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Applications of Forest Landscape Ecology and the Role of Knowledge Transfer in a Public Land Management Agency

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6.1. INTRODUCTION

Over the past two decades, the application of forest landscape ecological principles has gradually become an integral part of the operations of many public land management agencies in North America. The Canadian province of Ontario is a good example of an administration where forest management policies, guides, and practices include landscape ecological principles. In this chapter, we describe why this particular region has been successful in integrating these principles into forest management, as well as how this integration occurred. In particular, we discuss the role of knowledge transfer in this process.

The province of Ontario spans more than 1 million km^2, of which more than 80% is forested. Responsibility for managing the province's natural resources rests with the Ontario Ministry of Natural Resources (OMNR), a public land management agency that is also the principal steward of nearly 0.5 million km^2 of forest land that is managed extensively for multiple values. This area is unique for two reasons: the forest cover is largely contiguous, with minimal interruption by settlements or agriculture, and nearly 90% is public land. For forest management purposes, the area is divided into 47 large planning units that range in size from 0.12 million ha to 1.56 million ha (Figure 6.1). Each unit is managed under its own management plan, which spans 20 years and is revised at 5-year intervals. Although forest management policies are developed by OMNR, operational management of forest resources occurs through long-term leases granted to private forestry companies.

As was the case for much of Canada until the 1980s, Ontario's forest management focused primarily on the production of timber and wood fiber. A combination of a global policy change to embrace sustainability, public pressure in favor of more holistic ecosystem-based management approaches, and concerns about conserving biodiversity resulted in a major shift away from the former focus on timber production. In the late 1980s, the focus also changed from managing individual stands to considering the bigger picture—the whole system and the interrelationships between its components—and this helped move Ontario away from its traditional focus on timber to a focus on larger-scale issues and approaches, which in turn led to the need for landscape-level knowledge and tools.

The single ownership, vast extent, and contiguity of Ontario's forests make management naturally conducive to larger-scale management approaches and applications. The fact that research, policy development, knowledge transfer, and operational practice are all administered by the same organization offers OMNR significant advantages in the transfer of awareness, knowledge, and skills. However,

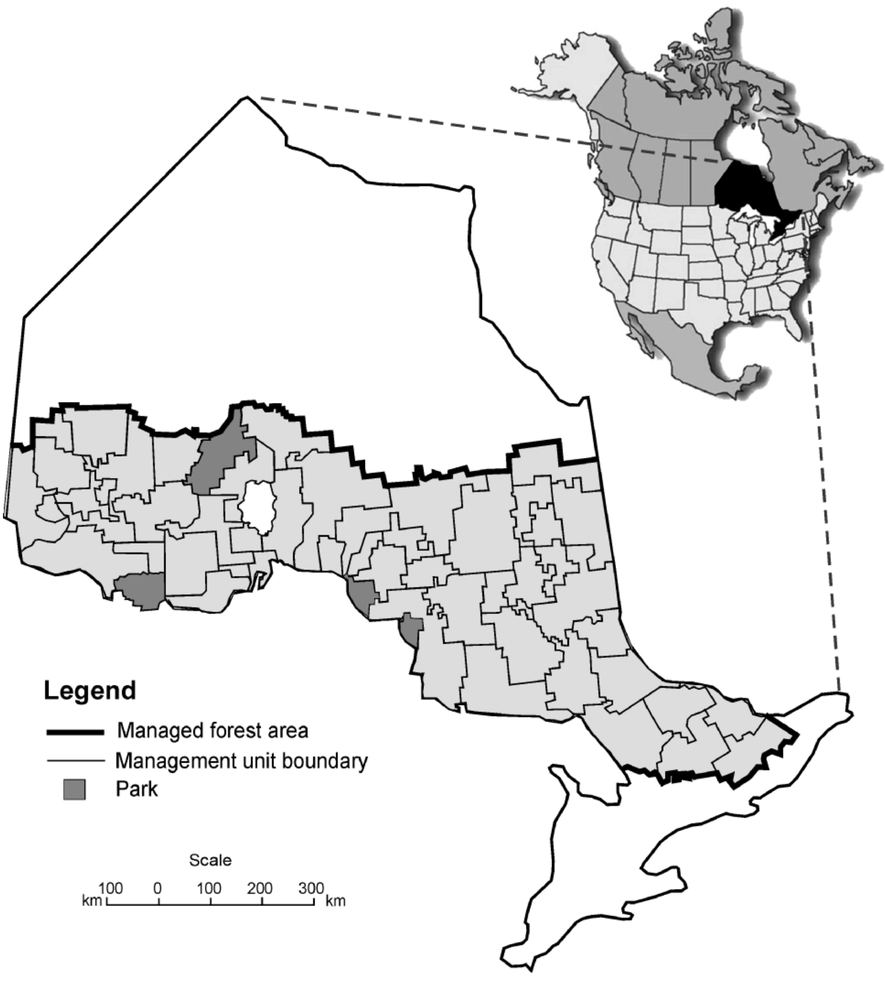

Figure 6.1. Forest management units within the managed forest area of Ontario, Canada.

additional research and practice are external to the organization, and the overall organizational structure (a public agency that develops the policies working with private companies that implement them) complicates the application of new knowledge. Thus, the process of increasing awareness, acceptance, adoption, and implementation of new concepts requires OMNR to engage a variety of audiences with very different needs and perspectives. This, in turn, requires an infrastructure that supports effective knowledge transfer.

The goal of this chapter is to examine the progress in adopting a landscape ecological perspective within a public land management agency, with an emphasis on the role of knowledge transfer in the process. Specifically, we:

- summarize where forest landscape ecological knowledge is embedded in OMNR's policies and management directions and, thus, where it is being implemented in Ontario
- examine the sociopolitical drivers and supporting infrastructure that helped to ensure that the available knowledge was adopted and applied in practice
- outline the role of knowledge transfer, and
- identify some general lessons that may help other organizations to advance the adoption and use of landscape ecological knowledge and tools in policy, planning, and practice

To illustrate our points, we provide specific examples of what has been transferred, and to whom, and explore why the concepts and tools have been adopted and are being applied. Because the choice of possible examples is large, we highlight examples with which we have firsthand experience wherever possible, including the description of an ongoing research study in which knowledge transfer was integrated from the outset.

6.2. APPLICATIONS OF FOREST LANDSCAPE ECOLOGY IN ONTARIO

Ontario's forest policy framework encompasses societal, economic, and ecological values that are addressed within global, national, and local contexts. The framework is organized into levels—strategic directions, legislative and regulatory requirements, provincial policies, and strategies—that are expressed in a series of forest management guides that direct planning and practice, as well as operational and administrative directions. As Euler and Epp (2000) pointed out, this framework is designed to allow periodic adaptation of policies and guidelines through regular reviews and revisions that permit the incorporation of new knowledge. All levels of this framework are informed by forest landscape ecological principles, thus providing a continuous link from legislation to policy and from policy to practice.

In this section, we explore some of the drivers that motivated recipients to embrace the new concepts, provide examples of where forest landscape ecological knowledge is embedded in both policy and practice in Ontario, and outline the enabling factors that supported the adoption of landscape-level approaches. First, we identify several factors that enabled Ontario to successfully adopt a landscape ecological perspective. These include an increased focus on sustainability and biodiversity worldwide, and a number of concurrent sociopolitical drivers at the local level, all of which were aided by the expanding global and local knowledge base in landscape ecology.

6.2.1. Sociopolitical Drivers

Global drivers. In the early 1980s, a global shift occurred in public awareness of the concept of biodiversity, leading to perceptions that forests comprise more than just trees and provide more values than just timber, and that biodiversity cannot be conserved solely at the scale of forest stands (Brundtland 1987). The shift within OMNR from timber management to broader-scale sustainable forestry occurred in the early 1990s, driven by these trends in conservation of biodiversity and concerns about overall forest health and sustainability. Epp (2000) provides a detailed chronology of how these events related to Ontario. More recently, the global trend in favor of third-party certification of forestry operations has required the forest industry to conserve biological diversity and associated values, water resources, soils, and unique and fragile ecosystems and landscapes. By so doing, the industry would maintain the ecological functions and integrity of the forest. As of September 2005, almost 27 million ha of managed forest area in Ontario (more than 50% of the total) were certified under one or more certification systems (Certification Canada 2006). As the requirements associated with maintaining certification evolve, they will continue to pressure forest companies to consider landscape dynamics and functions in their management practices.

Local sociopolitical drivers. In the late 1980s, an Ontario-wide environmental assessment of timber management practices (a Class Environmental Assessment) was undertaken (OEAB 1994), and this exercise provided the impetus for a series of changes in forest policy, and the recognition of the need for a series of forest management guides to provide direction during forest management planning. Many of the resulting guides focused on managing the supply of wildlife habitat for animals that require large or diverse areas (e.g., pine marten, *Martes americana*; woodland caribou, *Rangifer tarandus caribou*; moose, *Alces alces*; red-shouldered hawk, *Buteo lineatus*), with the associated knowledge encapsulated in specific directions (see Table 6.1b for examples of such guides). Creation of these guides required landscape ecological knowledge to provide context, mostly from sources outside the provincial government, and an additional push from researchers. This process coincided with the evolution of an early-1990s sociopolitical policy program, the Sustainable Forestry Initiative, that led to the creation of the Policy Framework for Sustainable Forests (OMNR 1994); this framework provided the overall context for forest management in Ontario and, most importantly, led to the development of a new forestry act (the Crown Forest Sustainability Act; Statutes of Ontario 1995) that entrenched forest sustainability at the legislative level. Euler and Epp (2000) provide considerable insight into the development of these directions.

6.2.2. Forest Management Policies and Guides

The Crown Forest Sustainability Act (Statutes of Ontario 1995) provides an overarching legislative direction for Ontario's management of public forest land and addresses the value of emulating natural landscape disturbance to conserve

Table 6.1a. Examples of where forest landscape ecological principles and knowledge have been incorporated into Ontario's major forestry legislation, policies, and planning directions

Title (reference)	Forest landscape ecological principles, knowledge, and directions
Legislation	
Crown Forest Sustainability Act (Statutes of Ontario 1995)	• Emulate natural disturbances and landscape patterns to sustain forests and conserve biodiversity • Ensure sustainable forest management
Policies and strategies	
Policy Framework for Sustainable Forests (OMNR 1994)	• Maintain ecological processes • Conserve biological diversity • Emulate natural disturbances and maintain landscape patterns
Ontario's Land Use Strategy (OMNR 1999)	• Expanded Ontario's provincial parks and network of protected areas to include a representative spectrum of Ontario's ecosystems and natural features (identified by ecoregion) • Protect and manage entire watersheds

Old Growth Policy (OMNR 2003)	• Provides a landscape management perspective for the conservation of old growth
	• Directs resource managers to:
	  • use spatial simulation modeling to assess current and future abundance and distribution of old-growth forests based on succession and natural disturbance patterns
	  • acknowledge the spatial and temporal dynamics of old-growth forests
	  • set targets for old-growth forests based on the probabilities of aging, occurrence, and distribution within ecoregions

Ontario Biodiversity Strategy (OMNR 2005)	• A landscape approach to biodiversity conservation
Planning directions	
Forest Management Planning Manual (OMNR 1996, 2004)	Directs forest managers to: • Assess landscape pattern indices as indicators of biodiversity in relation to provincial, regional, and subregional levels • Document current and future availability of wildlife habitat in provincial, regional, and subregional contexts • Document net primary productivity and water yield as indicators of landscape processes • Project forest succession and disturbance rates for 150 years

biodiversity and enhance the sustainability of forests. Several subsequent policies and strategies, such as Ontario's land-use strategy (OMNR 1999), contain further landscape ecological concepts, such as the need to maintain ecological processes and consider spatial and temporal variation at broad scales. Ensuing directions for forest management planning and guides to support forest management, all of which help to operationalize policies and strategies, contain specific landscape-level applications, such as using natural disturbance templates customized for each ecoregion to design spatiotemporal harvesting patterns, providing wildlife habitat at levels ranging from forests to ecoregions, and monitoring spatial heterogeneity and ecological processes in the managed forest. Table 6.1a summarizes where forest landscape ecological knowledge is embedded within Ontario's policy framework. For a complete description

Table 6.1b. Examples of where forest landscape ecological principles and knowledge have been incorporated into Ontario's forest management guides

Title (reference)	Forest landscape ecological principles, knowledge, and directions
Forest management guides	
Timber Management Guidelines for the Provision of Moose Habitat (OMNR 1988)	• The first forest management guide to consider spatial patterns of cut blocks (size, distribution, edges) over larger areas with respect to the effects on wildlife habitat
Forest Management Guidelines for the Provision of Marten Habitat (Watt et al. 1996)	• Identifies the need to consider landscape-level effects of management practices on overall habitat availability as part of forest management planning • Provides guidelines for maintaining landscape composition, patterns, and structure to benefit pine marten populations • Recommends use of habitat supply models to ensure that sufficient preferred habitat remains across management units
Forest Management Guidelines for the Provision of Pileated Woodpecker Habitat (Naylor et al. 1996)	• Identifies the need to consider landscape-level effects of management practices on overall habitat availability as part of forest management planning • Recommends use of habitat supply models to ensure that sufficient preferred habitat remains across management units
Forest Management Guidelines for the Provision of White-Tailed Deer Habitat (Voigt et al. 1997)	• Identifies the need to consider landscape-level effects of management practices on overall habitat availability as part of forest management planning • Recommends use of habitat supply models to ensure that sufficient preferred habitat remains across management units in each season
Forest Management Guidelines for the Conservation of Woodland Caribou—A Landscape Approach (Racey et al. 1999)	• Recommends that caribou be managed on very large spatial and temporal scales (i.e., spanning more than a single management unit over more than 80 years) • Directs that management decisions be supported by analyses of spatial habitat supply to ensure that sufficient contiguous forest is provided
Forest Management Guide for Natural Disturbance Pattern Emulation (OMNR 2002)	• Provides standards and guidelines for emulating natural (fire) disturbance patterns when harvesting forests

of Ontario's forest policy and legislative framework, see the Ontario's Forests Web site (http://ontariosforests.mnr.gov.on.ca/ontariosforests.cfm).

Over the next decade, new policies and guides were founded on the emulation of natural disturbance regimes, with the focus changing from fragmentation and habitat issues to biodiversity and conservation issues, driven in part by the Crown Forest Sustainability Act, which specified that forest management be based on emulating natural disturbance and landscape patterns. One example of a current large-scale provincial policy is the *Forest Management Guide for Natural Disturbance Pattern Emulation* (OMNR 2002), which directs forest managers to move toward natural landscape patterns; matching management approaches to what *could* happen rather than *what once happened* requires an assessment of larger-scale, longer-term landscape dynamics, and an understanding of the potential variation in disturbance patterns. The evolution of this policy is documented in detail by McNicol and Baker (2004). Another such policy is the *Old Growth Policy* (OMNR 2003), which requires larger-scale, longer-term thinking about how much existing old-growth forest should be conserved and where to plan for the future development of old-growth forest, which is not a static entity. Both the conservation of old-growth forest and the emulation of natural disturbance patterns were built into the directions provided in the provincial Forest Management Planning Manual (OMNR 1996, 2004). The land-use planning process has also incorporated landscape-level approaches. For example, a provincewide exercise conducted in the late 1990s incorporated an ecoregion-based land-use planning hierarchy for managing forest landscapes as well as watersheds and protected areas. Francis (2000) provides more details about strategic land-use planning in Ontario. More recently, a review of the existing forest management guides (AES et al. 2000) led to a consolidation of the existing documents into a concise set of five guides, one of which addresses topics explicitly at landscape scale and integrates forest landscape ecological knowledge and applications in a single document.

6.2.3. Applications of Forest Landscape Ecological Knowledge

As landscape ecological concepts were being incorporated into forest management policies, practitioners were faced with the challenge of implementing the policies in their planning and practices. To do this, they needed to understand the concepts (which required knowledge transfer) and a means to implement the policies (e.g., by providing tools). Thus, there has been a push both to increase awareness and knowledge of landscape ecological concepts and to develop tools that can help practitioners apply the new concepts embedded in the policies and guides. This required transfer of the relevant skills and knowledge that would enable practitioners to use the tools and to interpret and apply the output of the tools to achieve the desired management outcomes. For example, Ontario's management unit–level forest management plans require the application of landscape ecological principles, such as analysis of landscape patterns (e.g., connectivity, patch size), analysis of habitat supply, and monitoring of changes in primary productivity at local and regional levels.

User applications have been developed and revised to support these needs, in part because the policies created a need and in part because practitioners demanded an efficient and effective way of getting the information they needed to meet the new requirements (Table 6.2). These include tools for assessing landscape patterns (LEAP II, Perera et al. 1997; Patch Analyst, Elkie et al. 1999b; NDPEG Tool, Elkie et al. 2002), landscape processes (RHESSys, Band 1993; ON-FIRE, Li et al. 1996; BFOLDS, Perera et al. 2004; NPPAS, Schnekenburger and Perera 2003), habitat supply (Ontario Marten Analyst, Elkie et al. 1999a; OWHAM, Naylor et al. 2000), and landscape-level harvest planning (SFMM, Kloss 2002; Patchworks, SPS 2006). Most of these were initially used as research models or tools, but have since been transformed or are in the process of being transformed into desktop tools that can be used

Table 6.2. Examples of forest landscape ecological tools and applications developed to support forest management planning in Ontario

Tool or model	Name	Purpose	Description	User group
RHESSys (Band 1993)	Regional hydro-ecological simulation system	Quantify carbon, water, and nutrient fluxes	Simulates the spatial distribution and spatial and temporal interactions of carbon, water, and nutrient fluxes at the watershed scale.	Regional analysts
LEAP II (Perera et al. 1997)	Landscape ecological analysis package	Quantify landscape patterns	Supports the calculation of landscape metrics such as patch area, density, edge, nearest neighbor, diversity, and interspersion for various forest classification schemes.	Regional analysts and forest management planning (FMP) teams
Patch analyst (Elkie et al. 1999b)	Ontario Patch Analyst	Quantify landscape patterns	Supports the calculation of landscape metrics such as patch area, density, edge, nearest neighbor, diversity, and interspersion for various forest classification schemes.	FMP teams
OMA (Elkie et al. 1999a)	Ontario Marten Analyst	Assess habitat availability	Allows spatial assessment and classification of habitat based on forest resource inventory data through time; used primarily for identifying core pine marten areas and caribou habitat in northwestern Ontario.	Regional analysts and FMP teams
OWHAM (Naylor et al. 2000)	Ontario wildlife habitat assessment model	Assess habitat availability	Allows spatial assessment and classification of habitat based on forest resource inventory data through time. Used to identify habitat for moose, caribou, deer, red-shouldered hawk, and pileated woodpecker in northeastern and central Ontario.	Regional analysts and FMP teams
NDPEG tool (Elkie et al. 2002)	Natural disturbance pattern emulation guide tool	Analyze landscapes to support emulation of natural patterns	Summarizes historical fire data and analyzes current and future landscape disturbance patterns based on rules specified in the *Forest Management Guide for Natural Disturbance Pattern Emulation* (OMNR 2002).	Regional analysts and FMP teams
BFOLDS (Perera et al. 2003)	Boreal forest landscape dynamics simulation model	Simulate landscape dynamics over large areas and long time frames	A spatially explicit model that simulates natural disturbance and succession. Can be used to explore and understand the spatial, temporal, and random variations in fire disturbance regimes in boreal forests.	Regional analysts

by practitioners. Knowledge transfer initially comprised explanations of the models and guidance in interpretation of the results, but evolved into ongoing training on how to use the tools as their development progressed. The development and transfer of these tools were made possible by local generation of knowledge and the existence of an adequate technological infrastructure (e.g., sufficient computing power).

6.2.4. Enabling Structures

Several factors contributed to successful adoption of forest landscape ecological knowledge in Ontario. As outlined above, policies informed by landscape ecological concepts were developed in response to a combination of global and local drivers based on increased interest in sustainable forestry and biodiversity, which in turn created a niche for tools and databases to support the implementation of these policies. In essence, the development of knowledge pushed the development of a policy framework and the ensuing demand from forest resource managers pulled the development of more knowledge in the form of tools and knowledge to help implement the policies. This knowledge transfer process was enabled by Ontario's capacity for the generation of local knowledge and OMNR's organizational and supporting infrastructure.

Ontario benefits from a continuum of developers of basic and applied landscape ecological knowledge. These developers include researchers at 13 universities, the federal forest service, and a research branch within OMNR, all of whom generate landscape-level information and tools. This capacity has generated a considerable forest landscape ecological knowledge base in the primary and secondary literature, beginning in the late 1980s. This is evident in a recent compilation of research knowledge on the forest landscape ecology of Ontario (Perera et al. 2000). Moreover, OMNR has established a geographically dispersed network of science and information units in which science specialists support the transfer of global landscape ecological concepts to produce local applications and tools for forest resource managers.

In addition to knowledge generation and transfer capacity, an enabling infrastructure also supported the implementation of landscape ecological knowledge and tools, along with the necessary organizational resources. Extant Ontario-wide spatial databases include several sources of periodically updated data on forest cover (e.g., Landsat TM, airphoto-based forest resource inventory) and forest disturbances (e.g., harvesting, fire, insect epidemics); geographic information system (GIS) climatic and geological databases (e.g., soils, geology, climate, terrain, watersheds); databases on species habitats, wetlands, and other environmentally sensitive areas; and ancillary spatial information (Table 6.3). This array of readily accessible GIS databases made the practical application of landscape ecological tools feasible both at an Ontario-wide level for policy development and at the level of management units to support the management of forest resources. Simultaneously, fueled by the global growth in information technology, Ontario-wide networks and standards were established so that GIS databases, software, and

Table 6.3. Ontario-wide GIS databases available to support the development of forest policy, planning, and management

Category	Spatial database	Description
Forest cover	Airphoto-based forest resource inventory	Species and age composition and stand characteristics; updated every 10 years (1:20 000)
	Landsat TM forest cover classification	Broad forest-type classes; updated every 5 years (30-m resolution)
Physiography	Ontario Land Inventory Northern Ontario Engineering and Geology Terrain Survey	Broad soil groups, moisture capacity, nutrient regime, and other pedological characteristics (1:250 000 to 1:50 000)
	Ontario surficial geology atlas	Combination of terrain composition and spatial distribution of glacial geological materials (1:250 000 to 1:500 000)
	Ontario digital terrain model	Slope, aspect, and ruggedness (100-m horizontal and 5-m vertical resolution)
Disturbance history	Forest fire history	Burned area, dates of burns, and suppression activities (1:20 000), updated annually
	Forest harvest history	Harvest patches and residual areas (1:20 000), updated annually
	Ontario forest disturbance survey	Biotic and abiotic causal factors such as insect pests and windthrow (1:50 000), updated annually

hardware systems were compatible among knowledge developers and users. This ensured that any tools developed by researchers would be accessible and applicable in every forest management unit in Ontario. As a result, the practical obstacles encountered elsewhere in applying landscape ecology—a lack of data and the unavailability of appropriate computing technology—were not impeding factors in Ontario. Ontario's implementation of GIS-based planning and management approaches in the 1990s required that trained people be in place to ensure the successful transfer and use of new forestry applications of this technology. Beginning as early as 1992, all OMNR offices and the forest industry acquired personnel with GIS expertise, along with the supporting information technology, and this helped to ensure that landscape-level tools and databases could be used in all forest management organizations. The efforts to ensure compatibility of GIS data, systems, and skills across Ontario considerably facilitated the adoption of this technology and provided a unique avenue for the transfer and application of landscape ecological tools. However, the transfer of landscape ecological concepts and knowledge to policymakers and practitioners still had to occur.

6.3. TRANSFER OF FOREST LANDSCAPE ECOLOGICAL KNOWLEDGE

Transferring research knowledge and tools into practical use requires that knowledge developers know who their users are and actively engage them. In this section, we describe the primary users of forest landscape ecological knowledge in Ontario and provide a brief overview of how the province's knowledge development and transfer structure supports the transfer of knowledge to these audiences.

6.3.1. Users of Forest Landscape Ecological Knowledge

The hierarchy of Ontario's policy framework and the shared responsibility for forest management between the forest industry and OMNR make the community of users of forest landscape ecological knowledge both diverse and complex. We identify three broad user groups, each of which requires and uses different aspects of landscape ecological knowledge: decisionmakers, policymakers, and forest resource managers. These groups exist both in the public sector and in private forestry companies.

Decisionmakers include those who shape legislative directions in the public sector and broad-scale forest management strategies for forestry companies in the private sector. This group is receptive to landscape ecological concepts and their applications that are relevant to global and national forest management issues such as climate change, invasive species, conservation of endangered species, and forestry certification. They are also responsive to Ontario's socioeconomic and political milieu, and are responsible for incorporating landscape ecological concepts in several broad forest management strategies. However, decisionmakers such as politicians, leaders of public sector agencies, and forest industry executives receive this knowledge through their advisory staff, making the latter individuals the most direct users of broad-scale landscape ecological knowledge and therefore the direct recipients of knowledge transfer. These advisors typically have academic backgrounds and some practical experience in forestry or wildlife biology, and are interested in answers to the *what* and *why* of landscape ecological knowledge with respect to forest management.

Policymakers are also interested in landscape ecological concepts, but more in relation to forest management applications—that is, they serve as a bridge between broad-scale directions defined by decisionmakers and the actual practice of forest management by practitioners. This group belongs exclusively to the OMNR, the primary public sector forest management organization in Ontario. Ontario's forestry policymakers have a diverse array of academic backgrounds including biology, forestry, and land-use planning. They understand biological and ecological principles and commonly have practical experience in forest or wildlife management. Policymakers have the advantage of being in direct contact with both forest managers and knowledge developers. One challenge they face in developing new policies and guides that incorporate forest landscape ecological concepts is how to balance broad socioeconomic realities with the larger-scale and longer-term scope of landscape ecology. Knowledge developers have interacted with and continue to interact with policymakers to assist in the policy development process. Ontario's policymakers have been responsible for a series of forest management policies and guides that contain landscape ecological knowledge (outlined in Tables 6.1a,b).

Forest resource managers include professionals who plan and implement forest management operations under Ontario's forest policy framework; all are trained in forestry, wildlife biology, or related disciplines, with at least some level of university or college education. Forest resource managers in the public sector (OMNR) assist in developing and approving forest management plans, whereas those working for private forestry companies are responsible for developing and implementing those plans. Therefore, their use of landscape ecology is mainly focused on landscape ecological applications such as tools and databases. Although many are interested in the underlying landscape ecological concepts, and some pursue information beyond what is required to use the tools, their main focus remains the results of using the transferred knowledge and tools and their applicability in the context of the socioeconomic and short-term realities that constrain forest management. Knowledge developers and transfer specialists interact with forest resource managers by various means: presentations, workshops, training sessions, and one-on-one discussions. The proportion of forest resource managers who have not had an opportunity to learn landscape ecology and related spatial and GIS techniques has traditionally been high. Consequently, an intermediate user group, consisting of GIS technologists, has evolved as a necessary component in the process of applying the tools of landscape ecology. In contrast to the focus of decisionmakers and policymakers on the *why* and *what* of landscape ecology, this user group is focused on the *how* (i.e., on the practical and applied uses of landscape ecology in forest management).

Two other broad groups of indirect users of landscape ecological knowledge hold considerable influence in forest management in Ontario: case-specific stakeholders (e.g., other users of forested land, environmental nongovernmental organizations) and the general public. Although these groups have been instrumental in shaping some of the province's forest policies and management practices, we have not included them in our discussion in this chapter because they have no direct responsibility for management and thus are not primary (direct) recipients of the knowledge developer's transfer efforts.

6.3.2. Role of Knowledge Transfer

Ontario's capacity for knowledge transfer and its approach to transfer are unique. Ontario's universities do not have forest extension programs as are common in American universities. As well, unlike the federal forest service in the United States, Canada's federal forest service is not responsible for formal extension to forest managers or provincial policy developers—its transfer focus is national policy development. Therefore, the primary responsibility for knowledge transfer in Ontario rests with OMNR, specifically knowledge developers and transfer specialists. OMNR has three groups of terrestrial knowledge developers, all with research capacity in landscape ecology, and three transfer specialist groups that are geographically dispersed to match local forest landscape characteristics.

The knowledge developers are primarily researchers who generate landscape ecological knowledge in much the same way as academic researchers at a university, but are focused on applied problem-solving related to Ontario's policies and practices. Up to half of their time is devoted to actively participating in knowledge transfer. For example, in addition to generating new knowledge, such as models and research findings, and publishing the information in journals and books (as is customary for researchers), these individuals also are expected to produce material that is directly usable by policymakers and resource managers, such as user manuals and user-friendly software tools. The transfer specialists are science professionals, generally with some practical management experience, who adapt the knowledge created by the developers to meet the resource manager's needs and who provide training on associated concepts and tool use to resource managers.

For example, as part of regular training in forest management planning, these transfer specialists have developed an intensive training module specifically designed to introduce landscape-related concepts such as old-growth forests, biodiversity, and wildlife habitat assessment, and to train practitioners to use relevant tools (e.g., those outlined in Table 6.2) while developing management plans. This module became a means of providing ongoing transfer of existing and new knowledge and tools to forest management planners in OMNR and the forest industry on a 5-year cycle, with input from knowledge developers, policymakers, and practitioners. Ideally, developers and transfer specialists work together to transfer knowledge and applications by developing products together or through joint transfer efforts. As an example, the provincial landscape guide currently being developed involves a team approach in which a development team that includes forestry companies and stakeholders advises OMNR policymakers on the scope, content, and implementation of the guide, and two scientific teams that include knowledge developers, transfer specialists, and policymakers support the development team. These teams work together to make predictions and explore extremes in the possible outcomes of policy alternatives and in doing so, increase their understanding of the associated concepts and how the model works. This in-person, hands-on transfer requires dedicated, knowledgeable, and trained individuals, and a planned, yet flexible approach in which the landscape ecological concepts and rationale are introduced before and in conjunction with training in the use of models and tools. We briefly outline how this worked for two tools, one that has been successfully transferred to users (the OWHAM–OMA combination) and one that is in the process of being transferred (BFOLDS).

Wildlife Habitat Assessment Models

The Ontario Wildlife Habitat Assessment Model (OWHAM), which is used in the central and northeastern regions of Ontario, and the Ontario Marten Analyst (OMA), which is used in the northwestern region, both allow spatial assessment and classification of habitat through time based on local forest inventory data and knowledge of ecological succession. They evolved from a need identified by planning teams attempting to apply forest management guides for the provision of habitat for wildlife, including white-tailed deer (*Odocoileus virginianus*; Voigt et al. 1997), the pileated woodpecker (*Dryocopus pileatus*; Naylor et al. 1996), and the pine marten (Watt et al. 1996). For example, OMA was developed following requests for a method to analyze habitat availability and identify core pine marten areas within forest management units in a clear, consistent, and transparent manner. These models were transferred through a combination of presentations and training workshops and are now used by forest management planning teams in both government and industry.

The Boreal Forest Landscape Dynamics Simulator

The BFOLDS model simulates the boreal forest's fire disturbance regime and succession at the level of ecoregions (several millions of hectares) over time spans of several centuries. It is currently being used to simulate the probabilities of forest fire and forest-cover transition scenarios to provide benchmark information for the development of OMNR's landscape guide for forest management. In addition, it serves as a means to transfer the principles of longer-term variation in potential disturbance patterns, and to explore and understand the nature of the boreal forest's fire disturbance regimes and how these vary through time and over large areas. This knowledge provides insights into how resource managers can influence future forest landscape conditions in a spatially explicit manner. Model transfer has occurred through presentations that provide step-by-step explanations of the process and of the concepts behind emulating natural disturbance, including the inherent variability, and that discuss the results of simulation runs. Over the past 2 years, knowledge developers have used three hands-on training workshops, numerous presentations to users ranging from policymakers to forest managers, and a number of demonstration simulations using the model to facilitate transfer. As well, the professionals responsible for the development of landscape policy have been involved in calibrating the model and performing sensitivity-analysis simulations using local data and expertise. This interactive use of the model serves as a precursor to and as part of the training process for its future use in land-use planning at regional and management unit levels.

As the above examples demonstrate, the role of knowledge transfer in OMNR is shared among knowledge developers, transfer specialists, and policymakers, who work together to perform knowledge transfer activities that include presentations, workshops, and training in tool use in an applied problem-solving framework, leading to revised policy or improved approaches to forest management planning

A unique combination of global and local drivers, a large and expanding knowledge base, an appropriate support infrastructure, and in-house transfer capacity supported successful transfer of landscape ecological knowledge in Ontario. For the most part, the rationale (*why*) was a given that was entrenched in legislation and policies, so it was mostly the *what* (e.g., the scope and contents) and the *how to* that were transferred. Transfer included both increasing the awareness, knowledge, and skills of individuals, and enhancing policies and directions to support the development of revised management guides.

Given the drivers, the knowledge base, and the supporting infrastructure, how exactly does knowledge transfer occur? In the next section, we explore the mechanisms of knowledge transfer through an ongoing case study.

6.4. APPLYING KNOWLEDGE TRANSFER PRINCIPLES: A CASE STUDY

We are presently conducting a multiscale research study designed to increase our understanding of natural fire regimes in boreal Ontario and provide better guidance on how to emulate this form of natural disturbance through forest management. Knowledge transfer is being integrated into the study both to enhance the applicability of the research and to ensure that the intended audiences are aware of the knowledge as it becomes available. In this section, we briefly illustrate how this knowledge transfer is being accomplished within the context of the larger research project. Given that many examples of successful transfer of landscape ecological knowledge exist in Ontario, we based our choice of this example entirely on our familiarity with the project.

Following the researcher's initial concept or idea, research projects commonly progress through a series of stages: experimental design, implementation, analysis of results, and reporting the results. In some cases, and especially so for landscape ecological projects, developing applications of the knowledge and providing training in those applications follows the reporting stage. Engaging specific audiences at various stages throughout the study increases awareness not only of the project but also of the intended outcomes. We are using an integrated approach based on concurrent research and transfer of knowledge to the intended audiences (the potential users of study results) based on an ongoing discovery of their needs at various stages of the study.

6.4.1. Brief Description of the Study

This study addresses the characteristics of fire regimes at multiple scales: characteristics of the fire regime at an ecoregional scale, of fire events at a subregional scale, and of subfire events at a stand scale. In other words, we ask the following question: What patterns do fires create in a forested landscape at different spatiotemporal scales? Our study emphasizes an understanding of how and why these natural patterns vary in both time and space so that resource managers can better emulate these patterns through their management decisions. The knowledge gained by the study will be used to revise specfic forest policies and practices related to the broader policy of emulating patterns of natural forest disturbance (OMNR 2002).

6.4.2. Audience

The intended audiences for the natural fire regime study are decisionmakers, policymakers, and practitioners in boreal Ontario. For the purposes of our case study, we define these audiences as follows:

- *Decisionmakers* are those with the authority to decide research priorities and control funding. They require an understanding of the rationale for the study and how it fits conceptually with other organizational policies, directions, and priorities. Decisionmakers will also be interested in the general findings of the study and how these could be used in policy and practice.
- *Policymakers* are those who incorporate research results into resource management policies and guides. They require an understanding of the linkages and relevance of the study to specific policies, how the knowledge is being developed, where the new knowledge will be integrated into extant or new policies, the knowledge gaps that the study will and will not address, and their implications, as well as the eventual applicability of the results.
- *Practitioners* are those who will implement the policies and guides that result from the study in forest management planning and operations. They require an understanding of how the research results can assist them in solving management problems and are most interested in the tools developed to help them implement the results.

An overview of how these audiences are being engaged at various stages of our study is provided in this section to illustrate both the mechanisms being used to accomplish the transfer and the benefits of ongoing engagement with the intended audiences. At the time of writing, we have completed the study design and have begun the implementation stage. Therefore, we will describe knowledge transfer efforts with respect to what we did during the design stage, what we are doing during the implementation stage, and what we will do during subsequent stages. Table 6.4 summarizes our overall approach.

6.4.3. Designing the study

During the study design phase, the intended outcomes of knowledge transfer were awareness and engagement. To accomplish these outcomes, even before all the study details had been developed we presented an overview of the background and rationale for the study, the proposed approach, and an indication of how the findings will benefit the organization to decisionmakers and used their feedback to refine our study proposals.

Policymakers are especially interested in influencing how the research is conducted. To satisfy this need, we included several policymakers as formal study advisors; they reviewed our study proposals to critique the scope, goals, methods, and time frames of the research. Their involvement in the project was through more

Table 6.4. Overview of the knowledge transfer stages, audiences, objectives, and possible methods used at various stages of an ongoing research project on natural fire regimes in boreal Ontario

Research project stage	Transfer stage	Audience	Transfer objective and content	Transfer method
Design	Awareness	Decisionmakers	Concepts, Rationale	Overview presentation on the approach
	Early engagement	Policymakers, Practitioners	Concepts, Rationale, Methods	Technical presentation on the research design
	Incorporating user ideas			In-person discussions
				Joint field visits
				Analysis of knowledge gaps
				Review of research proposal
Implementation	Incorporating user ideas	Practitioners	Methods	Technical presentation on methods
				In-person discussions
	Maintaining engagement			Joint field visits
				Technical workshops
Analysis of results	Maintaining engagement	Policymakers, Practitioners	Concepts, Methods, Outcomes	Technical presentation on early results
	Sharing preliminary results			In-person discussions
Disseminate findings	Maintaining engagement	Policymakers, Practitioners	Concepts, Outcomes, Applications	Technical presentation on findings and applications
	Sharing final results			In-person discussions
Develop applications	Incorporating user ideas	Policymakers, Practitioners	Application tools	Training workshops
	Moving toward implementation	Decisionmakers	Outcomes, Applications	Overview presentation on general findings and potential uses

detailed technical presentations and discussions than those aimed at the decision-makers, and this engagement allowed us to incorporate their ideas and perspectives into the study design. As a result, policymakers understand what specific uncertainties in current policies are being addressed by this research, and how.

The practitioners we contacted included foresters, biologists, resource technicians, and planners. Initially, we also informed them of the study rationale and approaches through an overview presentation and discussions, and subsequently involved them in several field visits to potential research sites. During these visits, field foresters and biologists provided feedback on the proposed study design and offered relevant local data and information that could be used to enhance the proposed study. These small group discussions also identified additional questions that should be investigated during the study.

In summary, we engaged more than 10 different audiences, ranging from decisionmakers to policymakers and practitioners, to provide an overview of the study rationale, approaches, methods, and time frames by means of presentations, meetings, and field visits. This approach ensured that many individuals belonging to various groups of knowledge users became aware of the study, accepted the proposed approaches, and understood the value of and the need for this research. These activities thus represented early knowledge transfer, and provided a user-review of the research in parallel with traditional peer review of the methods by fellow researchers.

6.4.4. Implementing the Study

During the study implementation phase, our transfer focus is on the practitioners who will be involved in discussions about the research methods and applications of the results. For example, one aspect of our study uses high-resolution aerial photography to map patterns of fire residuals (patches and trees remaining in burned areas). We are illustrating the data collection process and the objective methods of error analysis to ensure that errors and limitations of the data are clear and acceptable to those who will be applying the results. In addition, their involvement in this stage of the study is stimulating interest in the early results, and is providing opportunities for feedback. As the study progresses, we will ensure continuity in engagement with this audience through interim presentations, field visits, and sharing of the interim study results. This will help us to familiarize our audience with new technologies being used in the research project and to discuss potential challenges in applying the expected results in the field.

6.4.5. Sharing Results

We plan to transfer interim study results to policymakers and practitioners who were involved during the study design and implementation phases. Policymakers will begin thinking about how these results may fit with existing policies or what policy revisions may be justified based on our findings, while practitioners can start incorporating results into their planning and operational practice. Preliminary results are best shared through presentations and discussions that review the study rationale and methods once more so that intended applications (and any associated limitations) are clear. Questions and ideas generated during these sessions can stimulate further data analyses and help us to refine our interpretations of the results. For researchers, this step may reveal which aspects of the results will be most difficult to communicate and transfer during implementation.

6.4.6. Disseminating Findings

Once final results are available, we will disseminate them to a broader audience. Even though awareness and understanding of the concepts and approaches remains important, the transfer goal will shift toward ensuring that the new knowledge becomes embedded in new or revised policies and practices. This step will be accomplished in concert with policymakers and practitioners through technical presentations and discussions, in addition to the standard publication and distribution of reports and journal papers. Transfer initiatives and products will again include a review of the study rationale and embedded concepts, but with the focus changing from the approach to the outcomes and potential applications of results.

6.4.7. Developing Applications

The complex information that results from such a study can be built into existing applications or used to develop new applications that practitioners can use to support their planning or operational practice. This will involve working with regional planners to develop tools and associated training workshops. Training workshops for users increase their comfort with the tools, provide an opportunity to address user concerns about the tools and their application, and increase awareness of the embedded landscape ecological concepts. Once again, incorporating ideas generated by our audience will increase the likelihood that the tools and their applications will be accepted.

Once the final outcomes and applications are developed, we will reengage the decisionmakers to present the general findings and potential uses of the knowledge. This step serves to reinforce the relevance of the study, creates awareness of how and where the results are being or may be used, shows linkages to other organizational needs, and relates the results to future research needs. This keeps decisionmakers informed of relevant advances and closes the knowledge transfer loop.

6.5. INSIGHTS ON THE TRANSFER OF LANDSCAPE ECOLOGICAL KNOWLEDGE

In this section, we summarize our experiences in Ontario over the past two decades to offer insights for developers of landscape ecological knowledge. Although we focus primarily on successes in knowledge transfer throughout the chapter, we also encountered many challenges in the transfer of landscape ecological knowledge in Ontario.

6.5.1. Challenges

Our experiences suggest a complex assortment of impediments to successful knowledge transfer: the problems may be transient, temporary, or long term; case-specific or systemic; limited or pervasive; and caused by individual personalities or organizational culture. Some of these challenges may be minimized by effective knowledge transfer.

- *Unfamiliarity with landscape ecology*. The traditional stand-level educational background of most resource managers makes them focus on short-term and small spatial scales, and poses an initial obstacle for their receptivity to landscape ecological knowledge. In addition, the abstract nature of landscape ecology and its inherent inability to always provide rapid empirical proof contrasts with customary fields of knowledge such as silviculture. The effects of this unfamiliarity are amplified by the inherent skepticism of practitioners toward a young science and the natural human resistance to change.
- *Unrealistic expectations*. When landscape ecological knowledge is introduced to forest resource managers, most expect to receive prescriptions or ready-made solutions for specific management problems. This expectation leads to disappointment because landscape ecology is more contextual and, in forest management, is used to develop and explore a range of management alternatives rather than to generate specific prescriptions. This situation is compounded when setting of goals is not explicit because forest managers sometimes expect landscape ecological knowledge to generate the missing goals.
- *Viewing GIS technology as a substitute for landscape ecological knowledge*. Although the ready availability of GIS technology and spatial databases assists in the transfer and application of many landscape ecological research findings, the technology may also interfere with transfer and application. Some users involved in policy development, strategic planning, and forest management believe that GIS manipulation of spatial data represents modeling and scientific research; because such explorations do not always include due consideration of the methods, assumptions, logic, or scientific basis for their approaches, the explorations can lead to false premises and entrenchment of misconceptions about patterns and processes in landscape ecology.
- *Information overload*. With the volume of available information increasing so rapidly, users may have access to more scientific knowledge than they can handle, and become overwhelmed. In addition, published scientific knowledge sometimes conflicts, or is duplicated with only subtle differences; as a result, potential users may misunderstand the value and applicability of the available knowledge. The onus is then on the researcher or transfer specialist to discern what knowledge is most relevant or applicable to each user's situation, and to focus on transferring only the most relevant knowledge.

Our experience with these challenges suggests that they are only temporary, though pervasive. Each can be overcome in time with sustained transfer efforts.

Some difficulties may not be readily overcome by transfer efforts alone because the problem lies in organizational cultures, and is more systemic and long term. Nonetheless, it is important for researchers to be aware of these problems, a few of which are outlined below, and to design transfer activities to address them.

- *Audience complexity and diversity*. Landscape-level approaches to forest policy and management often involve an audience hierarchy in which users have different knowledge needs even for the same topic. In addition, various organizations, landowners, and stakeholders are included in policy development, planning, and management. A clear understanding of the roles and responsibilities of these diverse audiences, as well as of their organizational cultures and educational backgrounds, is essential to ensure that each user obtains the knowledge they require in a usable form. This may mean having to transfer similar knowledge in multiple forms to different audiences, which requires flexible approaches and timing.
- *Continuous shifts in organizational priorities*. The need for and use of ecological knowledge by forest managers and policymakers are linked to organizational directions and priorities at any given time. Therefore, any sudden changes in organizational priorities—and these are common and systemic due to social or economic pressures—can also lead to sudden and unexpected shifts in knowledge needs. Adapting knowledge and tools to accommodate such shifts is an ongoing challenge, especially in public agencies.
- *Narrow windows of opportunity for knowledge transfer*. The reality is that most users of forest ecological knowledge, whether they are primarily involved in forest policy development, strategic planning, or forest management, are most receptive to new ecological knowledge when they face a problem and must seek specific solutions under tight time constraints. Although such policy and management crises can provide windows of opportunity for effective transfer, they are narrow and ephemeral. If knowledge developers are not vigilant and do not adapt to such conditions, they may miss many supplementary occasions to transfer knowledge.

In our experience, these challenges are difficult to meet because they require awareness of changing situations and the ability to respond quickly in a manner that is appropriate to each component of the audience. Although knowledge developers and transfer specialists may possess the necessary skills to meet each of these criteria, organizational constraints may prevent them from responding effectively. We are unaware of any general solution to this category of challenges other than to recognize its existence and take measures (e.g., striving to remain aware of the audience's changing context) to detect opportunities sufficiently far in advance to allow an appropriate response.

6.5.2. General Lessons for Landscape Ecologists

Although influencing organizational characteristics to make the situation conducive for successful knowledge transfer is beyond the capacity of landscape ecological researchers and transfer specialists, we believe that several factors are within the realm of their control. The insights we offer below are examples of issues that may be under the direct influence of landscape ecology knowledge developers.

- *More than practitioners can benefit from the transfer of landscape ecological knowledge*. Knowledge developers and transfer specialists can engage a broad range of audiences in addition to forest resource managers, including legislators, policymakers, and land-use planners, who may influence forest management at the many different hierarchical levels involved in solving a forest management problem. Recognizing the specific needs and characteristics of each distinct group of users helps to tailor knowledge transfer efforts accordingly.
- *Knowledge developers need to keep pace with existing policies and practices*. This awareness of the operational context helps researchers and transfer specialists to time the development and transfer of knowledge to match user needs, thereby maximizing effective use and application of the knowledge. When transfer occurs too early, users may be unreceptive because acceptance of the knowledge would demand too big a change from the status quo. If transfer occurs too late, users may no longer need the knowledge (i.e., they may have already developed alternative solutions) or it may no longer be relevant.
- *Continuous engagement and personal interactions are most effective*. Even when users are receptive, continuous engagement by knowledge developers, starting as early as the research design stage, builds mutual trust and facilitates progressive and gradual transfer of knowledge. Continuous engagement also provides opportunities to transfer the same knowledge in different forms to suit different circumstances. As a result, it is a powerful vehicle for knowledge exchange and for increasing the acceptance of new knowledge and its applications.
- *It is essential to establish the context for landscape ecological knowledge at the outset*. This is especially true when knowledge of the underlying concepts must be established before transfer of tools can succeed. Without understanding the concepts, users cannot apply the tools appropriately. Relying on GIS and computing technology supports the transfer of tools in the short term, but may actually impede the transfer of landscape ecological concepts in the long term if those concepts are not made part of the transfer of the tools.
- *A clear understanding of the user's expectations is important for transfer.* In addition to understanding the user's need for specific knowledge or application of the knowledge, researchers must be aware of the user's expectations. Users prefer directly applicable, user-friendly, validated knowledge, whereas researchers may prefer innovative, methodologically elegant, complex solutions to their problems.

In general, we found that the passive approach to knowledge transfer (i.e., expecting users to discover, read, understand, and apply published research knowledge) is ineffective. However, it is possible to provide examples of effective use of supply-driven ("push"), demand-driven ("pull"), and collaborative–iterative modes of active knowledge transfer (Perera et al. 2006) in Ontario. Most early applications of landscape ecology at strategic scales resulted from a push powered by education and the creation of awareness by researchers. This approach was effective in transferring landscape ecological concepts and setting the context at the levels of broad policy development and the production of management guides. Relying on demand (pull) from users continues to be an effective way to transfer landscape ecological tools at the scales of local management and tactical problem-solving, especially once the context is established. Last but not least, the collaborative–iterative approach is optimal in situations such as the development of management guides in which ongoing interaction and adaptability are key to ensuring that the knowledge will be used in an appropriate context and that the tools are adjusted to meet user needs.

6.6. CONCLUSIONS

The case study described in this chapter illustrates that it is possible for a public land management agency to successfully develop and transfer forest landscape ecological knowledge. Policies informed by landscape ecological principles, an awareness of their importance, and an emphasis on implementation have evolved over the past two decades, and practitioners are now using landscape ecological tools to solve forest management problems.

For this to occur, several interrelated enabling factors were essential:

- a combination of political will, driven to some extent by global pressures
- social pressures such as a provincial environmental assessment of forestry practices and new legislation
- enabling structures, including global and local science, provincial policy changes, a supportive organizational structure, and technological advances
- demands for new knowledge and acceptance of this new knowledge by land managers
- adequate resources, including both skilled people and the technological and organizational infrastructure required to support their efforts

All of these factors aligned simultaneously (and fortuitously) and continue to drive the process. Ontario benefited from a combination of these factors along with an institutional capacity for change and flexibility, and a willingness to incorporate new ideas and approaches. The demand for knowledge continues to increase as does the demand for tools to facilitate application of the knowledge by resource managers.

Despite the advantages enjoyed by Ontario, maintaining a connection between the expansion of landscape ecological knowledge and its application in the development of forest policy and in operational practice remains a challenge. Socioeconomic and political realities continue to complicate policy development and management at the broad scales where landscape ecology is most relevant. The structure of Ontario's forest land tenure, with public ownership and private management, and the resulting composition of stakeholders also pose challenges to the application of landscape ecological principles. The adoption process is slowed, for example, by the planning framework (i.e., goal setting) and by long implementation time frames; policy changes made today may not be implemented for up to 10 years, depending on the stage of the forest management planning cycle when the policy changes.

We have learned that just because knowledge is developed, published, and made accessible to practitioners, this does not mean that it will be applied successfully. We recognize that obstacles to successful application will continue to exist and will emerge inevitably at each level, from legislation to policy development, planning, and operational practice. Moreover, we believe that good knowledge transfer is essential, but is only the first step in successful application of landscape ecological knowledge; organizational and other barriers may delay or prevent this application. In this case, a sustained transfer effort is necessary to ensure that the available knowledge will be accepted and used in practice. Success requires dedicated individuals willing to lead, advocate, and push for change over a period of years.

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