-economic systems. Such a conceptual framework for management of natural resources recognises the complexity of systems (ecological, economic, and social), their hierarchical structures, the interactions and energy flows between these hierarchies, and their capacity for self-organisation. Applying systems thinking to forest management requires new approaches to conventional practices. Learning how to facilitate the ability of natural forest systems to self-organise, adapt and evolve, and to guide them towards a desired appropriate state is one of the challenges. The increasing importance of engagement, capacity building, and participation of all actors on the landscape as critical components for collaborative visioning, planning, and managing future options is recognised as a first step toward maintaining the provision of ecosystem services at the landscape level. Biosphere reserves, model forests, and other landscape-level initiatives that have already contributed to improved understanding of forest management issues and played key roles in establishing participatory decision-making approaches, are well-positioned to assist in testing and applying these new concepts.

Keywords: ecosystem management, integrated landscape management, systems management, ecosystem services, resilience

## 22.1 Evolution in Approaches to Forest Management

Sustainability is the thread linking the changing paradigms of forest management since the 16th century. First mentioned in a Saxon forest regulation associated with concern over timber shortage in central Europe (Köhl 2003), it was almost three centuries later that the need to balance economic development and conservation of the environment came to the global stage in Stockholm at the United Nations Conference on the Human Environment (UNCED) in 1972. Continuing discussions on this theme led to a keystone scientific contribution on adaptive management of natural resources based on an understanding of the structure and dynamics of ecosystems (Holling 1973). The World Commission on Environment and Development defined sustainable development as the concept whereby the needs

**Table 22.1. Malawi Principles. Complementary and interlinked principles of the Ecosystem Approach for implementing the Convention on Biological Diversity.**

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|---|---|
| 1 | The objectives of management of land, water, and living resources are a matter of societal choices. |
| 2 | Management should be decentralised to the lowest appropriate level. |
| 3 | Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems. |
| 4 | Recognising potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management program should reduce those market distortions that adversely affect biological diversity; align incentives to promote biodiversity conservation and sustainable use; and internalise costs and benefits in the given ecosystem to the extent feasible. |
| 5 | Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach. |
| 6 | Ecosystems must be managed within the limits of their functioning. |
| 7 | The ecosystem approach should be undertaken at the appropriate spatial and temporal scales. |
| 8 | Recognising the varying temporal scales and lag-effects that characterise ecosystem processes, objectives for ecosystem management should be set for the long term. |
| 9 | Management must recognise that change is inevitable. |
| 10 | The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity. |
| 11 | The ecosystem approach should consider all forms of relevant information, including scientific, indigenous and local knowledge, innovations, and practices. |
| 12 | The ecosystem approach should involve all relevant sectors of society and scientific disciplines. |

**Operational Guidance for Application of the Ecosystem Approach:**

- Focus on the relationships and processes of the system.
- Enhance benefit-sharing.
- Use adaptive management practices.
- Carry out management actions at the scale appropriate for the issue.
- Ensure intersectoral cooperation for sharing information and experiences.

Source: CBD 2000.

of the present should not compromise the ability of future generations to meet their needs (Brundtland 1987). The 1992 UNCED in Rio de Janeiro, highlighted the importance of this concept and introduced the three supporting pillars: economic, social, and environmental. Agenda 21 was issued as a blueprint for sustainable development, with Chapter 11 (Combating Deforestation) and Chapter 15 (Conservation of Biological Diversity) highlighting the significant role of forests, while Chapters 23–32 refer to all social constituencies that deal with forest landscapes and forestry (UNEP 1992). For forests, the most significant outcome from UNCED was the development of *The Forest Principles: the Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation, and Sustainable Development of all Types of Forests* (Annex 22.1). These Principles provided the basis for the development of criteria and indicators that integrated the ecological, economic, and social functions of forests into frameworks for sustainable forest management.

Since 1992, the goals of various sustainable development policies have focused on the creation and maintenance of prosperous social, economic, and ecological communities across the landscape. The Ecosystem Approach was described in the Convention on Biological Diversity (CBD), another major outcome from UNCED, as a strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use in an equitable way. It formed the underpinning for implementation of the Convention. Twelve underlying principles (the Malawi Principles, Table 22.1), and five points for operational guidance were developed to assist with implementation (CBD 2000).

By 2003, there were nine regional/international criteria and indicators processes established to monitor and assess the state of forests and promote participation from multiple stakeholders at both management and country levels. (For C&I processes see Section 23.3.3 and for certification Section 23.5.1). A decision at the 7th meeting of the Conference of the Parties recognised the linkage between the Malawi Principles and the Forest Principles, and noted that the criteria and indicator processes provide a means of applying the Ecosystem Approach in forests. Criteria and indicators have also been used to support international certification processes. Certification is a marketplace instrument based on independent third-party audits, where products that originate from forests that are managed to standards for sustainable forest management are identified. International and market acceptance of these criteria is acknowledgement that forests are socio-ecological systems linking nature and society, and that sustainable forest management is as much about the people who inhabit, work, or utilise forests as it is about managing the biological systems (Innes et al. 2009).

To mark the millennium and as a means to track progress in integrating economic, social, and environmental outcomes for advancing sustainable development, the United Nations (UN) General Assembly adopted goals for collective action by the world community and national governments. These goals are referred to as the Millennium Development Goals (MDGs). The following eight goals are monitored by international agencies:

1. End poverty and hunger
2. Universal education
3. Gender equality
4. Child health
5. Maternal health
6. Combat HIV/AIDS
7. Environmental sustainability
8. Global partnership

With these goals in mind, over a thousand social and natural science experts worldwide participated in the Millennium Ecosystem Assessment (MEA), a scientific appraisal of the condition and trends in the world's ecosystems, the services they provide, and the options to restore, conserve, or enhance the sustainable use of ecosystems. The main findings of the assessment (MEA 2005) describe how, over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period in human history, largely to meet rapidly growing demands for food, fresh water, timber, fibre, and fuel.

The changes that have been made to ecosystems have contributed to substantial net gains in human well-being and economic development, but these gains have been achieved at growing costs in the form of substantial and largely irreversible loss in the diversity of life on Earth, the degradation of many ecosystem services, increased risks of nonlinear changes, and the exacerbation of poverty for some groups of people.

Based on case study analyses, the findings of the assessment recommended that new approaches to managing natural and social capital are needed. In order to halt the degradation of ecosystems, the services they provide, and the associated impact on human well-being (Figure 2.5 in Chapter 2), it was also recommended that new approaches to management should be based on an understanding of ecosystems, with the maintenance of ecosystem services as a primary goal.

Many forests are still not managed in accordance with the Forest Principles. Some of the obstacles that have been identified, particularly, but not only in developing countries, include the following: inadequate financial and human resources for the preparation, implementation, and monitoring of forest management plans; the absence of mechanisms to ensure the participation and involvement of all stakeholders in forest planning and development; and inappropriate forest legislation, regulation, and incentives to promote sustainable forest management practices (FAO 2009). In addition, many forest management plans are limited to ensuring sustained production of fibre with little consideration of other forest products and services or their potential values. In some cases, plans for fibre production may be only symbolic as a result of weak implementation or power struggles.

### *22.1.1 Definitions, Theories, and Applications*

As society's expectations for an array of products and services increase, the role of forests as multifunctional landscapes becomes more important, and the planning and management required for providing these services becomes more complex. Several approaches for planning and managing human activities, where ecological and socioeconomic processes are linked through recognition of social benefits flowing from ecosystems, have been described. These include ecosystem or ecosystem-based management, Ecosystem Approach, eco-social approach, bioregional planning, adaptive management, and integrated land, landscape, watershed or systems management. While all of these concepts have been widely interpreted, the outcomes that they are trying to achieve are comparable. The underlying philosophy is based on holism and sustainability, with an effort to integrate and apply science to management and to learn from these experiences. Feedback from adaptive management has given rise to various combinations and configurations of these approaches; e.g., systems-thinking applied to a landscape approach to ecosystem management.

Among the numerous definitions of ecosystem management, the International Union for Conservation of Nature (IUCN) provides the following definition for practitioners: *Ecosystem management seeks to organise human use of ecosystems in order to strike a balance between benefiting from natural re-*

*sources available from an ecosystem's components and processes, while maintaining an ecosystem's ability to provide these at a sustainable level* (Pirot et al. 2000). Managing for sustainability implies planning for the future. Managing multiple benefits for the future requires understanding and assessing conditions over many decades, or even centuries. In addition, spatial heterogeneity of resources, their governance and non-source-point impacts, have led to a developing consensus indicating that management coordination across landscapes, or units larger than forest stands and conventional management boundaries, is required in order to provide sustainable levels of the multiple ecosystem services provided by forests.

Landscape ecology research has demonstrated that landscape pattern strongly affects ecosystem processes, and that land management decisions have strong effects on landscape pattern and ecosystem processes (Radeloff et al. 2006). In a landscape approach, forests are managed for the maintenance of ecological integrity and multiple benefits by controlling spatial landscape structure and its dynamics (Baskent and Yolasigmaz 1999), including the interactions between humans and ecological systems. These authors have outlined four critical elements: social, economic, ecological, and science and technology. The social element is about people, society, institutions, and governance. It emphasises the right and responsibility of citizens to be involved in public land management, and to benefit from the ecosystem services essential for human well-being. Community engagement in local and regional issues creates a sense of place, relating geographic context to friendship, kinship, and employment, and fosters social learning. The economic cost of producing multiple values together should be lower than producing them separately as a result of sound management design and the ability to redistribute profits to pay for expenses. Local management of landscape benefits provides incentive for stewardship of resources. Two key ecological features of forest landscapes are interspecific differences and disturbances. Disturbance promotes biodiversity and biodiversity facilitates resilience. Landscape management attempts to maintain all forest structures within the landscape by mimicking, avoiding, and recovering from disturbances as the forest changes through natural population processes. It is therefore prerequisite that science and technology applied for the generation and management of ecological knowledge is seen as the key to implementing landscape management (Baskent and Yolasigmaz 1999). Knowledge of forest condition, dynamics, and response to disturbances is of particular relevance. Transformative technology to manage this wealth of information and to generate models and visualise scenarios for management options is critical for landscape-level decision-making.

Systems-thinking is based on studies of evolutionary biology in the 1920s (von Bertalanffy 1968), which emphasised the importance of understanding how elements of a situation fit together through connectedness and feedback loops rather than focusing on the cause-and-effect of single elements (Kay 2008). Systematically describing the nature of the inter-relationships of the elements and processes of events provides a means to improve understanding. Systems are composed of elements (and their relationships) and processes, which in ecosystems, are more commonly referred to as structures and functions. Tansley (1939) proposed the term *ecosystem* in order to better understand complexity in nature as a hierarchy of nested systems. Rowe (1961) introduced the concept of integrated levels of organisation as a means to understand the functional relationships between components of the natural hierarchy (cells, organs, organisms, and ecosystems). Later, Simon (1974) recognised an adaptive significance for the mutually reinforcing interactions between nested hierarchies (structures and functions).

With their global systems dynamics model, which examined the interdependence of ecological and economic systems, and recognised the exponential growth and threshold levels of system components, Meadows et al. (1972) contributed to shaping the systems concept. The work of C.S Holling (1973, 2001) and numerous collaborators (Folke et al. 2004, RA 2009) further advanced understanding of systems functioning and management by showing that both human (socio-economic) and natural (ecological) systems are complex and continually adapting through cycles of change.

Holling's theoretical systems dynamics, or "panarchy" model (Figure 22.1), describing four dynamic phases of an ecosystem, provides a helpful context for understanding the nested hierarchies in "systems thinking." Phase 1 of the model represents the colonisation of an area by different organisms and their subsequent development. Phase 2 occurs as biomass accumulates; in a forest, this phase occurs when trees grow appreciably and extends over the maturation period. While the maturation of a forest spans many decades and may appear stable, it is sensitive to disturbances, such as fire or pest outbreaks. When disturbance occurs, the transition to the release phase (Phase 3) can be initiated and usually occurs rapidly. Following disturbance, Phase 4 begins with a period of re-organisation. In a forest, the release of nutrients following a burn provides opportunities for re-colonisation by the same or different organisms. For the new ecosystem to maintain the same functions as the previous one, a sufficient diversity of organisms to provide these functions should be available. Seed banks, legacy structures, or mobile species that can introduce reproductive material play

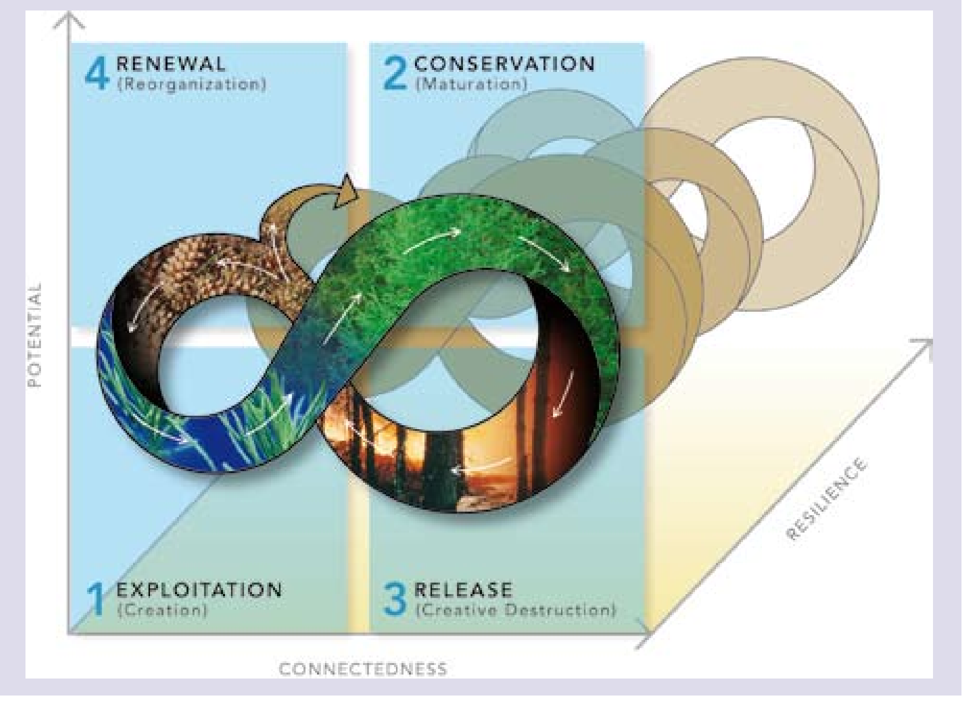


**Figure 22.1. Conceptual representation of Holling's systems dynamics (Panarchy) model (adapted from Gunderson and Holling 2002).**

key roles in this phase.

Holling (1973) described the built-in capacity of a system to buffer disturbances and maintain the capacity to provide ecosystem functions as *resilience*. In the panarchy model (Figure 22.1), resilience is envisioned as a nested configuration of figure-eight cycles (Phases 1–4) representing systems operating at different scales, making them resilient and able to absorb shocks and adapt to changes, without collapsing into a qualitatively different state, controlled by a different set of processes. The term panarchy was proposed (Gunderson and Holling 2002) to describe the interplay between change and resistance, and between the predictable and unpredictable in evolving hierarchical systems with multiple interrelated elements. The panarchy conceptual model can also be applied to social and economic systems to describe how natural systems and human systems are linked in continuing cycles of growth (exploitation), accumulation (conservation), re-structuring (release), and renewal (Gunderson and Holling 2002). Developing an understanding of these cycles and the scales at which they operate permits identification of leverage points, which can be used to foster resilience and sustainability within a system.

Re-visiting Holling's model with humans as the dominant species (Holling 2001, Hansell and Bass 1998), the first phase is marked by development, expansion, and prosperity. There is growth and accumulation of capital and wealth by the dominant species as it establishes control over its environment. Though changes in the second phase may be slow, the effects can become substantial as they gradually accumulate. The trigger initiating the back-loop in the model may be sudden, such as when cumulative changes reach a tipping point. During this phase of "creative destruction and re-organisation," predictability is low, with constant potential for surprises. A sudden event like a forest fire or a pest epidemic can unexpectedly flip an ecosystem and an economy into a qualitatively different state by triggering the release of biomass, capital, and wealth. The recent outbreak of the mountain pine beetle (*Dendroctonus ponderosae*) in western North America provides an example of a trigger event. As of 2009, over 600 million $m^3$ of trees have been killed in British Columbia, Canada, in an area more than four times the size of Vancouver Island. It is predicted that 80% of the merchantable pine in the central and southern interior of British Columbia will be destroyed by 2013 (BC Ministry of Forests and Range 2009). During and immediately after the outbreak, the forest was converted from a small net carbon sink to a large net carbon source (Kurz et al. 2008). Allowable annual cuts were adjusted to recover economic value and to speed regeneration (BC Ministry of Forests and Range 2009). The mountain pine beetle is normally an innocuous forest pest. Outbreaks have occurred several times in the last century, but cold weather usually confined them to specific geographic areas (Safranyik and Wilson 2006). In this recent wide-scale outbreak, it is unknown whether the ecosystem services – such as recreation, scenic values, tourism, fish and wildlife habitat, water control, and other non-timber products – will be retained in future years.

Holling (2001) emphasised the importance of maintaining resilience to increase the probability that an ecosystem will continue to supply goods and services required by humans following disturbance. Research on the ability of systems to retain the same functions, structure, identity, and feedback loops has indicated that human activities, such as land use change, resource exploitation, climate impact, and altered disturbance regimes, can lead to erosion of resilience, with ecosystems becoming vulnerable and shifting to less desired states in their capacity to provide services to society (Folke et al 2004, Laliberte et al. 2009). These authors advise that management efforts to reduce the risk of undesired shifts between ecosystem states should focus on facilitating the gradual changes that affect resilience rather than trying to control disturbance and changing conditions.

Biodiversity acts as biological insurance, balancing ecosystem processes in the face of environmental changes (Yachi and Loreau 1999). For example, functionally diverse communities are more likely to adapt to climate variability and change within a given ecosystem. A multi-scale approach for the maintenance of biodiversity is suggested as a means to assist the ability of ecosystems to remain within their desired states by creating conditions favourable for recruitment of the key species contributing to ecosystem functioning following changing conditions or disturbance (Thompson et al. 2009). Modelling results indicate that there is a critical rate of climate change beyond which even diverse ecosystems will not be resilient (Cox 2008).

Respecting natural disturbance regimes, setting aside areas in permanent or temporary nature reserves, and creating corridors and stepping stones of habitat to enhance dispersal of organisms are some basic ecological tools for managing biodiversity at the landscape level (Mönkkönen 1999). De Camino and Breitling (2007) highlight the importance of distributing conservation efforts in both disturbed and undisturbed areas as part of adaptive management. Thompson et al. (2009) point out two specific actions that can be taken at the genetic level to increase resilience in forest ecosystems. The first relates to isolated tree species at the margins of their geographic ranges. Populations of these species require special conservation attention because they are the most likely to represent pre-adapted gene pools for responding to climate change (Cwynar and MacDonald 1987). The second involves the selection of trees for harvesting. Management objectives should ensure that selection is not based on site, growth, or form, because selective tree-harvesting has been shown to alter gene frequencies, especially among rare alleles (Schaberg et al. 2008).



Adaptive management is a key component of managing for resilience. This dynamic process, based on the experience and information generated by stakeholders who, in turn, are also responsible for adjusting the process based on new information acquired through management cycles, allows for flexibility in management response. Monitoring ecosystem changes and identifying the thresholds that trigger systems to flip between the stages described in the panarchy model, allow for learning, based on prior experiences, to inform and guide future conditions (Gunderson and Holling 2002). Folke (2006) indicates that the conventional approach to natural resource management focusing objectives (e.g., for water levels, population numbers, etc.) on stability and control of change in systems (Phases 1 and 2 of the panarchy model), ignores the opportunity for innovation provided by disturbance as a trigger for change and renewal. Resilience management is guided by renewal (Phases 3 and 4 of the model); turning the focus from stability to management of the capacity of ecological and social systems to cope, adapt to, and shape change.

While the theoretical literature on resilience is rich, guidance on implementation is an emerging field of research (RA 2009). Knowledge of system dynamics: diversity, variability, relationships, and the energy flows between socio-economic and ecological components and the critical processes that influence system changes, is a key input to management. This chapter explores these concepts through selected examples to illustrate how current knowledge of forest structures and processes can be applied to design and implement policies that foster eco- (ecological and economic) sociological inter-linkages. The roles of inventory, monitoring, modelling, and risk assessment as components or tools for adaptive management to deal with complexity and drivers of change in multifunctional landscapes are also discussed.

## 22.2 Approaches, Instruments, and Design

### *22.2.1 Management Planning to Integrate Ecological, Economic, and Social Values*

*Using a Triad Approach in Canada*

It is an ongoing challenge to develop practices that reconcile the social, economic, and ecological values associated with Canada's vast forests. The triad


**Photo 22.1 A typical agro-forestry landscape in eastern Quebec, Canada where management focuses on sustainable benefits from agriculture and forestry.**

approach to forest management, dividing the forest into three distinct zones – conservation, natural disturbance-based ecosystem (NDB) management, and intensive silviculture (Seymour and Hunter 1992) – is one way of addressing this challenge. Each zone has its own management objectives, but the overall goal is to increase the ecological, economic, and social sustainability of the entire forest. In the conservation zone, the goal is to conserve native biodiversity and ecosystem processes and functions. No industrial activity is carried out here, and human activities are limited to those that do not interfere with the overarching goal of conservation. In the NDB management zone, the goal is to preserve the resiliency and adaptability of the forest and its native biodiversity while accommodating human use. Logging is thus permitted, but in keeping with this goal. Natural disturbance-based management practices are designed to mimic patterns created by natural disturbances (Kuuluvainen 2002, Bergeron et al. 2004, Gauthier et al. 2008). Under many circumstances, the use of partial cutting in the NDB management zone allows for timber production while preserving ecosystem resiliency and adaptability. The practices rely mostly on natural regeneration and offer multi-entry harvesting opportunities that help regulate long-term logging schedules. Finally, in the intensive silviculture zone, the main goal is timber production. This zone is set up to compensate for merchantable timber not harvested from the other two zones so as to maintain the timber supply, and thus the economic viability of the wood-products sector. The more timber that can be extracted from this zone, the larger the area that can be set aside for conservation and the less timber that needs be extracted from the ecosystem management zone. To achieve productivity gains, various types of traditional silvicultural practices, such as thinning and vegetation management, are implemented. Genetically improved trees and fast-growing hybrids may also be planted (Messier et al. 2003), although care must be taken to select strains that will not interfere with the functioning or species composition of the rest of the forest through invasion or hybridisation.

Properly applied, the triad approach may be able to address many of the challenges facing contemporary forest management. In theory, it could help reduce the shortage of mature and accessible wood, while at the same time providing for increased conservation and allowing for NDB management to be applied across much of the forest. As such, the triad approach should be economically, ecologically, and socially beneficial. Economically, transportation and silvicultural costs should be reduced by locating the intensive silviculture areas close to the mills and transportation infrastructure. Ecologically, biodiversity should be conserved through NDB management and the setting aside of relatively large unharvested conservation areas, counterbalanced economically by high returns from the intensive silviculture zone. Socially, the less-intensive harvesting of the NDB management zone should provide better access for recreational and other non-timber users while still providing timber for the wood-products sector and habitat for wildlife.

When the three zones are examined as complementary parts of a whole management unit, there may be even more benefits. Plantations in the intensive silviculture zone and replanting in the NDB management zone may allow for native tree species that do not easily regenerate on their own after logging to regenerate, thus maintaining the overall biodiversity of the managed forest. Conservation areas act as controls against which the state of the present and future managed forest may be gauged, facilitating the creation of guidelines for sustainable forest management in the NDB management zone. Conservation areas can also constitute source habitat for plant and animal species, thus helping to maintain more-natural levels of biodiversity than might otherwise be found in the surrounding managed forest. In turn, natural levels of biodiversity can provide future economic opportunities, as well as environmental and social values.

Although the triad concept has attracted a lot of interest recently (Burton et al. 2003, MacLean et al. 2009), it remains largely theoretical. Most studies on the concept have been simulations (Bos 1993, Krcmar et al. 2003, Boyland et al. 2004, Montigny and MacLean 2006). The concept is currently being tested on a 0.86 million ha forest management unit in central Québec. Five years into the study, the results indicate that the triad is economically viable and socially acceptable in this area. Although many aspects of managing a large forest management unit had to be modified to be able to implement the strategy (e.g., regulations, etc.), the consensus among the various participants in this project is that a triad zoning approach may be a good fit for the public forests of Canada, with its many different interest groups and stakeholders, and valuable natural resources (Messier et al. 2009).

### *Linking Nature-Oriented Forestry to Economic Gains in Germany*

Although German foresters have claimed ownership of the term "sustainable forestry" (von Carlowitz 1713), for many years, the primary concern was maximising the output of wood from mostly even-aged forest stands. As production costs and natural disturbances from storms, drought, insects and diseases, and game browsing increased over time, the aim to continuously increase wood production did not continue to yield positive economic results, especially in public forests.

In 1994, after eight years of research, soil surveys, forest inventory, biotope analysis, and much discussion, the concept of "Nature-Oriented Forestry" for the 5000 ha of temperate forest in the city of Lübeck was presented first to the public and later to the international community (Fähser 1995). One of the goals of the Lübeck forest was to demonstrate how the UNCED 1992 goals could be put into practice locally. The Lübeck Concept of Nature-Oriented Forestry, known in German as "Prozessschutz-Konzept" (protection of natural processes), is a holistic concept guided by natural processes (i.e., natural regeneration and competition of trees, minimal interference). Underpinning the concept is the premise that a healthy forest ecosystem is the basic precondition for economic success in forestry (Fähser 1988). The following ideas are central to the Lübeck Concept:

- Achieving sustainable timber production means managing forests so that their composition, structure, and functioning match the local natural forest associations having the complete natural biological diversity of the area.
- The targets for the output from the forest should not exceed the potential productivity of the natural ecosystem. In Germany, for example, the sustainable range for timber harvest, based on the productivity of natural forest ecosystems, is between 4 $m^3$ to 15 $m^3$ per hectare per year. Exceeding this volume goes beyond the natural capacity of the forest for renewal.
- The principle for achieving economic benefits is based on minimising the input rather than maximising the output. The basis of this principle is that when living systems, such as forests, are used for industrial production, there is only limited response to inputs, and excessive inputs to the system may even cause collapse, as a result of stress from overfeeding, shock, or unnatural impacts.

The following list outlines some of the technical components of the Lübeck Concept. These concepts were developed based on information from detailed soil surveys, forest inventories, and biotope analyses (Strum 1995).

- Selective single tree cutting is practised. The opening of the canopy may not exceed 0.25 hectare.
- Natural regeneration is the main source for renewal. Planting should be the exception and, if done at all, only with native species.
- The concept can do without tending in most cases because self-structuring is preferred. Thinning should remove poor quality stems and competing exotic trees, but it should not eliminate competition between trees.
- Final harvest of single trees is defined by mini-

mum target diameters for the different species. These are 65 cm at 1.3 m height for beech trees (*Fagus sylvatica*), and 75 cm for oak trees (*Quercus* spp.).
- To maintain self-organisation, the forest requires at least 10% of the trees to remain permanently as snags, nest trees, biotope trees, or other functional habitats of specific species.
- In order to practice adaptive management and learn from nature, at least 10% of the forest area should remain unmanaged as "reference areas."
- Clear-cuts, monocultures, introduction of exotic tree species, application of pesticides and fertilisers, soil disturbance (by compacting or ploughing, etc.), clearing an area, burning of biomass, drainage of moist areas, activities that might cause disturbances during ecologically sensitive times of the year, and feeding of wild animals, are not permitted.

In 2004, a follow-up assessment of forest structures, dynamics, and the associated socio-economic observations (Fichtner 2009) produced the following results:

- Production, based on timber volume, increased from 290 $m^3$/hectare to 360 $m^3$/hectare.
- Annual timber yield increased by 15%.
- The proportion of natural tree species in the upper canopy increased by 11%, even more in the lower canopy and in new regeneration.
- Damage from natural disturbances (e.g., windthrow, insects) decreased.
- Annual profit increased 20%.

The Lübeck Concept rapidly gained support. In 2008, the German Federal Foundation for Environment project, focusing on the ecological potential of beech forests as an aspect of multifunctional management, confirmed these results (DBU 2008) and demonstrated that, in comparison with conventional forestry, the Lübeck Concept not only improved ecological values, but also produced better economic yield. Similar findings are reported by Kaiser and Strum (1999) and Duda (2006). Observations from regional monitoring groups reported that over a 15-year period, there was increased abundance in a number of sensitive and rare species, particularly bat, woodpecker, crane, white-tailed eagle, and black stork (Struwe-Juhl and Grajetzki 2007, Ellenburg 2008,).

The environmental community used the Lübeck Concept as the basis for an international forest campaign. The forest industry supported the concept by sponsoring an award for Environmental Management. The principles were adopted by the Forest Stewardship Council, and several of the technical components (i.e., reference areas, natural forest association, biotope trees, precautionary principle) became certification criteria. Criteria and indicators of the Lübeck Concept constituted the first national "Naturland"-certification scheme for forest management. Many German community forests have implemented practices originating with the Lübeck Concept (Fähser 1997a).

Based on respect for the complexity of natural processes, the Lübeck Concept also embeds adaptive management (Fähser 1997b). The German Federal Agency for Environment adopted the Lübeck Concept as its vision for "best practice" in forestry (Brendle 1999, Winkel and Volz 2003, Bundesamt für Naturschutz 2009). The increased frequency and severity of weather events in recent years has sparked new interest, both in Europe and beyond, in nature-oriented forestry and the ideas of self-adapting and site-adapted forests.

*Landscape-Level Land Use Planning Using the Ecosystem Approach in Bosque Seco Chiquitano*

The Chiquitano Tropical Dry Forest ecoregion (BSCh) is a transitional zone between the subtropical dry forests (the "Chaco"), the pre-Andean forests, the Gran Pantanal, and the Amazon rain forest. This complex system of tropical dry forests, the "Cerrado" savannahs, and flooded savannahs covers approximately 24.7 million ha in eastern Bolivia, western Brazil, and northern Paraguay (Vides-Almonacid et al. 2007) and provides the following ecosystem services: valuable timber supplies, wild non-timber resources for commerce and trade, wild animals, food and medicines for the local population, water regulation, pasturelands for sustainable cattle ranching, drinking water, agricultural and industrial production, carbon sequestration from avoided deforestation, climate regulation, maintenance of soil fertility, bioregulation, and scenic landscapes for tourism.

Over a ten-year period, increasing pressures from the economic system (favourable export market conditions for agricultural products, especially oleaginous plants [soy] and foot-and-mouth disease-free meat) linked with a stimulus in the agriculture sector (64% increase in intensive agriculture), interacted with the structures and processes of the ecological system until there was a system change (loss of natural vegetation). Following this system change, several other process and structural changes followed. Large blocks of forest and woodland were fragmented. Wildlife populations were reduced or eliminated as a result of structural changes in natural habitats, over-exploitation, and modification of biological and ecological patterns, global and regional climate changes and development (roads, mining exploitation, and other industrial growth). In response to this perceived threat to the ecological integrity of the area, representatives from the community and

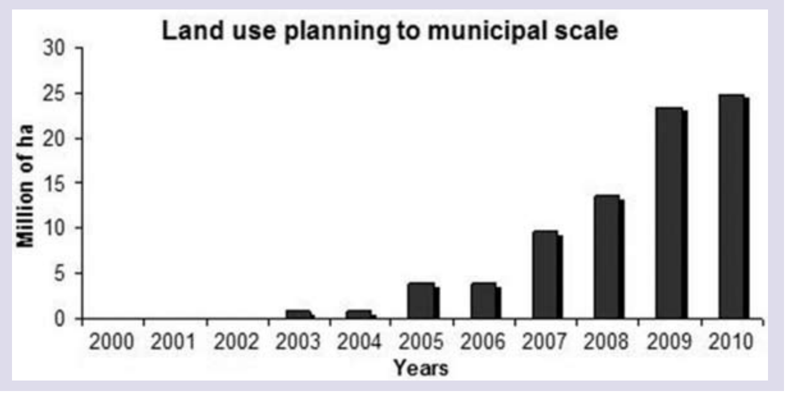


**Figure 22.2 Area under territorial land use planning at the municipal scale for those municipal districts that have significant portions in the Chiquitano Dry Forest ecoregion until 2007, and projected until 2010 (derived from Justiniano 2003).**

several organisations worked together to develop an integrated plan for conservation and sustainable development for 7.7 million ha of the BSCh (Ibisch et al. 2002). The plan used the Ecosystem Approach (EA) as the supporting technical-scientific basis for conservation actions and sustainable development on a landscape-ecoregional level and for guidance on participatory management. The Malawi Principles were used in the planning process: to define the geographical scope for management; as a basis for integrating conservation activities with socio-economic development; to promote the objectives of long-term natural resource management; and as a basis for providing incentives for local participation in decision-making. The primary drivers for the plan were based on the following needs: to make strategic and operational decisions linked to territory management; to find alternatives for sustainable management of forestry resources; to empower local stakeholders; to integrate scientific and traditional knowledge; and to generate opportunities for dialogue and agreement among the participating sectors.

This plan eventually grew into an ecoregional land planning system (Vides-Almonacid et al. 2007), where an ecoregion is defined as a "recurring pattern of ecosystems associated with characteristic combinations of soil and landform that characterise that region" (Brunckhorst 2000). An ecoregion also involves areas where there is spatial coincidence in characteristics of geographical phenomena associated with differences in the quality, health, and integrity of ecosystems (Omernik 2004). The primary outcomes achieved were as follows: scaling up planning to landscape-ecoregional level (going from 7.7 to 24.7 million ha); defining priorities and actions based on maintaining the ecological integrity of the component ecosystems (areas with a high level of biological diversity with respect to the number and variety of species within an ecosystem and across the ecoregion, and creation of biological corridors to link reserve areas and permit species migration); strengthening local natural resource management (through municipal governments, local organisations), utilising territorial land at different scales (private farms, communal lands, municipalities); identifying economic value for wild plant resources (wild fruit, valuable timber); and integrating scientific and traditional knowledge to better manage wildlife, medicines, and native fruits. The area of the ecoregion under territorial land use at the municipal scale has grown significantly since the outset of the management system established under the paradigms of the EA (Figure 22.2). Similarly, the protected areas under local management increased from zero hectares in 2000 to nearly half a million hectares in 2007, with projections for more than a million hectares by 2010, considering only those that promote natural resource management at the lowest suitable level.

During the process of applying the EA throughout the Chiquitano Dry Forest, several challenges were encountered. These included: lack of effective "ownership" of the EA conservation and sustainable development paradigms by the local stakeholders; rapid changes in social and political scenarios at the national, departmental, and municipal levels; numerous political and economic interests of stakeholders; and gaps in the information and knowledge regarding ecosystem functioning and the economic valuation of the ecosystem services, to the degree that an acceptable analysis of the services/benefits would be feasible.

Through continuous adjustments and improvements, the EA has functioned as a frame of reference for assessing the activities undertaken in the Chiquitano Tropical Dry Forest ecoregion over a span of approximately 20 years. During this period, the following lessons were learned:

1. Knowledge about and engagement in the EA concept is best achieved through tangible processes (e.g., implementing territorial land use or developing sustainable production activities) rather than through theoretical definitions.
2. Flexibility and adaptive capacity are important in order to take advantage of opportunities and to face difficulties arising from rapid changes in social and political scenarios at the national, departmental, and municipal levels.
3. Experience gained from working on large-scale jurisdictional-administrative units (e.g., associations or commonwealths of municipal districts) is useful to make the planning and territorial management processes viable, integral, and compatible in ecological terms (e.g., watersheds, biological, political-jurisdictional, cultural, and socio-economic corridors).
4. Taking "ownership" of the integrated management of the territory, by making conservation and socio-economic development compatible, begins with formal planning instruments, such as municipal land use plans. Processes for managing a specific natural resource usually had links to other resources (e.g., forestry, tourism, water use, biodiversity, land use, etc.).

This case study from Latin America demonstrates the usefulness of the EA in managing forest ecosystems within an economic context that seeks to contribute to effectively reducing poverty, while contributing to maintaining the viability of the principal ecological services. However, one of the keys to the success of applying the EA in practice will be its integration in multi-sector and participatory public policies. The main lessons learned indicate the need for greater emphasis in applying principles aimed at ecosystem management in an economic context (e.g., effective measurements of the cost-benefit ratio when using environmental goods and services, a more effective means of decentralising decision-making power, and a way of integrating scientific and empirical know-how). Finally, it was concluded that applying the EA to management on a landscape-ecoregional scale allows for integration of social, political, and economic issues, and presents opportunities for both conserving biodiversity and sustainable development.

This case study also demonstrates that focusing land management primarily on economic objectives can lead to changes in the ecological system and interruptions in ecosystem services. Ecological integrity should guide management decisions on types and levels of ecosystem goods and services. Focusing land management on ecological integrity may equally allow for system recovery.

### 22.2.2 Inventories and Monitoring

As pointed out in the previous section, maintaining or restoring the integrity of forest ecological systems is a precursor for healthy economic and social systems. Inventories and monitoring are primary sources for gathering knowledge on system status and dynamics.

*Inventories of Multi-Sectoral Assets*

Natural resources provide the power supply for local and global societies. A primary step towards ensuring that these resources will be conserved and used sustainably with optimum benefits for society is the development of an inventory of all assets. This inventory should include a listing and the potential of natural, human, social, and economic assets. It should include the condition, trends, and intensity of use of all ecosystem services. Ecosystem services are described in Chapter 2.

Natural assets comprise the natural resources or environmental features that provide a flow of goods and services (Pearce and Turner 1990). An inventory of natural assets can be used to determine rates of depletion or responsible utilisation. Examples include the following: water may be polluted, wasted or technologies for irrigation, distribution, and consumption may not be suitable; conversion coefficients for standing trees to final products may indicate that only a fraction of the total biomass is being utilised; imported substitute products may be used as a result of insufficient knowledge of local biodiversity; a low proportion of the chain of value may be processed with little value directed for local benefits; lack of attention to soil quality, or use of inappropriate technology may lead to soil degradation leaving poor quality and limited quantity available for local people; high transaction costs may favour illegal use of resources in order to make natural resources products profitable.

Human assets include the collective attitudes, skills, and abilities of people. Investment to develop local capacities may be insufficient and the comparison between the actual and the potential development of human assets may be enormous. The absence of vocational programs in rural schools obliges local youth to search for opportunities beyond the region. Where educational standards are set nationally, orientation and directives may be disconnected with the realities of the landscape. In a landscape dominated by forests, education and vocational training should be oriented to the conservation of forests, water, biodiversity, and other natural resources. Programs should focus on learning how to develop and manage projects that make sustainable use of soil, water, and forests; to establish sustainable cropping systems in agriculture, silviculture, and aquaculture; and to utilise and market the array of natural resources-related goods and services.

Social assets are shared norms or values that facilitate individual or collective action generated by networks of relationships, reciprocity, trust, and social norms (Fung and Wright 2003, Escobar 2005). In the most basic aspect, social assets may be considered as connections. They can be formal, such as the role of an organisation in landscape management, or informal, such as traditional cultural approaches to conflict resolution. Social assets can be measured by the amount of trust and reciprocity in a community or between individuals. A starting point for increasing social assets at the landscape level is the development of strong team leadership, with capacity for leading discussions and decisions on the use of community assets. These community leaders then need to be connected to other communities across the landscape, the region, etc. to create a web of leaders with a capacity for sharing knowledge and for negotiating. Taking stock and optimising the use of social assets will also allow communities to be better represented at regional and national discussions, and to voice their rights and priorities and to ensure accountability of decisions. Developing the social assets of a community is the basis for mobilising most of the other assets of the landscape.

Financial assets may be considered as those that can be directly converted into money. Rural communities often lack connections to the banking system and access to loans. Current banking systems can grant credit only to people that can provide collateral, such as a land title, as a guarantee for the money that they receive. A natural catastrophe may result in loss of lands to the banks similar to the events described in the novel "The Grapes of Wrath" by John Steinbeck (1939). Funding for landscape management should come from the internalisation of all externalities through prices for goods (market prices that internalise environmental and social impacts) and services (through environmental taxes and services payments). Achieving this goal needs the commitment of international stakeholders and funding agencies in order to develop a straightforward system that reduces intermediation and ensures benefits to people in rural areas. The development of community social assets has enabled organisations to be successful in preparing and getting funds for implementing projects, and in creating and managing micro-credit organisations (e.g., Grameen Bank).

Infrastructure assets are those that are constructed. A basic set of landscape production and communication infrastructure consists of schools, health stations, roads and bridges, and water provision facilities. Community social assets can be deployed to urge the national and local governments to establish these infrastructure assets. Communities have also to invest their own human capacities in the improvement and maintenance of the existing infrastructure. Low capacity to organise and react on time can lead to infrastructure collapse.

The assets described above may also be referred to as natural, human, social, and economic capital (Pelling 2005).The "capital approach" to sustainable development (Neumayer 1999, 2003) requires that the overall capital capacity should be maintained over intergenerational time scales. This approach is premised on the assumption that the various types of capital can be substituted by others; e.g., natural capital can be depleted and substituted by man-made capital (Neumayer 1999, 2003); while others (Pearce and Turner 1990, Ekins et al. 2003) have pointed out that because natural capital provides ecosystem services, it is a direct determinant of human welfare. It is thus of greater importance than other forms of capital and cannot be substituted. Sustainability, then, requires the entire stock of natural capital to remain intact over generations. The idea of "critical natural capital" (Gunderson and Holling 2002, de Groot et al. 2003, Dietz and Neumayer 2007) emerged to distinguish the portion of natural capital that performs important and irreplaceable ecosystem services.

Complex dynamic ecosystems are important natural capital assets (Deutsch et al. 2003). Their complexity and dynamic nature make determining and maintaining sufficient levels of renewable natural capital to provide for the needs of society, now and in the future, a challenge. A current problem in society is that natural capital is generally not accounted for or properly valued on market balance sheets (TEEB 2009). Deutsch et al. (2003) point out how using resilience as a unifying theme across ecological, economic, and social systems may help to address this problem.

Resilience is measured by the amount of change a system can undergo and still remain within the same state, the degree to which the system is capable of self-organisation, or to which it can build the capacity to learn and adapt. As discussed in Section 22.1.1 of this chapter, biodiversity contributes to ecosystem resilience by providing a variety of species for recruitment following change. The loss of groups of species that carry out key functions in an ecosystem will impact the capacity of ecosystems to re-organise following disturbance, and will thereby impact the flow of ecosystem services for human well-being (Deutsch et al. 2003). The inclusion of functional species as part of a system inventory and monitoring program can be useful to indicate both ecosystem performance and the status of natural capital.

*Monitoring and Adaptive Management, Northwest Forest Plan, USA*

The traditional approach to assessing forest resources over large areas is to use forest inventories. These typically have consisted of temporary or permanent plots designed to produce a statistically valid estimate of timber resources for single or multiple ownerships. In the United States Pacific Northwest, the Forest Inventory and Analysis (FIA) program of the United States Department of Agriculture (USDA) Forest Service consists of a grid of fixed plots spaced about 5.4 km apart (one plot for about 3000 ha) across millions of hectares of public and private forest land (Moeur et al. 2005). About 10% of the plots are re-measured every year, resulting in a 10-year cycle for visiting all the plots, and a statistically based estimate of changes in forest structure and composition. The FIA measurement program has evolved over the years in response to increased demands for information about ecological phenomena. For example, measurements are now taken on coarse woody debris and fine fuels. Plot-based inventories like these are not able to characterise the spatial pattern of vegetation and other biophysical phenomena. To obtain spatial information, other methods (e.g., satellite imagery, aerial photography) must be used.

Demands for more ecological information about forests and landscapes led to the development of entirely new policies for federal and private lands in Washington, Oregon, and northern California (Johnson and Swanson 2009). On the federal forest lands, the Northwest Forest Plan (NWFP) of 1994 made management for old-growth and associated fungi, plant, and terrestrial and aquatic animal species the dominant goals for federal forests in the western half of the region. The NWFP set up a landscape system of reserves and actively managed areas that were intended to meet the new biodiversity goals while producing a sustainable, but much lower, level of timber harvest. It was recognised that it would take many decades to achieve the ecological outcomes, and the NWFP was designed to achieve its goals after 100 years. The NWFP also called for monitoring and adaptive management to evaluate the implementation and effectiveness of the plan, and provide quantitative information that could be used as a basis for changing the plan. This monitoring program, which was one of the most ambitious multi-scale forest monitoring efforts ever conducted, was implemented and has produced a 10-year report detailing findings about trends describing effects of key ecological and social components of the plan (Haynes et al. 2006).

The monitoring plan was based on three biophysical measurement approaches: 1) a forest plot inventory mentioned above; 2) a spatial analysis of current vegetation and landscape pattern and change based on Thematic Mapper (TM) imagery; and 3) demographic monitoring of Northern Spotted Owl (*Strix occidentalis*) populations. In addition, socioeconomic monitoring was conducted on timber, jobs, and community well-being.

The monitoring strategy was based on collecting biophysical information about species and ecosystems at multiple levels of the biological hierarchy. In this case, the hierarchy included tree and vegetation information, populations of sensitive species, and landscape structure and dynamics. An underlying assumption of the approach is that knowledge of forest vegetation structure, composition, and dynamics can serve as a surrogate or approximation for knowledge of many individual species or ecosystem processes. This strategy has both scientific and practical motivations. The scientific basis lies in demonstrated relationships between species occurrences and/or ecological processes and vegetation structure, composition, and dynamics (Mulder et al. 1998). This approach has been called a "coarse filter" approach (Hunter 1991), and it is generally accepted that forest structure-based indicators should be part of an overall conservation strategy (Lindenmayer et al. 2001). However, it is also clear that so-called coarse-filter approaches have limits when it comes to predicting the abundance of individual species (Cushman et al. 2008). The practical basis lies in the fact that agencies and research institutions do not have the resources and expertise to monitor a large number of species and ecosystem processes.

After 10 years of monitoring the effectiveness of the 100-year NWFP, many trends were observed, including the following:

1. The total area of older forest increased faster than expected as a result of lower levels of logging than were allowed, and growth of mid-sized conifer stands into the lower diameter range of the old forest class.
2. In dry parts of the region, however, the amount of older forest lost to stand-replacement wildfire was relative high, and if such trends continued it would be difficult to reach restoration goals for old growth in those areas.
3. Populations of the Northern Spotted Owl declined at close to expected rates in the region as a whole, but in the northern third, the population declined at the high end of the expected rate probably because of the spread of a competitor species – the Barred Owl (*Strix varia*) – into territories of the Spotted Owl.

These trends, and other information collected in monitoring, were invaluable in providing a scientific basis for continuing the NWFP and making some changes to how it is implemented. For example, managers and policy-makers have used the information to increase efforts at reducing fuels in dry forests,

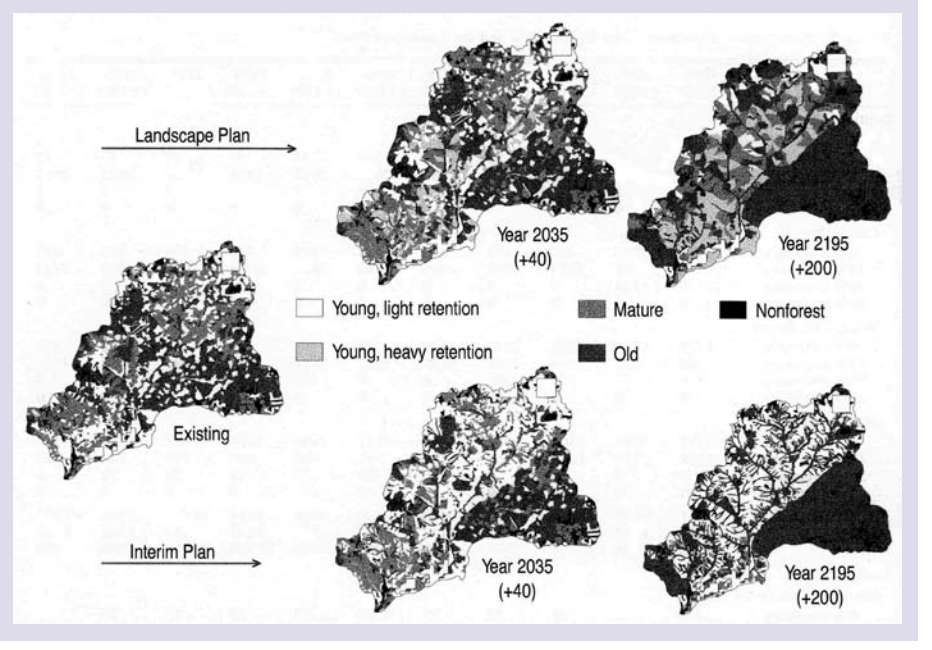


**Figure 22.3 Projected conservation scenarios for federal forest lands based on spatial pattern and frequency of fire (Cissel et al. 1999). Reprinted with the permission of the Ecological Society of America.**

and have created a new conservation strategy for conserving owl habitat in fire-prone landscapes. Furthermore, research efforts are now being directed at learning more about the habitat needs and influences of the Barred Owl.

The lessons from conducting the monitoring were several:

1. It is important to state expected ecological and socio-economic outcomes of a landscape plan, otherwise it is difficult to put monitoring results into context.
2. It may be necessary to monitor both habitat and populations for a few species, because habitat and population trends, and drivers of those trends, may differ.
3. It is not practical, either economically or politically, to survey for large numbers of rare and poorly known species (e.g., fungi, bryophytes, invertebrates). Structure-based approaches may be all that agencies can afford for most species.
4. Scientists and managers must approach monitoring through a partnership. Managers need the scientists to help develop protocols and analyses, but managers should do the monitoring work because there are too few scientists to do that work, and if monitoring is to become part of management culture, then managers should conduct it.

### *22.2.3 Landscape-Level Modelling*

*Applying Integrated Landscape-Level Models in Oregon, USA*

Monitoring landscape change is only one part of a strategy for sustaining forests in a dynamic world. Landscape modelling is another important component of adaptive management because it allows assumptions about management actions to be assessed (Walters 1986). While it can take many different forms and have different goals, it is generally used to better understand how management actions and biophysical processes could change biodiversity and ecosystem structure, function, and services across large heterogeneous areas (Monserud 2003, Scheller and Mladenoff 2007). Landscape modelling varies in scale and resolution, often includes the activities of humans, and relies on either simulation or optimisation approaches to produce spatially explicit outputs. While scientific models are often used for prediction, the complexity and spatial nature of landscapes make such models difficult to validate and use to predict outcomes. Instead, such modelling is often used to evaluate assumptions and project possible outcomes of different scenarios.

In the US Pacific Northwest, integrated landscape models have been used for a variety of purposes. At a relatively small landscape scale (23 990 ha), managers and scientists used landscape models to evaluate how historical fire regimes could be used to create alternative conservation plans for federal forest lands in Oregon (Figure 22.3). This modelling

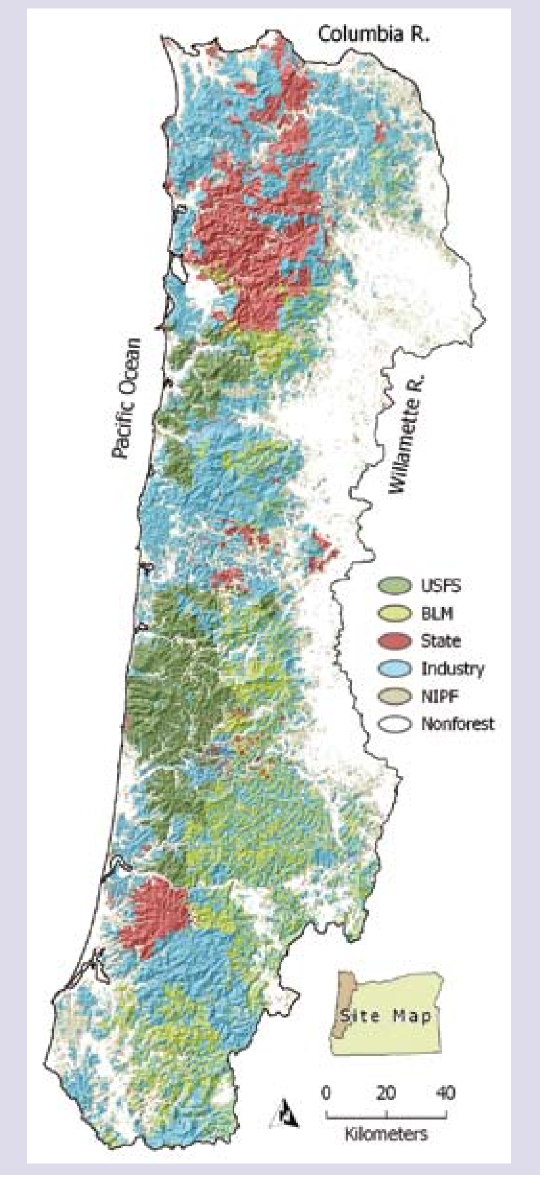


**Figure 22.4 Ownership pattern of the 2.3 million ha Coastal Landscape Analysis and Modelling Study (CLAMS) in coastal Oregon. Abbreviations: USFS = United States Forest Service; BLM = Bureau of Land Management; State = State of Oregon; Industry= forest industry; NIPF = non-industrial private forest and other miscellaneous owners; Nonforest = other land uses (Spies et al. 2007). Reprinted with the permission of the Ecological Society of America.**

effort demonstrated that a landscape management strategy based on the spatial pattern and frequency of fires could improve biodiversity outcomes compared to the existing plan that was less sensitive to disturbance history.

Another effort, the Coastal Landscape Analysis and Modelling Study (CLAMS), which focused on a 2.3 million ha multi-ownership landscape of coastal Oregon, evaluated how current and alternative management policies might affect a suite of biodiversity and socio-economic metrics (Spies et al. 2007) (Figure 22.4).

That landscape modelling effort projected how the policies and actions of different public and private forest land owners over many decades could scale up to the region. CLAMS found that individual landowner forest biodiversity plans, which were not coordinated, could result in some unintended outcomes. For example, under current policies, landscape patch diversity and intermixing, early successional stages, hardwood forest types, and several species of vertebrates would decline, as illustrated in Figure 22.5.

Alternative policies, which increase retention of trees in cutting units on private lands, could mitigate some of these potentially undesirable changes. A theoretical scenario in which the landscape was allowed to be shaped by the historical fire regime would require several centuries before the landscape structure would return to its historical range (Nonaka and Spies 2005). That scenario illustrated the fact that, for many landscapes, it is really not possible to return to the historical landscape structure or dynamics. Instead, managers can only hope to approximate some of the processes and patterns that support the desired elements of biodiversity and ecosystem services. The CLAMS effort has helped policy-makers take a broader landscape view of conservation practices, and led to new tools that are now being used in landscape planning. CLAMS also revealed that few policy institutions are set up to deal with multi-ownership issues that arise from the cumulative effects of individual ownership activities.

What has been learned from forest landscape modelling in the US Pacific Northwest?

1. Spatial models are now the standard for planning and evaluation of forest management.
2. Modelling approaches are quite variable, and no single approach is suitable for all questions and issues.
3. Developing the underlying geographic information system (GIS) layers and supporting models for conducting landscape modelling can take considerable time and effort.
4. Validation of landscape models is extremely difficult and is often approximated with sensitivity analysis to understand the robustness of the outcomes (Monserud et al. 2003).
5. Most landscape models have to rely on a mix of relationships derived from empirical studies on expert judgment.
6. Landscape modelling using scenarios can help people understand the possible consequences and cumulative effects of site- and landscape-level plans and activities.
7. Modelling alone rarely changes policy and management, but it is a critical part of a systems-based

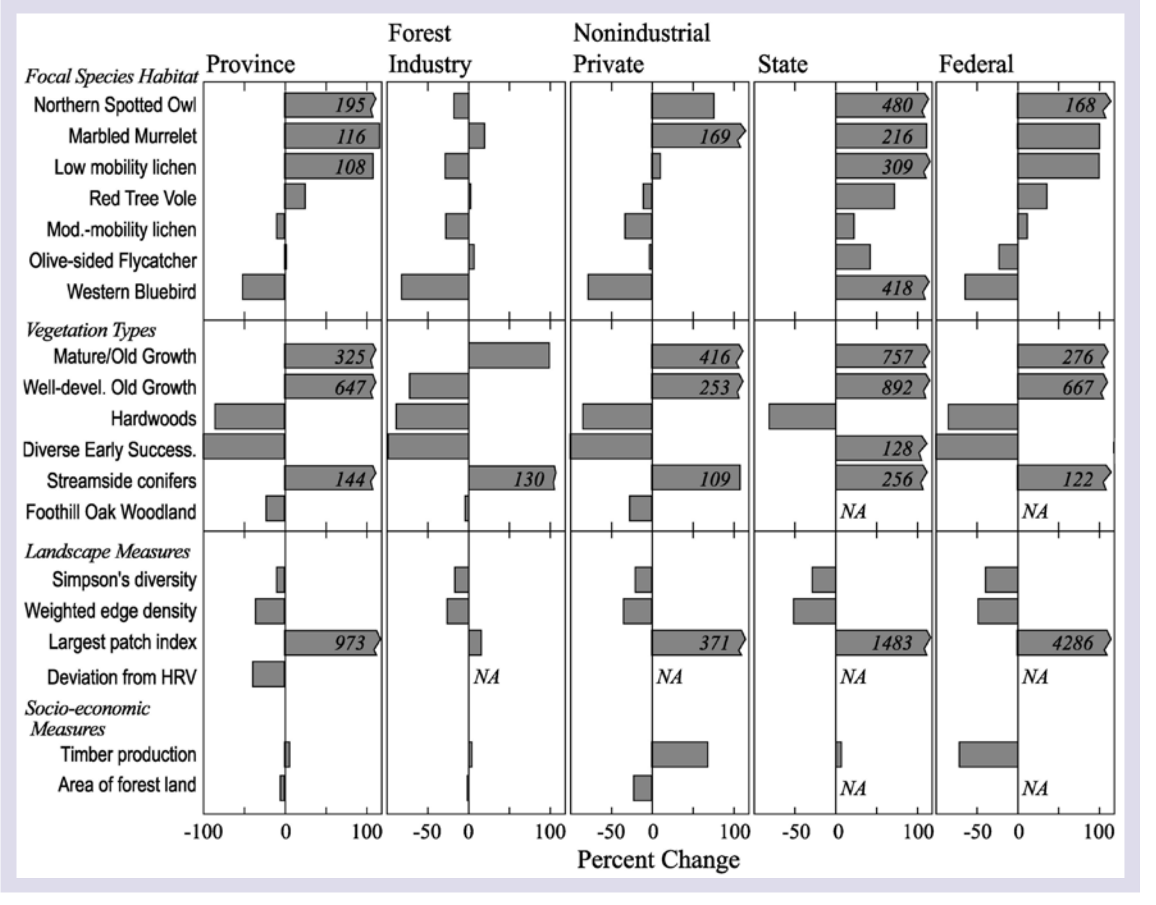


**Figure 22.5 Projected (a 100-year simulation) landscape changes based on policies and action plans of different public and private forest land owners. Numbers indicate relative change percentages that exceed 100; deviation from historical range of variation (HRV) is mean deviation (%) of forest age classes from the expected distribution of either the high or low end of the range of values under the historical disturbance regime. Timber production is change (%) in harvested volume (m³/year); NA= not applicable (Spies et al. 2007). Reprinted with the permission of the Ecological Society of America.**

landscape management process that includes monitoring, research, and stakeholder involvement.

8. While landscape models are proliferating and becoming more widely used, the complexity and hidden assumptions of even simple models make it imperative that users explain their assumptions, and the limitations and uncertainties.

## 22.3 Addressing the Challenges in Managing for Change

### *22.3.1 Forest Adaptability and Resilience*

The theory underlying resilience management is supported by advances in chaos theory (Stewart 1989), complexity studies (Holland 1975), and computing power, which, in turn, have fostered investigations of the organisation and relationships among individual parts or processes of systems, how they give rise to emergent behaviours, and how the system adjusts and adapts to changing conditions (Levin 1998, 2005; Solé and Bascompte 2006). Complexity science suggests that no aspect of forests may ever be highly predictable. In fact, the accumulating knowledge about the processes that determine ecosystem dynamics shows that these processes are not united by comprehensive theories, but rather by their unpredictability. While qualitative forecasts to predict the general trend of forest development following disturbance are possible, accurate quantitative predictions of attributes at a particular place and time, such as total biomass, continue to be a challenge.

A systems framework taking into account the lack of certainty, and integrating the spatial and temporal range of variation within forest ecosystems, can serve as guidance to develop new management practices that will allow the forest to adapt and be resilient (Puettmann et al. 2009). Policies that accommodate and promote complexity, variability, and some uncertainty of outcomes are a dramatic shift in the premises underlying conventional forestry. Forest managers have expended a lot of effort to control disturbances and to be able to predict forest development. Accepting heterogeneity and lack of predictability as important and inherent characteristics of forests implies allowing forest development to follow a variety of possible paths. This would mean that rather than trying to force individual stands to move to a specific condition described in growth and yield tables, silviculturists would attempt to move toward a prescribed envelope of possible future conditions. Giving up specific predictability of a particular future stand condition may seem a step backward in efforts to manage forests on a scientific basis. For example, many forest owners demand precise predictions of future condition so that they can calculate how much timber can be extracted in a sustainable way and assess financial yield. While science has greatly increased foresters' understanding of forest dynamics and conditions that lead to regeneration failure, repeated assessments of the impacts of disturbances on harvesting levels have shown that accurate prediction is not possible. Research on how to prepare envelopes of potential future conditions for a variety of landscape and ownership objectives may be necessary. In letting go of predictability, managers may actually gain a lot of flexibility and save time and effort from combating the natural forces acting in each and every stand, and across the landscape as a whole. Resilience theory suggests that forest managers must be prepared to be flexible if the short term catastrophic industry collapses associated with overly rigid management practices of the past are to be avoided (Holling and Meffe 1996).

To account for the lack of certainty, forest managers need new tools that permit the integration of the spatial and temporal ranges of variation of forest ecosystems. The goals for forest production must be flexible and adapt to events and to the response of ecosystems. The spatial and temporal limits that are imposed by human management need to be reconsidered to improve flexibility and allow management to operate at many levels (Drever et al. 2006). This range of variation is an aspect of the resilience of the system. Managing for system resilience means recognising that ecosystems are in non-equilibrium, and changes in ecological processes at one level can affect processes at other levels in non-predictable ways.

It is possible to analyse a forest ecosystem to estimate the probability at which it would be expected to remain near a single steady or cyclic state following perturbations of different types and severities. Measuring system shifts from one state to another indicates the amount of change or disruption that is required to transform a system from being maintained by one set of mutually reinforcing processes and structures to a different set of processes and structures. Searching for a single steady or cyclic state focuses on efficiency, control, and predictability – all core attributes for fail-safe design and optimal performance. Searching for the threshold of a particular state focuses on persistence, adaptability, variability, and unpredictability – attributes that are at the heart of understanding sustainability.

The value of managing forests as complex adaptive systems will increase in anticipation of expected changes in social and environmental conditions. *Complex* refers to the diversity of forest systems with a multitude of interconnected elements. *Adaptive* refers to the capacity for forests to change and incorporate information and learning from the change experience. A potential benefit of this management approach is a higher likelihood that forests are able to respond to a variety of changes.

### 22.3.2 Risk Assessment and Risk Management

While forest management has always been a complex undertaking embedded in both biophysical and social systems that are only partly understood (Haynes et al. 2005), the rapidity of change and complexity of emerging new drivers of change bring new challenges. Previous sections in this chapter highlight the importance of considering the non-linear and non-equilibrium nature of ecosystem dynamics (Kay 2000), which are amplified by the effects of human activity. This recent knowledge of ecosystem dynamics presents a paradoxical challenge for sustainable forest management. Although the aim is to "meet the needs of the present without compromising the ability of future generations to meet their own needs," the ability to forecast future changes and impacts (on both the landscape and future generations) is challenged by the intrinsic unpredictable nature of ecosystems and our limited scientific knowledge base, as well as the longer-term time frames over which forest ecosystems function relative to other industrial sectors (Hoogstra and Schanz 2007). Over time, and through adaptive management, the knowledge base about the potential short-term and long-term impacts on both the landscape and socio-economic conditions is growing, and the need to make informed decisions is increasing with the complexity of emerging forest issues. Practitioners of sustainable forest management (SFM) need guidance for applying the best data and knowledge available to deal with uncertainty and unpredictability.

A formal practice of risk assessment and risk management may provide such guidance. Formal risk management frameworks are commonly used to support decisions in many areas of society, such as engineering, transportation, economics, and the insurance industry. Some aspects of risk analyses are common in many areas of environmental science and ecology (e.g., studying the effects of a toxin on a particular species in a defined habitat) (EPA 2000). The broader concepts of "risk management" and "risk assessment" have yet to find widespread formal adoption in SFM and ecosystem-based management (EBM) decision-making frameworks. Risk analysis and management applied at the whole-system scale deals with near- and long-term sustainability planning, and examines the risks to ecosystem structures and processes. For example, a risk assessment might analyse projected socio-economic costs and benefits to a particular management plan and its effect on the overall ecosystem integrity of a region.

The intrinsic uncertainty and unpredictability of ecosystem processes poses a significant challenge to the utility of a quantitatively rigorous risk-based approach, in the context of SFM/EBM. As Kay (2000) emphasises, it is equally important to consider what we do <u>not</u> know about a particular ecosystem as compared to what we <u>do</u> know, and to make all uncertainties explicit. Although the scientific data and knowledge-base have grown significantly in the past several decades, coverage and representation are limited relative to the spatial and temporal scales over which ecosystems have evolved and operate. It is also now recognised that ecosystem processes exhibit higher degrees of stochastic behaviour, in particular along key pathways in forest succession models (e.g., such as that described by Holling 2004). These aspects require more complex mathematical modelling. Control of key risk factors may not be possible, and additional factors beyond the basic elements concerned with predictive capacity and confidence may need to be considered.

Early definitions of "risk" (R) involved estimating the probability or frequency (f) of a particular event occurring, combined with an assessment of the human exposure and consequences (c) of the event ($R = f(f,c)$). In recent years, debates about the fundamental definition of risk have resulted in the addition of a more qualitative third term, "risk perception" (p) to the definition (($R = f(f,c,p)$). For example, we can quantify the risk involved in gambling to win or lose USD 1000. For a gambler who has thousands of dollars, then neither outcome is a major risk (loss or gain); but a gambler who has only USD 1000 is risking everything and the stakes are much higher. The decision, therefore, depends highly on these qualitative aspects of relative circumstance. Applying this formulation to an SFM/EBM scenario, it may be possible to estimate the risk of habitat loss for a critical species under a particular forest harvest scenario (see Figure 22.6, components A–D). In this case, a trade-off analysis may be conducted to determine the locations where the maximum economic

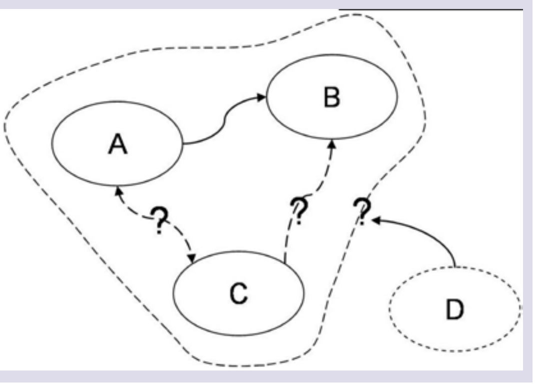


**Figure 22.6. Hypothetical risk modelling scenario considering an anthropogenic activity such as a particular forest management plan (A) and its estimated effect on a biospheric component (B) (e.g., a particular species habitat). A third factor (C) may be known, but lack of data or knowledge about its effect on both A and B introduces uncertainty. Factor D is an external unknown factor. (Developed by Brian Eddy).**

value (A) may be attained at the lowest risk to the particular species habitat (B). In reality, however, on a broader ecosystem scale, there are many more factors operating that need to be taken into account. Climate change or natural disturbances (e.g., fire or insect) will also affect both species habitat and timber yield estimates (C), and there may be unknown external factors (D) that affect the system in uncertain ways.

A risk-based approach for SFM/EBM may provide a robust means for stakeholders to think "critically" about preferences and alternatives, to promote transparency of the decision-making process, and to openly make explicit the uncertainties involved in particular courses of action. A number of key challenges remain in developing a risk-based approach that is scientifically robust, yet can also accommodate different stakeholder values and perceptions, including the communication and translation of model outputs into forms of information that are meaningful to stakeholders. These include the following:

- SFM/EBM is a highly public-oriented process involving the participation of multiple stakeholders with different areas of expertise, risk perception, and values with respect to priorities and alternatives. A robust, yet reflexive risk-based approach may serve as a means for mediating stakeholder perspectives and values if they are adequately captured in stakeholders' own terms and translated for incorporation in further analysis and modelling of scenarios.
- Where possible, risk estimations, analyses, and models should be explicitly "geospatial," enabling adequate characterisation of the inter-dependen-

cies of ecosystem components over multiple temporal and spatial scales. Therefore, they require the development of a comprehensive and multi-thematic geospatial information base for a region, along with a flexible and diverse suite of analysis and modelling tools that are appropriate for particular SFM/EBM decision-making contexts.

- Risk models will typically focus on projected losses and gains associated with both competing and complementary stakeholder values under different scenarios. This represents an essential step in the mediation and accommodation of stakeholders' preferences. Whether such models and scenarios are quantitative or qualitative, it is also necessary that they are communicated effectively to stakeholders. This will often require translating science-based information into alternative forms of information that are meaningful to stakeholders, while simultaneously allowing feedback for iterating alternative scenarios.
- Risk frameworks must also consider practical policy and management tools to ensure that there are instruments for implementation and ongoing, long-term monitoring. These include making use of existing laws, policies, or programs, and where there are deficiencies, a sufficient governance capacity to develop new implementation mechanisms as required. The geospatial information base and analytical models may be used to continually monitor progress and iterate the process as needed.

### *22.3.3 Climate Change*

The forest landscape response to climate change is a multiscale complex process, making accurate predictions for future response difficult (Xu et al. 2009). Forested landscapes can be expected to exhibit some dramatic changes in the decades and centuries to come. The key climate change impacts on forest ecosystems are an increase in rate and intensity of forest disturbances (Hogg and Bernier 2005). Expansions and contractions in the ranges of many plant, animal, and pathogen species are expected as a direct result of shifts in climate, although the lag in biotic community adaptation could be great (Peterson et al. 2002, Wilson et al. 2005). We can count on invasive species being more problematic as a result of anthropogenic disturbance, climatic warming, and more globalised trade (Bright 1999, Dukes and Mooney 1999). In general, future climates will support greater forest productivity (Melillo et al. 1993), but reduced productivity in portions of the globe where water becomes limiting (Boisvenue and Running 2006). The potential for increased biomass production must also be offset against increased levels of natural disturbance (wildfires, insect outbreaks, wind storms) expected in many parts of the world (Dale et al. 2001, Volney and Hirsch 2005). Collectively, these biophysical impacts will likely result in further land use changes, shifts in community priorities, and increase or decrease in local/regional economic activity. These shifting values are often not reflected in the values and priorities expressed by local stakeholders in land use planning and forest management, as there tends to be an inherent inertia (conservatism, slowness to react, perhaps especially in rural areas) on the part of the general public as the world changes around them (Williamson et al. 2005). Protected areas, resource emphasis zones, biological legacies in managed landscapes, and locally adapted (fine-tuned) management practices may no longer be able to protect and sustain the values they were designed to conserve. Examples of climate change impacts throwing land management plans awry are accumulating at a growing rate: apparent desertification in the Sahel region of Africa (Mortimore and Adams 2001), prolonged drought and extreme bush fires in Australia (Campbell 2008), and an unprecedented outbreak of the indigenous mountain pine beetle in British Columbia, Canada (Safranyik and Wilson 2006).

These consequences of climate change affect how we manage our resources. Conservation planners and forest managers, for example, must take proactive measures to adapt to and mitigate potential climate change impacts on their respective resources (Pyke and Fischer 2005, Spittlehouse 2005). The current ecological paradigm places static boundaries (e.g., a cutblock, planning unit, or land use zone) on an inherently dynamic system; as plant, animal, and pathogen species migrate in response to climate change, this paradigm's flaw becomes apparent. Parks and protected areas, for example, are unlikely to maintain their conservation objectives as climate-driven changes reassemble and re-organise ecosystems (Bartlein et al. 1997, Leemans and Eickhout 2004).

The classical ecological paradigm is based on the assumption that ecosystems have recognisable boundaries, and that they follow a linear progression to a stable or climax state. In contrast, the non-equilibrium paradigm recognises that ecosystems can be open and heterogeneous, spatially and temporally variable, with many contingent pathways of succession and alternative stable states, and that their interaction on the landscape influences the mechanics of other ecosystems (Hannah and Salm 2005, Wallington et al. 2005). Recognising the temporal and spatial dynamics of ecological systems is fundamental to the successful integration of a non-equilibrium approach to conservation and sustainable resource management (Stuffling and Stocks 2002, Scott and Lemeiux 2005). More effective, holistic, and systems-based management can be achieved by closing the gap that exists between current landscape management policies and emerging scientific perspectives (Scott and Lemeiux 2005, Wallington et al. 2005). The development of dynamic protected area networks is an example of innovation and progress at the landscape or regional level. By tracking the temporal and spatial dynamics of a network, managers can more easily ensure that suitable habitat for the widest possible array of target organisms, and biodiversity in general, is continuously available (Rayfield et al. 2008).

Possible solutions for coping with emerging shifts in climate (but also shifts in the milieu of invasive pests and diseases, social values, global markets, etc.) all depend on timely information being made available to decision-makers and the public so that the appropriate investments in "resistance," "resilience," and "response" (Millar et al. 2007) can be made. This means reliable and ongoing data on trends in weather (climate), hydrology (stream flows and water quality), productivity of timber and non-timber resources, species range shifts, and the incursion of new invasive species. Successes and failures in ecosystem management need to be communicated rapidly and widely, including efforts to adapt to climatic shifts through facilitated migration, productivity enhancement, protected area management, and ecosystem restoration. All such efforts are strongly dependent on computer resources based on efficient database management, geographic information systems, and weather/climate interpolation tools (e.g., Wang et al. 2006) that can incorporate the best available projections of the future climate. Research and teaching institutions, oversight agencies and management arms of government, as well as forest managers and the consultants that do much of the strategic and operational planning for forest landscape management, will all have to invest in more monitoring and capacity building. Long-term plans will still be needed, but refinements to include new "pulse taking" and "best available projections" will have to be incorporated with increasing frequency if sustainable landscape management is expected to keep up with climate change.

A consensus seems to be emerging that when accurate and timely environmental information is available, and when the public is well-educated and engaged, then constructive and pro-active management actions can be undertaken to promote landscape health, sustainability, and resilience in the face of an uncertain future (Noss 2001, Millar et al. 2007, Campbell 2008). Ecosystem management principles, such as the avoidance of forest fragmentation, the maintenance or emulation of natural disturbance regimes, the protection of representative areas of primary forest, and the practice of low-intensity forestry become even more important under climate change in order to maintain biodiversity and management options for the future. Other measures include the protection of diverse gene pools, greater emphasis on landscape buffers and connectivity, careful zoning of land uses or resource management emphasis, and the designation of parks or reserves over large areas and preferably over environmental gradients. Direct intervention – in terms of the facilitated migration of species or climatic races of desired plants, timely control of exotic and invasive species, and the deployment of multiple approaches (active adaptive management) to resource management activities – is also an important option for promoting system resilience in many parts of the world. As in other sectors that deal with risk on a regular basis, the way forward can be navigated with greater confidence when landscape managers have reliable information and stay alert to emerging issues, hold a diverse portfolio, employ a wide range of practices, and maintain flexibility in their objectives, timelines, and priorities.

### 22.3.4 Empowered Participatory Governance

Earlier in this chapter, the importance of social capital in mobilising other landscape assets was highlighted. Well developed social assets also facilitate self-organisation and adaptation to change. With respect to communities, empowered participatory governance is a key concept for land use planning and asset utilisation. Fung and Wright (2003) and Escobar (2005) emphasise the need for enabling conditions and identify the following principles for successful management of territories, landscapes, and their systems: *practical orientation, bottom-up participation*, and *deliberative generation of solutions*. Box 22.1 provides additional details about the examples provided in this section, while Box 22.2 describes a government experience with public participation.

Organisations that are working with communities to develop assets are usually driven by concrete concerns related to practical problems, such as encouraging actors who are used to competing for power and resources to co-operate and foster more congenial relationships. The pilot forestry plan for the *ejidos* (the people who work and manage communal farmland expropriated from large private landowners), who did not have the right to use the wood in their territories in Quintana Roo, Mexico (Bray 1993), is a typical example. In another example from Hojancha, Costa Rica, the community was facing soil degradation as a result of water scarcity (Salazar et al. 2007, Serrano et al. 2008). This water problem, coupled with migration, resulted in a nearly 50% reduction of the population within 10 years. In El Petén, Guatemala, community concerns focused on

Jaques Robert

**Photo 22.2 Partners in the Waswanipi Cree Model Forest Project (Northern Québec, Canada) discussing the implications of management options during a scenario planning session.**

poverty, deforestation, and illegal logging (Actores Sector Forestal de Petén 2007).

Bottom-up participation is the process whereby the search for new channels and approaches for community management of natural resources is performed by those who are the most directly affected by the problems, and who can apply their inventive capacity to the formulation of solutions. For example, the forest ejidos of Quintana Roo, the Community Concessions of El Petén, and the Hojancha community, developed their own management structures, primarily controlled by members of the community. Essentially self-motivated, they tried to solve concrete problems similar to those mentioned above. Bottom-up participation allows local people to arrive at realistic solutions that empower the community. External participation is increasingly becoming limited to more passive and task-specific activities, which are submitted to the scrutiny of the grassroots community organisation and made to follow the preferences indicated by the community in accordance with their culture and traditions.

Deliberative generation of solutions occurs when participants listen to each other and use these positions to inform group decisions. Participants search for solutions acceptable to the group that can be translated into collective action, not necessarily those that can be totally endorsed or appear to be most advantageous. Building a sense of solidarity by trying to see things from another's perspective is a goal of this process and is demonstrated in the approach taken by the examples from Mexico, Guatemala, and Costa Rica. Each example describes a specific defined and regulated discussion mechanism. These examples also demonstrate that including women, and acknowledging their common rights over resources and their roles on directive boards or special action groups responsible for concrete tasks and specific production, can greatly increase participation.

The characteristic elements of design for participatory governance include the following: *devolution*, *centralised supervision and coordination,* and *state-centred and non-voluntaristic governance*.

Devolution occurs when the state gives control and accountability to communities and local organisations. Grassroots organisations can have substantial public authority when they become responsible for the fulfilment of laws. In El Petén, communities have enjoyed control over the management of their forest for 25 years. In Quintana Roo, communities have established organisations that make decisions over the resources that belong to them. In Hojancha, the community has created a series of specialised organisations whose purpose is to make decisions regarding sectoral issues. In addition, local representatives of the community now hold key positions in national institutes and agencies in order to serve the community directly. In Honduras, a community forestry project became the foundation for the development of a broad social forestry movement in areas owned by the state and municipalities.

Fung and Wright (2003) suggest that centralised supervision and coordination is neither about democratic centralism nor about absolute decentralisation, since both are considered to be unrealisable. Rather, it is about developing new forms of coordinated decentralisation. It assumes that organisations and their actions enjoy a substantial degree of power and discretion, but not as autonomous entities, fragmented in their decision-making. Accountability and communication bring local units together with subordinate institutions. In El Petén, Guatemala, while the National Commission of Protected Areas of Guatemala (CONAP) is responsible for transferring access and control, the community is also self-accountable and duly monitored with regard to compliance with the terms of the contract. There is an important interaction in Quintana Roo with state authorities, specifically with the governor's office, as well as with the Secretary of Agriculture and Water Resources. Finally, in Costa Rica, the community enjoys the support of several non-government organisations who are responsible for different aspects, but who also work in close contact with the authorities in the Ministry for the Environment who are responsible for the conservation area of Guanacaste.

**Box 22.1 Enabling condition and power balance: Case studies from Guatemala, Costa Rica and Honduras**

*Ronnie De Camino, Carolina Baker and Leonardo Espinoza*

**The Case of Hojancha County in Costa Rica**

This case study demonstrates how enabling condition and balance of power can be achieved by extension of the carrying capacity through better use of capital planning. Hojancha is a community of immigrants. From 1950–1970, it was mainly devoted to cattle. In the mid-1970s, meat prices collapsed and increased deforestation for pasture "dried" the Nosara River, a water supply for the community. As a result of this land and aquifer degradation, more than 50% of the population migrated within a two-year period. A local leadership development exercise led to many positive changes in the community. For example, the community created the Monte Alto Reserve. After 15 years of restoring degraded areas, water returned to the community. Reforestation from the '80s now enables some small sawmills to operate and sell timber, furniture and tree seeds, providing important sources of income for the Cantonal Agricultural Centre. The school of Hojancha integrates secondary education with specialised training in agriculture, forestry, agroforestry, and ecotourism. The coffee cooperative in the county has a trust fund and a program to support fellowships for higher education for youth.

**The Petén community concessions in Guatemala**

In the early '90s, the tropical forests of the Petén region in Guatemala were under concession contracts to some 15 private forest companies. These companies did not do a good job of managing forests and did not bother to maintain the integrity of state-contracted forest land. Deforestation and forest fires caused heavy losses of timber and increased the illegal occupation of territories. In the mid-1990s, the National Commission of Protected Areas of Guatemala (CONAP), with support from international cooperation, created the Maya Biosphere Reserve. It includes concession areas, national parks, and buffer zones. Following its creation, forest concessions for timber production were granted mostly to communities and to a couple of private companies, provided that they would certify their forest management operations according to international standards of sustainability. Today, 13 community concessions and two industrial concessions are internationally certified, producing timber and non-timber forest products. Private companies and communities have taken different approaches to forest management. The community organisations have matured, been consolidated, and have even replaced non-governmental organisations in providing technical and market services to their members. Every year, large areas of forest in the core areas of national parks and buffer zones of the Biosphere Reserve are burned. The significantly lower incidence of fire in the concession areas is attributed to the community sense of ownership for their forests and the stewardship activities they practise. Improvement in capital has definitely increased capacity in the Petén.

**Community forestry in Yuscarán county, Honduras**

This case study shows that a change of perspective can be sufficient to transform a serious problem into a great opportunity. Fourteen years experience working with communities of "forest dwellers" in Honduras showed that saving the forest required a shift from a reductionist approach that targets only traditional forest management toward comprehensive development of forest and nearby communities. The tragedy of rural inhabitants in the tropics is the almost total dependence on natural resources, which are under increased and accelerated degradation partly as a result of involuntary actions of the inhabitants. In Honduras, more than half of the population that is below the poverty line lives in public forests and communal lands. Every year, the state spends tremendous resources in an unproductive effort to control illegal logging and forest fires, the combined actions of which decimate this vital resource every year.

In 1994, GTZ, the German international cooperation enterprise for sustainable development, at the request of the Government of Honduras, along with the Honduran Forest Development Corporation (COHDEFOR), initiated a project to try to resolve these problems. A participatory analysis of the situation identified that if the management of the forest, including all benefits and obligations, was transferred to communities of "forest dwellers," it would be possible to solve the problems of forest conservation and poverty simultaneously. The task of transforming subsistence farming communities into small forest entrepreneurs needed to demonstrate the technical feasibility of the solution to the forestry authorities and to the farmers. The experience started with participatory rural appraisals in five communities of Yuscarán County, Honduras. The diagnosis revealed extreme poverty with high levels of malnutrition and the continued presence of bronchopulmonary and gastrointestinal diseases. In addition, it noted that people were psychologically affected by chronic neglect and absence of hope for change or improvement. People readily participated in a series of workshops taking advantage of the opportunity to raise their self-esteem through dialogues and role-playing games. Families began enriching their home gardens with annual and perennial crops, and fruit and forest trees of high commercial value, to configure a highly diversified and utilitarian agroforestry system. This production unit was called an Integrated Agroforestry Unit.

An analysis of the area of influence of communities was carried out on roughly 3000 ha of publicly owned pine forest, where there were no tenure conflicts. The community prepared an integrated management plan covering wood-productive forest areas, protected areas, and areas for water recharge, wildlife management, agricultural production, recreation, housing, etc. The plan, including the right to manage the area under a usufruct agreement for 40 years, was presented to COHDEFOR. Under the motto "You shall never solve a problem of the community," every circumstance was used as a pretext to train the community (men and women of all ages) in various forms of analysis and troubleshooting, to enable them to learn to find solutions. In this way, Integral Agroforestry Farms, Integrated Forest Management, and Integral Human Development became the three pillars of what evolved into Community Forestry (CF). This process resulted in the following achievements in Yuscarán:

Economic Impacts
- Forestry operations generated 80 new permanent jobs with revenues of nearly USD 9000/year.
- Integrated farms generated USD 1000/year.
- Forty-three to 46% of household incomes came from implementation of the Community Forestry Strategy.
- The average annual income of participating families (USD 26 000) was higher than the average annual income of the county (USD 20 000).

Ecological Impacts
- The area affected by fire was reduced to less than 1% in forests throughout the municipality.
- Annually, more than 150 people were involved in protection (50% was voluntary activity).
- Farmers abandoned slashing and burning, and slowed down the advance incursion of agriculture into forests.
- Agrochemical use was reduced.

Social Impacts
- The Guadalupe Cooperative increased its membership from 80 to 140 partners (20% women).
- Women achieved important positions in the board of the Cooperative, Honduran Federation of Cooperatives, the Honduran Institute of Cooperatives, and the Council of Organisations and Indigenous Agroforestry (CICAFOC).
- Participating communities were better able to manage land use conflicts.
- There was evidence of a mindset shift to proactive lobbying (high degree of appropriation).
- Community organisations were more effective, with a greater degree of perseverance, cooperation, and integration.
- The participation of women in family and community life, and forestry and agriculture significantly improved, including significant changes in self-esteem.

Once the experience of Yuscarán was validated, in March 2003, it was also institutionalised in AFE-COHDEFOR as the Community Forestry Strategy for the country by an institutional resolution. The experience was replicated with 40 communities in the municipality of Gualaco in an area with 40 000 ha of National Forests.

State power is colonised, and formal governance institutions are transformed in a state-centered and non-voluntaristic design. Organisations try to influence decisions made by the State through external pressure. The idea is that in future, as a result of this pressure, the State begins to replicate the three principles and the design elements mentioned above. For example, the use of an advanced forest fertiliser system in Costa Rica, introduced to benefit communities, was first started in the county of Hojancha, and its application is now expanding into the entire country. The same is true of the ejidos in Mexico. Application was initiated in Quintana Roo, and then it was applied in the ejidos of the Mayan zone. Positive outcomes led to applying this same or a similar solution in other ejidos. In Guatemala, communities even began to bring the State into compliance with community concession contracts and questioned the government's decision to declare a mega-park in the areas granted as concessions. In Honduras, after the experience in Yuscarán regarding community forestry, which involved the transfer of a mere 3000 ha of pine forest, 27 000 ha were transferred to the communities in the municipality of Gualaco, Olancho. These examples illustrate how communities have put pressure on the government to go along with compromises.

In addition to the principles and design characteristics indicated above, several enabling conditions are necessary in order to successfully implement empowered participatory governance and to achieve a balance of power between the parties participating in the process. This balance of power is achieved through literacy and capacity building, discouraging any potential for domination, through an obligation to consult before taking decisions, and by allowing for the possibility for forestry authorities to be questioned. In Hojancha, the community has taken over the institutions and intensively trained their technical support, administration, and other professional staff. In Guatemala, the communities have organisations within their network, such as the Petén forestry communities' associations (ACOFOP), which challenge the state or private interests when a situation of conflict arises. In Mexico, the ejidos act independently, but form part of civil society groups. This mechanism protects communities from potentially unlimited power that might be inflicted upon them by external actors.

The three cases described in Box 22.1 (Hojancha, El-Petén, and Yuscarán communities), share several common aspects. They have followed the livelihoods approach, considering the five capitals of the territories. They have also intuitively followed the Empowered Participatory Governance Strategy, which includes the following elements: a) practical orientation from the perspective of the local people, b) bottom-up participation, c) deliberative generation of solutions, d) devolution (of access to land and other resources), e) decentralisation, with clear responsibilities at the local level, f) colonisation of the State by the community, transforming the national natural resources agenda into implementation of a local agenda for using natural resources guided by the ecological integrity of the area.

## 22.4 Opportunities for Adaptive Learning

### *22.4.1 Adaptive and Collaborative Management of Ecosystem Services in Latin America*

Holling (1973) proposed adaptive management as a flexible and responsive means to deal with uncertainty and unpredictability. Adaptive collaborative management occurs when interested persons (often communities) agree to collaboratively plan, observe, and learn from the implementation of their plans (Prabhu et al. 2002). The assumptions associated with adaptive collaborative management are that both ecological and social systems are complex and adaptive, that surprise is inevitable, and that accurate prediction is not possible. This suggests that a process to deal with conservation and development cannot be formulated through central planning agencies (Prabhu et al. 2002). Rather, this process needs to be cultivated through the development of capacity in communities.

The Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) is a regional scientific center dedicated to management of natural resources, sustainable rural development, and poverty reduction in tropical America. It has promoted and studied various approaches for management of ecosystem services in Latin America, particularly model forests, biological corridors, and watersheds (Barriga et al. 2007). Using these three types of landscape arrangements, CATIE has developed and tested adaptive collaborative landscape management as a community approach to improve the provision of ecosystem services at a landscape scale through a process that takes into account the linkages between society, the environment, and the economy. The work also entails creating conditions for discussing topical regional issues, such as land tenure, human rights, equity, pollution, water scarcity, vulnerability to natural disasters, and measures for strengthening social capital. Experiences from 10 cases and 20 initiatives within five countries in Latin America have demonstrated that the success of the initiatives can be attributed to the following five basic characteristics: (i) effective governance, (ii) participatory planning, (iii) sustainable financial mechanisms, (iv) adaptive management and learning, and (v) public-private sector alliances. All initiatives have similar governance architecture, with various platforms including those for strategic decisions, support, operations, or communities. Preliminary evidence shows that these platforms serve to improve the interaction among government, society, and the private sector, and help to transform private interests into common objectives. The associated governance instruments include legal recognition, statutes and regulations, and co-management plans. In these plans, the process is more important than the product because it permits intense interaction of stakeholders. Finally, all cases include elements for financial institutional sustainability.

The general observation from these studies was that improvement in ecosystem service provision at the landscape level in Latin America begins with the promotion of a favourable environment for dialogue and negotiation among stakeholders. As discussed in Section 22.2, it was also observed in these case studies that preserving and improving natural capital (ecosystem services) requires work on human, social, and financial capital. Lessons learned from these case studies include the following basic actions that are required to maintain and improve each of these types of capital.

Actions related to human capital:
- Recognise and encourage member commitment.
- Engage resident, paid management personnel that are accountable to the group.
- Provide facilities to encourage full participation of all members in all activities and processes.

Actions related to social capital:
- Encourage group identity.
- Remember that the planning process is as important as the plan.
- Network across sectors and activate multi-sectoral alliances.
- Build on existing experiences.
- Use the potential of the initiatives to link with public policies.

Actions related to financial capital:
- Diversify funding sources for fundamental, strategic activities.
- Protect the environment through payment of ecosystem services.
- Use micro-credits as a tool to develop sustainable production processes.

### *22.4.2 UNESCO Biosphere Reserves and Model Forests*

Over the past three decades, scholars and practitioners have shifted their understanding of how to “manage” landscapes for environmental protection and sustainability. First, there has been a rejection of the idea that people should be separated from protected areas and an acceptance that people must remain embedded within landscapes in order to protect both biological and cultural diversity (Berkes 2004). Second, there has been a shift from expert-based ecosystem management approaches towards participatory approaches that seek ways to include local knowledge, perspectives, and interests (Berkes 2004). These processes require strong linkages and partnerships across spatial and temporal scales, successful exercises in trust-building, capacity-building, and mutual learning, plus sufficient time and resources (Berkes 2007) and an appropriate distribution of authority across multiple institutions at different scales to sustain and improve conservation practices (Barrett 2001). Neither top-down nor bottom-up management processes are sufficient to achieve sustainability.

*Biosphere Reserves*

Biosphere reserves and model forests are two types of institutions being used in Canada to address ecosystem management through participatory approaches that bridge temporal and spatial scales, and engage participants in research, demonstration, and learning opportunities that build trust and capacity for management. Both of these institutions are intended to serve as practical, flexible, and innovative mechanisms for environmental governance through partnerships with a wide range of stakeholders who work collaboratively to define priorities, goals, and actions for sustainability. Despite their different origins and funding situations, both model forests and biosphere reserves have been promoted as exemplars by serving as hubs of learning for replication elsewhere in the country, and internationally as a means of cooperation with other countries (UNESCO 2000, 2008; Besseau et al. 2002). They also provide a concrete means of addressing international obligations, such as Agenda 21, the Convention on Biological Diversity, and the Millennium Development Goals.

Both institutions have a significant history. Biosphere reserves are geographic areas nominated by local people and recognised by the United Nations Education, Scientific, and Cultural Organisation (UNESCO) intended to demonstrate how people can live and work in harmony with the natural environment. Prior to designation, “local” representatives

**Box 22.2 Public participation: Status and challenges in Quebec, Canada**

*Catherine Martineau-Delisle*

On the social side of the new forest management approaches, there are two distinct components (Endter-Wada et al. 1998). One concerns considering humans as an integral part of ecosystems, which refers to both understanding how humans impact natural systems and how changes in natural systems impact humans (including community capacity to adapt and respond to these) (FEMAT 1993). The other component concerns greater public involvement in decision-making. Many of the new ecosystem-based approaches make participatory processes a necessity (Yaffee 1996, Cortner and Moote 1999). For example, systems thinking involves cross-jurisdictional problem solving and consideration of issues that cut across traditional interests and coalitions. It also requires multidisciplinary interactions that breach norms about appropriate expertise and information (e.g., traditional knowledge). Calls for forest management based on a wider range of social values – and thus based on public participation – go back to the environmental movement in the 1970s (Stefanick 2001). Public participation is also central to many of the outcomes from the UNCED (UNEP1992). In Agenda 21, local authorities are encouraged to engage in a dialogue with all stakeholders and to seek new participation processes that go beyond consultation and allow for cooperation. Four of the twelve Malawi Principles relate to public participation (CBD 2000).

**Forest-related participatory processes at a glance**

A comprehensive review of forest-related involvement mechanisms over the past 25 years in Québec, Canada, shows important changes in the number and ways of involving the public in forest management (Martineau-Delisle, in prep.). Consisting mainly of consultation mechanisms (e.g., public hearings) in the 1980s, participatory processes started to increase and diversify in the 1990s to literally explode by the turn of the century. The first decade into the new millennium is distinguished by the quantity of processes in place, the growing decentralisation of decision-making to local and regional entities and, above all, by the dominance of more deliberative forms of public participation (e.g., consultative committees), such as those in model forests and biosphere reserves.

**Potential contributions of participatory processes**

Deliberative processes are said to have many benefits. A study involving co-ordinators from 113 Québec forest committees revealed numerous potential impacts from such processes (Martineau-Delisle, in prep.). Co-ordinators of forest committees identified ten potential impacts of the processes. The results present the percentage (%) of the respondents that have identified one or more of each impact type. Only the impacts mentioned by more than 20 % of the committee co-ordinators are presented.

- 65% – Development of collective capacity of participants (e.g., networking, collaboration, conflict resolution, consensus, etc.);
- 51% – Creation of a place for stakeholders to engage in and contribute to the management process;
- 49% – Achievement of results and greater effectiveness of the management process;
- 35% – Change in attitudes and behaviours (e.g., perception of others: trust and credibility);
- 36% – Direct power and influence on forest management-related decisions;
- 27% – Acquisition and exchange of information and knowledge by and between participants;
- 23% – Enhancement of communication among the stakeholders; and
- 21% – Opening up of the decision-making process to new stakeholders and new values.

**The false promises of participatory processes**

Several major challenges associated with forest committees were identified in the study, based on gaps existing between potential outcomes and observed achievements. The components of impacts mentioned by more than 10% of the 113 respondents were isolated and expressed as a percentage. The following results represent the respondents that consider the elements to be challenges rather than achievements. Only challenges identified by more than 65% of the respondents are presented. The challenges relate to:

- 88% – Appropriateness of the information made available, given the varying levels of knowledge among participants (technical and scientific complexity, and limited resources for interpretation made this a sensitive issue);
- 81% – Commitment and continued interest from participants (because of redundancy of initiatives

or different levels of concern about the issues discussed);

- 78% – Resources at the disposal of participants to cover all costs of participation (which are unequal among participants);
- 76% – Availability of participants to meet regularly and ensure process continuity (high member and staff turnover made this a sensitive issue);
- 75% – Establishment of a process allowing free expression and respect for all opinions and values;
- 73% – Capacity to influence decisions and apply actions;
- 73% – Conflict management and consensus building (i.e., achievement of consensus while respecting the interests of each party in the presence of diverging expectations and related incompatibilities);
- 65% – Funding and time allocated to the participatory process (which, if not available, limit effectiveness and outcomes of the process).

**Addressing the challenges**

The study shows that the committees have little or no decision-making power, which makes it difficult to ensure that their recommendations are considered in decisions (Boon and Meilby 2000). In addition, with a few exceptions, forest committees are rarely involved beyond decision formulation, i.e., into the implementation and monitoring phases. Limited resources allocated to support participants' involvement in these processes is also an issue (Parkins et al. 2006), as it is the case of other resources dedicated to the committees (information, funding, time, etc.). Furthermore, some challenges are associated to the "collaborative side" of committees' activities, such as consensus-building. These tendencies may have adversarial effects on processes' effectiveness and recruitment. Considering that participants are mainly volunteers and that public participation mechanisms are increasing (coupled with overlap of issues and areas to which their mandate applies), this may lead to "participant burnout" and affect recruitment, which is already difficult. All of these challenges will have to be addressed if public participant processes are to be effective components of forest planning and management, and to fully contribute to sustainable forest management.

must demonstrate the ecological, cultural, and social significance of the area under consideration. The first biosphere reserves internationally were created under the UNESCO "Man and the Biosphere" program in 1976 – roughly the same time as Holling (1973) proposed ideas about resilience theory. As of February 2008, there were 531 biosphere reserves in 105 countries. In Canada, there are 15 biosphere reserves, 9 of which were designated in the 2000s.

Biosphere reserves are intended to demonstrate three functions: environmental protection; logistical provisioning for scientific research and education; and sustainable resource use. To do so, they contain three zones, much like those described in the triad system above: (1) a core that must be protected, typically by national legislation; (2) a buffer, where research and recreation uses compatible with ecological protection are allowed; and (3) a transition zone or "area of cooperation," where sustainable resource use is practised. Thus, biosphere reserves retain some form of protected area at their core, but they must also incorporate adjacent areas and the inhabited surrounding "working landscapes" to demonstrate how they integrate conservation with sustainable development. Biosphere reserves are typically established on the basis of watersheds or other landscape-level features that extend beyond the administrative boundaries of local human communities.

Biosphere reserves are areas of recognition, not regulation. Thus, once designated, biosphere reserves are subject to all legislation or regulations that exist or are introduced by municipal, provincial, or federal governments. UNESCO does not provide funding or any substantive "control" over how biosphere reserves operate. Until 2007, projects were funded on a project-by-project basis and through partnership arrangements with other organisations. Canada's federal government has provided some term funding. It brings new opportunities and challenges to individual reserves, as well as tests their ability to collectively identify priorities and share the new-found wealth.

*Model Forests*

In 1992, the Government of Canada provided USD 10 million to support multistakeholder partnerships, or model forests, to work on sustainable forest management at the landscape level. The intention was to link the principle of sustainable forest management, emphasised in Canada's National Forest Strategy and the new Canada Forest Accord, to landscape-level implementation in various sites across the country's diverse forested regions. Today, while there is no longer a dedicated program for funding them, there are 14 model forests in Canada and some of them receive federal government funding.

Also in 1992, Canada introduced the Model Forest Program to an international audience at the UNCED as one way to advance global priorities for sustainable forest management as articulated in the Forest Principles (UNEP 1992), and pledged resources to start an international network. In 2009, there were 57 model forests operating in 23 countries. Model forests include partners from several different perspectives and sectors. While the model forest itself has no legal jurisdiction over land management decisions, its partners include participants who do have the ability to make decisions about the forest at various levels. Model forests were intended to be experimental sites for sustainable forest management, not only in the science and practice of managing forest landscapes, but also in multistakeholder governance.

### *Areas of Convergence: Linking People with Ecosystems*

Biosphere reserves and model forests have shared and distinctive insights to bring to the issue of "systems" management, although they were born out of slightly different motivations. Biosphere reserves were created out of a concern to protect biological diversity and ecosystem processes through scientific research and the application of its results. Promoters of biosphere reserves were typically natural scientists, and some government representatives, who believed that modern science would help local people establish rational methods of resource use that would help them conserve the world's biodiversity. Over the years, the connection between protecting ecosystems and protecting livelihoods became stronger. By the mid-1990s, UNESCO suggested that biosphere reserves should help people who live and work within them by demonstrating how to attain a sustainable future. While the natural sciences were prominent in biosphere reserves in early years, contemporary research in biosphere reserves places greater emphasis on socio-ecological systems. Biosphere reserves attempt to demonstrate innovations in environmental governance that can help to meet international obligations. With their history of linking protected areas with human activities, they are well-positioned to serve as experiments in environmental governance, community-based conservation, sustainable development, resilience, and adaptation.

Model forests were initiated as models for working landscapes, primarily to encourage sustainable resource use (Sinclair and Smith 1999), with protection of ecological diversity as a secondary feature. According to the 1991 call for proposals, model forests should "include the delivery of wood products," and "support or be capable of supporting a range of 'best management practices' through appropriate silviculture," along with other management concepts relating to good internal governance, management of multiple forest values, and multi-disciplinary research (Forestry Canada 1991).

In Canada, both biosphere reserves and model forests are now viewed as "living laboratories" for learning how to practice sustainability with a "systems perspective" at a landscape scale (e.g., Brunckhorst 2001; LaPierre 2002; UNESCO 2000, 2008; Ishwaran et al. 2008). They both offer researchers opportunities to link theory and practice on complex drivers of change and stressors on ecological and social systems, as well as strategies for resilience and adaptation. The results of this research can also contribute to advancing the goals and objectives of the Millennium Ecosystem Assessment and the related discourse on sustainable development.

### *Areas of Convergence: Building Partnerships*

Both model forests and biosphere reserves are encouraged to establish partnerships to achieve sustainability objectives. Model forests have had an advantage in this respect because initial funding spurred research on questions of sustainable development and encouraged people to approach forest resource issues from a broader spatial and temporal scale. Funding may also have kept people talking around the table when they may not have otherwise done so, and provided an incentive for groups who had previously been antagonistic to one another to co-operate and learn from each other. In the Western Newfoundland Model Forest, for example, funding directed towards research on the endangered Newfoundland Pine Marten (*Martes americana atrata*) brought together industry, government, conservation, and community groups to determine why marten populations were declining and what could be done to reverse the trend. Although there were some heated debates, the Model Forest helped to build trust and social capital through the research it catalysed. In the longer term, this experience opened up opportunities for groups to collaborate on other projects that go beyond the model forest program. Another example of collaborative learning is the current project of the Canadian Model Forest Network and their partners, to develop a guidebook to assist communities in developing pathways to climate resilience. The guidebook proposes the following steps for communities: i) preparing members of the community; ii) documenting local climate observations; iii) mapping impacts and opportunities; iv) assessing risks and potential actions to increase resilience; and, v) prioritising and taking actions (Pearce 2009).

Many biosphere reserves have been challenged to establish strong partnerships because they are not well-supported financially or logistically by their local or national governments. For example, Canadian biosphere reserves have generally relied on considerable volunteer labour to advance their interests, making their ability to complete projects and reach out to other groups a slow, sometimes halting, process. In general, the success of biosphere reserves in meeting their mandate is predicated on the initiative and skills of a small number of people who often spend years dedicated to demonstrating the links between environmental protection and sustainable development.

Consequently, biosphere reserves have had mixed success with networking across regions. Some have been very successful in identifying regional-scale projects, and securing financial and in-kind support from the private sector, public sector, and other community groups to engage in projects in which networking forms a major part. For other biosphere reserves, the lack of direct funding has hampered their ability to initiate projects and reach out to other groups. Local volunteers have laboured on fairly small-scale projects, exhausted their personal resources, and have not recruited new volunteers to renew their efforts. Funding frequently came in the form of support for specific projects, often requiring the initiative of local scientists. These circumstances made biosphere reserves locations for research rather than partners in identifying research priorities. Nevertheless, some important research projects, such as understanding ecological recovery following the ice storm in the region surrounding Montreal in 1998, have been conducted. The Biosphere Sustainability Project at the University of Waterloo is a current study addressing the interrelated concepts of resilience analysis, sustainability assessment, and social innovation generation (University of Waterloo 2010). In addition, joint projects, such as the recently initiated *Environmental Governance for Sustainability and Resilience: Innovations in Canadian Biosphere Reserves and Model Forests*, are facilitating convergence of these two institutions to enrich learning experiences.

*Areas of Convergence: Engagement*

Both model forests and biosphere reserves are areas of "recognition" rather than "regulation." Their presence does not alter the configuration of laws, policies, or property rights over landscapes. Both, however, have provided opportunities for engagement of local people in environmental issues, networking with other groups and agencies on common agendas, providing demonstration areas for specific kinds of research or development priorities, and serving an honest broker function to advance specific initiatives.

Both also face a range of challenges, including broadening the base of participation at the local and regional levels, and broadening the scope of interest. Broadening the scope of interest also broadens the necessary source of expertise: it requires interdisciplinary work, access to multiple kinds of knowledge (including sometimes traditional ecological knowledge), and public participation. These challenges have been quite significant for biosphere reserves because they have operated with very little funding and thus have typically attracted the large-hearted with small pockets. These challenges also require exercises in trust-building. Experience across all model forests and biosphere reserves suggests that gaining legitimacy as an honest broker takes considerable time, particularly when drawing on volunteer resources. Both have had uneven success in encouraging particular groups to participate. In some places, the representation of Aboriginal people, youth, and women has been a challenge.

Observations of the evolution of these institutions in Canada suggest that model forests and biosphere reserves have played significant roles in advancing understanding and application of sustainable development. This has been achieved by: introducing systems level thinking; linking ecological, economic, social, and cultural systems; and engaging in enduring partnerships and endeavours that extend beyond jurisdictional boundaries. This situation positions them well to advance understanding and application of resilience theory as a means of addressing emerging drivers of change through collaborative adaptive management. There are three Canadian examples where model forests and biosphere reserves have overlapping boundaries, making it possible to observe further convergence of the two models and to learn from their experiences. These areas are located on the west coast of the province of British Columbia (Clayquot Sound), in the eastern part of the province on Ontario ( Frontenac Arch / Eastern Ontario Model Forest), and in the western portion of the province of Nova Scotia (Southwest Nova / Nova Forest Alliance).

## 22.5 Summary

Highlights of the substantial advances in forest policy and the associated knowledge that has been used to inform development of management plans and practices are summarised in Section 22.1 of this chapter. The accumulated knowledge, based on research, observations, and learning arising from adaptive management and case studies, such as those from the Americas and Europe presented in this chapter, point towards a developing consensus that long-term sustainability of forest resources requires a multi-level (spatial and temporal) collaborative approach where management units are viewed as eco-sociological systems. Such a conceptual framework for management of natural resources recognises the complexity of forest systems (ecological, economic, and social), their hierarchical structures, the interactions and energy flows between these hierarchies, and their capacity for self-organisation.

Trying to predict and control outputs in systems where the dynamics are not well known has always been a challenge of forest management. This goal is further complicated by the complexity of interactions at multiple levels. Identification of the vital system attributes and the development of an understanding of the underlying processes, weak links, and critical limits of these processes is a starting point for addressing this challenge by using systems thinking to improve forest resilience. The case studies from Bosque Seco Chiquitano and the Lübeck forest highlighted the importance of understanding the linkages between ecological structures and processes, and the associated and economic values and benefits for social systems. In both cases, it was demonstrated that management guided by principles of ecological integrity provided greater economic benefits than a management plan based on objectives for improved efficiency.

Scientists play a key role in collecting, compiling, and synthesising all types of information on system attributes and processes. This information is shared with all stakeholders, who contribute additional insights to the analysis of the future forest condition, the associated services and benefits, and what actions need to be taken to facilitate maintenance or evolution of the system in the desired direction. In applying principles of resilience management, the expectation for science to provide solutions is replaced by a collaborative approach to addressing issues and a convergence in the roles and working relationships between scientists, managers, and policy-makers. Scientists are called upon to provide expert opinion, but have additional roles in facilitating knowledge transfer, sharing information about options and trade-offs, and developing mechanisms by which science can be made accessible in ways that are useful to all.

Scenarios of possible future outcomes and lessons learned from previous experiences serve as inputs to collective decision-making. Landscape modelling is one tool that has greatly improved capacity to visualise future forest scenarios. Its capacity to quantify change and change dynamics provides a means to use science as guidance for policy and land and resource management. Models still require inputs of empirical data, and developing these data layers can be time consuming and require considerable effort (Section 22.3). Additional work is needed to improve methods for testing landscape models, to evaluate uncertainty, to develop robust means for all stakeholders to understand and think critically about preferences and alternatives, to promote transparency of the decision-making process, and to openly make explicit the uncertainties involved in particular courses of action (Section 22.3.2).

Adaptive management is an important aspect of managing for resilience because it provides a flexible and responsive means to deal with uncertainty and unpredictability whereby policies are viewed as experiments from which learning can be advanced. Adaptive collaborative management is a process that allows all persons and organisations with interests in the landscape to contribute points of view, to participate, and to agree to collaboratively plan, observe, and learn from the implementation of their plans. Concepts for collaborative management (Sections 22.4.1 and 22.4.2) have stimulated ideas about new institutional arrangements required to facilitate integration of information across disciplines, temporal and spatial scales, and administrative boundaries. The development of human and social capital to facilitate full and effective public participation is a stepping-stone towards empowered participatory governance. The ejidos in Quintana Roo, incorporating indigenous values, ecological integrity, economic efficiency, and democracy, were able to take responsibility and became stewards of their lands, reversing deforestation trends and diversifying their economy. This example, along with the other case studies from Latin America (Section 22.3.4, Box 22.1), demonstrates the potential for communities to promote awareness, to self-organise, and to develop and enforce rules to make community use of shared forest assets sustainable. These case studies show that social coordination and governance can be achieved with minimal external resources. Resource inputs should focus on gaining understanding about the dynamics of local systems and on developing community capacity in order to allow local knowledge to be used for creative development and implementation of place-based governance to deliver local benefits. Finally, it can be observed that the first step toward improvement in ecosystem service provision at the landscape level begins with the promotion of a favourable environment for dialogue and negotiation among local stakeholders.

In the face of global change, it will become more difficult to rely on the past as a template for the future. As the rate of change accelerates, management actions will gain importance as a means to maintain landscape resilience and a supply of forest goods and services. Complex systems theory can serve as guidance to develop new management practices that will allow the forest to adapt and be resilient. A systems framework describes a way of seeing and thinking about forests and systems. Applying systems thinking to forest management requires some changes in basic approaches to conventional practices. It differs from the traditional reductionist approach to management by taking into account the lack of certainty and integrating the spatial and temporal range of variation within forest ecosystems. In order to do this, the spatial and temporal limits that are imposed by human management need to be reconsidered in order to improve flexibility and allow management that operates at many levels. For example, objectives for increased growth would be refocused on those that favour resilience and allow the forest to adapt to events and to system responses. Maintaining levels of native biodiversity can contribute to balancing ecosystem processes in the face of change. The challenge will be in learning how to facilitate the ability of natural forest systems to self-organise, adapt and evolve, and to guide them towards a desired appropriate state.

Systems thinking requires trans-disciplinary approaches to solving problems. Integration will be a key activity: integration of science and policy, integration of environment and the economy, integration of biodiversity conservation and climate change adaptation activities, integration of science and traditional and local knowledge, integration of costs and benefits, and integration of sectoral and jurisdictional activities. Forest and land management policies will require revision in order to consider uncertainty principles and changing forest conditions. Partnerships will become the foundation for collaborative governance where actions are implemented through adaptive management based on associated knowledge generation and learning. Engagement, capacity building, and participation of all actors on the landscape as critical components for collaborative visioning, planning, and managing future options, will gain importance as standard operating procedure. Existing models, such as biosphere reserves and model forests (Sections 22.4.1 and 22.4.2) that have already contributed to improved understanding of forest management issues and played key roles in establishing participatory decision-making approaches. Such organizations are well positioned to assist in testing and applying these new concepts to incorporate adaptive learning and management in dealing with uncertainty and change in order to create opportunity for development driven by innovation.

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**ANNEX 22.1 The Forest Principles: Non-legally binding authoritative statement of principles for a global consensus on the management, conservation, and sustainable development of all types of forests (UNEP 1992)**

*PRINCIPLES/ELEMENTS*

1. (a) States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies and have the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.
   (b) The agreed full incremental cost of achieving benefits associated with forest conservation and sustainable development requires increased international cooperation and should be equitably shared by the international community.
2. (a) States have the sovereign and inalienable right to utilise, manage, and develop their forests in accordance with their development needs and level of socio-economic development and on the basis of national policies consistent with sustainable development and legislation, including the conversion of such areas for other uses within the overall socio-economic development plan and based on rational land-use policies.
   (b) Forest resources and forest lands should be sustainably managed to meet the social, economic, ecological, cultural and spiritual needs of present and future generations. These needs are for forest products and services, such as wood and wood products, water, food, fodder, medicine, fuel, shelter, employment, recreation, habitats for wildlife, landscape diversity, carbon sinks and reservoirs, and for other forest products. Appropriate measures should be taken to protect forests against harmful effects of pollution, including air-borne pollution, fires, pests and diseases, in order to maintain their full multiple value.
   (c) The provision of timely, reliable and accurate information on forests and forest ecosystems is essential for public understanding and informed decision-making and should be ensured.
   (d) Governments should promote and provide opportunities for the participation of interested parties, including local communities and indigenous people, industries, labour, non-governmental organisations and individuals, forest dwellers and women, in the development, implementation and planning of national forest policies.
3. (a) National policies and strategies should provide a framework for increased efforts, including the development and strengthening of institutions and programmes for the management, conservation and sustainable development of forests and forest lands.
   (b) International institutional arrangements, building on those organisations and mechanisms already in existence, as appropriate, should facilitate international cooperation in the field of forests.
   (c) All aspects of environmental protection and social and economic development as they relate to forests and forest lands should be integrated and comprehensive.
4. The vital role of all types of forests in maintaining the ecological processes and balance at the local, national, regional and global levels through, inter alia, their role in protecting fragile ecosystems, watersheds and freshwater resources and as rich storehouses of biodiversity and biological resources and sources of genetic material for biotechnology products, as well as photosynthesis, should be recognized.

5. (a) National forest policies should recognise and duly support the identity, culture and the rights of indigenous people, their communities and other communities and forest dwellers. Appropriate conditions should be promoted for these groups to enable them to have an economic stake in forest use, perform economic activities, and achieve and maintain cultural identity and social organization, as well as adequate levels of livelihood and well-being, through, inter alia, those land tenure arrangements which serve as incentives for the sustainable management of forests.
   (b) The full participation of women in all aspects of the management, conservation and sustainable development of forests should be actively promoted.
6. (a) All types of forests play an important role in meeting energy requirements through the provision of a renewable source of bio-energy, particularly in developing countries, and the demands for fuelwood for household and industrial needs should be met through sustainable forest management, afforestation and reforestation. To this end, the potential contribution of plantations of both indigenous and introduced species for the provision of both fuel and industrial wood should be recognized.
   (b) National policies and programmes should take into account the relationship, where it exists, between the conservation, management and sustainable development of forests and all aspects related to the production, consumption, recycling and/or final disposal of forest products.
   (c) Decisions taken on the management, conservation and sustainable development of forest resources should benefit, to the extent practicable, from a comprehensive assessment of economic and non-economic values of forest goods and services and of the environmental costs and benefits. The development and improvement of methodologies for such evaluations should be promoted.
   (d) The role of planted forests and permanent agricultural crops as sustainable and environmentally sound sources of renewable energy and industrial raw material should be recognized, enhanced and promoted. Their contribution to the maintenance of ecological processes, to offsetting pressure on primary/old-growth forest and to providing regional employment and development with the adequate involvement of local inhabitants should be recognized and enhanced.
   (e) Natural forests also constitute a source of goods and services, and their conservation, sustainable management and use should be promoted.
7. (a) Efforts should be made to promote a supportive international economic climate conducive to sustained and environmentally sound development of forests in all countries, which include, inter alia, the promotion of sustainable patterns of production and consumption, the eradication of poverty and the promotion of food security.
   (b) Specific financial resources should be provided to developing countries with significant forest areas which establish programmes for the conservation of forests including protected natural forest areas. These resources should be directed notably to economic sectors which would stimulate economic and social substitution activities.
8. (a) Efforts should be undertaken towards the greening of the world. All countries, notably developed countries, should take positive and transparent action towards reforestation, afforestation and forest conservation, as appropriate.
   (b) Efforts to maintain and increase forest cover and forest productivity should be undertaken in ecologically, economically and socially sound ways through the rehabilitation, reforestation and re-establishment of trees and forests on unproductive, degraded and deforested lands, as well as through the management of existing forest resources.

(c) The implementation of national policies and programmes aimed at forest management, conservation and sustainable development, particularly in developing countries, should be supported by international financial and technical cooperation, including through the private sector, where appropriate.

(d) Sustainable forest management and use should be carried out in accordance with national development policies and priorities and on the basis of environmentally sound national guidelines. In the formulation of such guidelines, account should be taken, as appropriate and if applicable, of relevant internationally agreed methodologies and criteria.

(e) Forest management should be integrated with management of adjacent areas so as to maintain ecological balance and sustainable productivity.

(f) National policies and/or legislation aimed at management, conservation and sustainable development of forests should include the protection of ecologically viable representative or unique examples of forests, including primary/old-growth forests, cultural, spiritual, historical, religious and other unique and valued forests of national importance.

(g) Access to biological resources, including genetic material, shall be with due regard to the sovereign rights of the countries where the forests are located and to the sharing on mutually agreed terms of technology and profits from biotechnology products that are derived from these resources.

(h) National policies should ensure that environmental impact assessments should be carried out where actions are likely to have significant adverse impacts on important forest resources, and where such actions are subject to a decision of a competent national authority.

9. (a) The efforts of developing countries to strengthen the management, conservation and sustainable development of their forest resources should be supported by the international community, taking into account the importance of redressing external indebtedness, particularly where aggravated by the net transfer of resources to developed countries, as well as the problem of achieving at least the replacement value of forests through improved market access for forest products, especially processed products. In this respect, special attention should also be given to the countries undergoing the process of transition to market economies.

   (b) The problems that hinder efforts to attain the conservation and sustainable use of forest resources and that stem from the lack of alternative options available to local communities, in particular the urban poor and poor rural populations who are economically and socially dependent on forests and forest resources, should be addressed by Governments and the international community.

   (c) National policy formulation with respect to all types of forests should take account of the pressures and demands imposed on forest ecosystems and resources from influencing factors outside the forest sector, and intersectoral means of dealing with these pressures and demands should be sought.

10. New and additional financial resources should be provided to developing countries to enable them to sustainably manage, conserve and develop their forest resources, including through afforestation, reforestation and combating deforestation and forest and land degradation.

11. In order to enable, in particular, developing countries to enhance their endogenous capacity and to better manage, conserve and develop their forest resources, the access to and transfer of environmentally sound technologies and corresponding know-how on favourable terms, including on concessional and preferential terms, as mutually agreed, in accordance with the relevant provisions of Agenda 21, should be promoted, facilitated and financed, as appropriate.

12. (a) Scientific research, forest inventories and assessments carried out by national institutions which take into account, where relevant, biological, physical, social and economic variables, as well as technological development and its application in the field of sustainable forest management, conservation and development, should be strengthened through effective modalities, including international cooperation. In this context, attention should also be given to research and development of sustainably harvested non-wood products.
    (b) National and, where appropriate, regional and international institutional capabilities in education, training, science, technology, economics, anthropology and social aspects of forests and forest management are essential to the conservation and sustainable development of forests and should be strengthened.
    (c) International exchange of information on the results of forest and forest management research and development should be enhanced and broadened, as appropriate, making full use of education and training institutions, including those in the private sector.
    (d) Appropriate indigenous capacity and local knowledge regarding the conservation and sustainable development of forests should, through institutional and financial support and in collaboration with the people in the local communities concerned, be recognized, respected, recorded, developed and, as appropriate, introduced in the implementation of programmes. Benefits arising from the utilization of indigenous knowledge should therefore be equitably shared with such people.
13. (a) Trade in forest products should be based on non-discriminatory and multilaterally agreed rules and procedures consistent with international trade law and practices. In this context, open and free international trade in forest products should be facilitated.
    (b) Reduction or removal of tariff barriers and impediments to the provision of better market access and better prices for higher value-added forest products and their local processing should be encouraged to enable producer countries to better conserve and manage their renewable forest resources.
    (c) Incorporation of environmental costs and benefits into market forces and mechanisms, in order to achieve forest conservation and sustainable development, should be encouraged both domestically and internationally.
    (d) Forest conservation and sustainable development policies should be integrated with economic, trade and other relevant policies.
    (e) Fiscal, trade, industrial, transportation, and other policies and practices that may lead to forest degradation should be avoided. Adequate policies, aimed at management, conservation, and sustainable development of forests, including, where appropriate, incentives, should be encouraged.
14. Unilateral measures, incompatible with international obligations or agreements, to restrict and/or ban international trade in timber or other forest products should be removed or avoided, in order to attain long-term sustainable forest management.
15. Pollutants, particularly air-borne pollutants, including those responsible for acidic deposition, that are harmful to the health of forest ecosystems at the local, national, regional, and global levels should be controlled.