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Knowledge Transfer in Forest Landscape Ecology: A Primer

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1.1. WHY SHOULD FOREST LANDSCAPE ECOLOGISTS FOCUS ON KNOWLEDGE TRANSFER?

The science of landscape ecology has evolved rapidly from a relatively obscure topic, then a young discipline, to a popular focus for researchers. This evolution is reflected in a recent issue of *Ecology* (2005:86(8)) that is dedicated to the topic *landscape ecology comes of age*. As the knowledge base of landscape ecology expands and its range of topics broadens, researchers are becoming increasingly aware of the value of landscape ecology applications in managing both terrestrial and aquatic resources (Gutzwiller 2002; Liu and Taylor 2002).

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In particular, the concepts of landscape ecology have increasingly been integrated into the study of forested environments in North America over the past two decades. In fact, the very first research paper in the inaugural issue of the journal *Landscape Ecology* addressed spatial patterns in a harvested forest landscape (Franklin and Forman 1987). The focus of forest landscape ecology, at least in a North American context, is large tracts of land where the cover is dominated by forests (i.e., the matrix) interspersed with areas where forest cover may be temporarily absent due to disturbances such as harvesting and fire (i.e., patches) (Perera and Euler 2000). This differs from the traditional milieu of landscape ecology, in which forest cover exists in patches (i.e., is fragmented) within a matrix of nonforested area and the transformation of forest patches to nonforest cover is usually permanent.

Viewing forested landscapes as broad-scale ecosystems and studying their composition, spatial patterns, spatial interactions, temporal change, and range of functions have direct applied value because most forests in North America are managed at broad scales to provide a range of uses: resource extraction, recreation, and conservation. Efforts to elucidate various broad-scale ecological patterns and processes in forested landscapes are essential to attaining the broad forest management goals of conserving forest biodiversity and attaining forest sustainability, as well as to understanding and mitigating the regional and global consequences of local forest management.

Although the value of landscape ecology applications is increasingly recognized, the transfer of knowledge in landscape ecology from those who develop it to those who apply it is not commonly identified as an explicit role for researchers. A literature search, for example, in the journals *Ecology*, *Ecological Applications*, *Forest Ecology and Management*, *Landscape Ecology*, *the Canadian Journal of Forest Research*, and *Forest Science* from 1960 to 2005 shows that no publications on landscape ecology or forest landscape ecology during that period contained any of the following keywords in the publications' titles, keywords, or abstracts: knowledge transfer, technology transfer, and extension. Furthermore, the topic of knowledge transfer was not addressed until 2004 at the annual meeting of the U.S. chapter of the International Association for Landscape Ecology, traditionally the principal gathering of landscape ecologists in North America. Although an extensive literature on knowledge transfer exists in social science journals, landscape ecologists do not readily encounter such studies. As a result, knowledge transfer remains for them an obscure topic of study.

Few developers of knowledge in forest landscape ecology, however, would dispute that the necessary next step in the evolution of the field is to move from the accumulating wealth of scientific and technical knowledge to applications of that knowledge. Forest landscape managers are in urgent need of such applications in formulating policies, planning the use and conservation of resources, and developing management strategies. As is the case with mature applied sciences such as agriculture and forestry, the progression from concepts and principles (i.e., knowledge in its primary form) to application of those concepts and principles requires forest landscape ecologists to engage explicitly and actively in knowledge transfer.

Our goal in this chapter is to introduce researchers and other knowledge developers in forest landscape ecology to the concept of knowledge transfer. To do so, we examine the key factors that influence knowledge transfer, focus on aspects that are unique to forest landscape ecology, and suggest a role for knowledge developers in the knowledge transfer process.

1.2. WHAT FACTORS INFLUENCE KNOWLEDGE TRANSFER?

First, let us define our terms. By *knowledge transfer* we mean a group of activities that increase the understanding of landscape ecology with the goal of encouraging application of this knowledge. *Technology transfer* implies a specific instance of knowledge transfer that increases levels of skill in the use of tools. *Extension* refers to a very broad group of practices geared toward knowledge and technology transfer that enable the successful application of knowledge. Although use of the term *extension* is common, we prefer the more specific term *knowledge transfer*, and we use that term in its broadest sense throughout this chapter, except when there is a specific need to differentiate between knowledge transfer and technology transfer.

We recognize five major factors that will influence knowledge transfer from the view of forest landscape ecology: the generation of research knowledge, the potential for application, the users of the knowledge, the infrastructure capacity, and the process by which knowledge is transferred. In the remainder of this section, we outline these factors and address how they interact during the process of knowledge transfer. We provide only a broad description since a detailed treatise on knowledge transfer principles and concepts is beyond the scope of this discussion. For that we refer the reader to other sources (e.g., Reed and Simon-Brown 2006; Rogers 1995).

1.2.1. The Generation of Research Knowledge

The increased academic interest in forest landscape ecology in North America is manifest in the growth of research capacity: almost all major universities have established graduate programs providing advanced training in this area of study. One indicator of increased activity is that 84 North American graduate thesis and dissertation titles contained the keyword “forest landscape” between 1990 and 2004, compared with only 5 prior to 1989. In addition, most major forest research agencies outside universities have developed directed research programs and projects on this topic. The resulting growth in the body of published scientific knowledge has been rapid, and is evident in the proliferation of research papers that specifically address forest landscape ecology (see Figure 1.1) and books in the field (e.g., Mladenoff and Baker 1999; Perera et al. 2000, 2004; Rochelle et al. 1999). All major journals that consider ecology and ecological applications now regularly publish research studies conducted on forested landscapes. The number of forest landscape ecology presentations delivered during scientific conferences, particularly by graduate students engaged in thesis research, has also increased considerably.

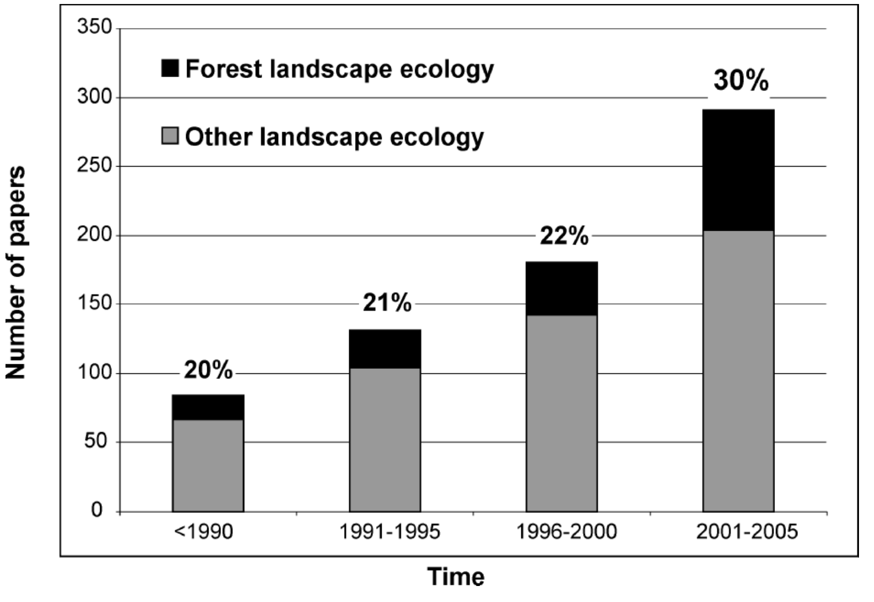

Figure 1.1. Research papers on forest landscape ecology and on other landscape ecology topics published in the journal *Landscape Ecology* from 1987 to 2005. (Percentages refer to the proportion of the total accounted for by papers on forest landscape ecology.)

The topics addressed by forest landscape ecology have also expanded and become increasingly specialized. Although early forest landscape ecology research focused primarily on habitat fragmentation and population dynamics, on the basis of island biogeography theory, recent research has embraced more of a systems view of forested landscapes, including attempts to apply other null models such as disturbance-resilience theory. For example, research papers published in the journal *Landscape Ecology* from 1987 to 2005 addressed a variety of aspects of forested landscapes, including the following: spatial heterogeneity (forest ecogeography, landscape indices, mapping and spatial pattern analyses of forest cover); forest landscape function (primary productivity, carbon sequestration, and hydrogeochemical processes); forest landscape change (succession and forest aging); disturbance (insect epidemics, windthrow, and forest fire); habitat provision (habitat suitability and capability, fragmentation, and population dynamics of wildlife); and forest management and planning strategies. Figure 1.2 shows the composition of these topics, in terms of number of studies published.

In addition to the diversification of topics, published knowledge in forest landscape ecology has begun to address related areas. Researchers in this field are advancing ecological concepts, discovering new spatial mapping and analytical techniques, formulating simulation models to extend research hypotheses, and projecting scenarios of spatial processes and patterns. They have begun to explore avenues

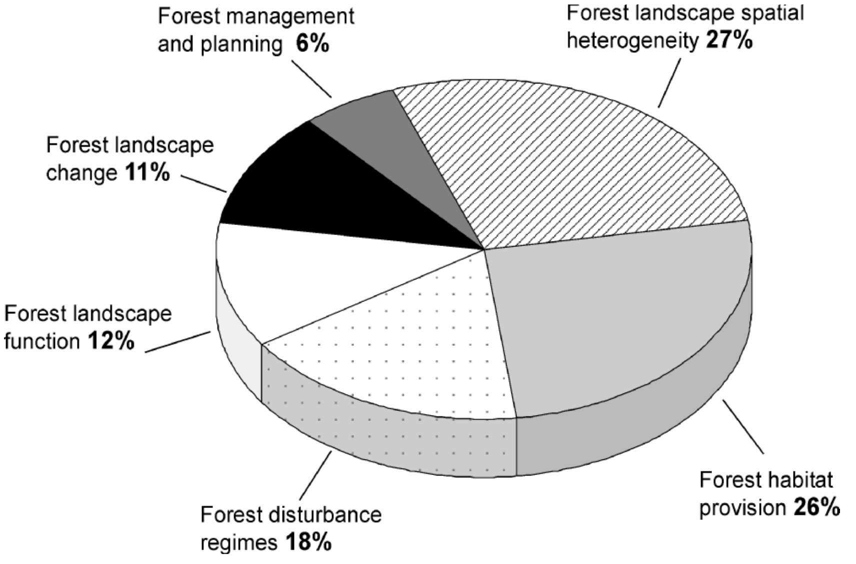

Figure 1.2. Published knowledge in forest landscape ecology has diversified as evident in the composition of the topics in research papers on forested landscapes (total = 170) published in the journal *Landscape Ecology* (1987 to 2005).

for improving forest land-use policies and planning, and to develop applications in support of forest management decisions. The trend of expanded research capacity, specialized subject matter, and increased generation of information is leading to a significant wealth of accumulated knowledge on the ecology of forest landscapes. Even as research knowledge grows, the potential for applications increases, creating the opportunity—and posing the challenge—for knowledge developers to engage in knowledge transfer.

1.2.2. The Potential for Applications

Since the 1980s, a gradual but conspicuous broadening of the goals has occurred in North American forest management driven by various social, ecological, and economic factors (Crow 2002). It is primarily a shift in focus from the supply of timber to the more complex goal of regional sustainability of natural resources, resulting in an associated expansion in forest management planning units from traditional forest stands to larger geographical extents such as ecoregions (Perera and Euler 2000). Attempts to manage forests over broader spatial scales and longer temporal horizons have made forest resource policymakers and managers increasingly aware that a landscape ecological view is necessary to manage toward the goal of forest sustainability.

There are many early examples of this paradigm shift toward a landscape ecological approach in North American forestry. These range from broad legislation in Canada (e.g., the 1994 Ontario Crown Forest Sustainability Act) to environmental assessment processes (e.g., Ontario's 1994 environmental assessment of timber management) to regional plans in the U.S. Pacific Northwest (e.g., Swanson et al. 1990), and to managing for specific conservation values at regional and landscape scales (e.g., spotted owl, Verner et al. 1992, USDA and USDI 1994; old-growth forest, Harris 1984). In addition, forest management planning processes such as the landscape coordination groups commissioned by the Forest Resources Council in Minnesota (Minnesota Statutes 2002) and the Southern Forest Resource Assessment (Wear and Greis 2002) have evolved to rely on landscape ecological approaches. Some jurisdictions, including the province of Ontario, Canada, have explicitly embedded landscape ecological concepts in their forest management directions at all hierarchical planning levels (Table 1.1). Adoption of a landscape ecological view and integration of landscape ecological applications involve substantial growth in the demand for knowledge related to landscape ecology. The question, then, is how the knowledge is incorporated at these levels. To understand this, we need to consider who is (or could be) using the accumulating knowledge base.

1.2.3. Users of the Knowledge

Forest resource managers who develop and operationalize plans to harvest, regenerate, and conserve forest landscapes are the most recognized group of users of forest

Table 1.1. Levels of forest management directions in Ontario, Canada, as an example of a hierarchy that embeds concepts and applications of landscape ecology

Level of forest management directions	Specific articulation	Direction provided	Embedded landscape ecological concepts
Legislation	Crown Forest Sustainability Act (Statutes of Ontario 1995)	Emulating natural forest disturbances as a basis for forest management	A coarse-filter approach to conserving biological diversity
Policy	Old-growth policy for Ontario's Crown forests (OMNR 2003)	Identifying and conserving old-growth forest conditions	Ecoregional heterogeneity in natural disturbances and landscape aging
Guide	Forest management guide for natural disturbance pattern emulation (OMNR 2002)	Using spatiotemporal fire disturbance patterns as a guide to designing harvest patterns	Spatiotemporal variability in crown fire regimes in boreal and near-boreal forest landscapes
Management planning	Forest management planning manual (OMNR 2004)	Managing forests in the context of landscape heterogeneity and dynamics	Long-term forest cover trajectories, wildlife habitat supply, landscape edge, corridors and patch interior

landscape ecology knowledge. However, the realm of potential users of forest landscape ecology knowledge is broad and complex and includes legislators, policymakers, land-use planners, and forest resource managers. Moreover, the decisions of these users are interrelated. They influence the patterns and processes in forest landscapes at various spatiotemporal scales in a nested hierarchy, as illustrated in Figure 1.3. These hierarchical levels are also scale-specific, with different knowledge requirements for their decisions related to forest management. Though most evident in the public sector, these hierarchies of decisionmakers also exist in private sector forest companies. These users may not only have different specific goals in the forest landscape management process, but may also represent differences in a multitude of other traits such as educational backgrounds, institutional cultures, and technological infrastructure, all of which are important in determining whether and how they may use landscape ecology knowledge (Turner et al. 2002).

In addition to those knowledge users who influence forest management decisions directly, many others, loosely referred to as "stakeholders," have an indirect, yet considerable, influence on such decisions. These include recreationists, conservationists, commercial tourist outfitters, public citizen organizations, and environmental nongovernmental organizations, operating at national, regional, or local levels. Such stakeholders are becoming important participants in forest landscape planning processes and, therefore, constitute another group of knowledge users.

Although the exact composition and characteristics of the users of forest landscape ecology knowledge may vary from case to case, all above-mentioned groups collectively play a role in shaping future forest landscapes, and thus represent direct beneficiaries of advances in landscape ecology knowledge. Knowledge developers who are interested in influencing whether and how their knowledge is received and applied will benefit from understanding the roles, goals, and existing knowledge base of these users.

1.2.4. Technological Infrastructure

Another consideration is whether users can accommodate the knowledge base within their technological infrastructure capacity (that is, the technological resources available to the user) and, thus, whether we are at a point at which applications of landscape ecology knowledge are feasible outside the research realm. The past two decades have seen tremendous technological progress in large-scale data-capture methods such as satellite and airborne image recording. As landscape ecology researchers are aware, the accuracy and efficiency of data capture have improved, but data costs have also decreased, making data sources such as Landsat, AVHRR, IKONOS, SPOT, and LiDAR images readily available. Parallel advances in image analysis and GIS software, as well as their increased user-friendliness, coupled with improvements in data storage and computing hardware, have made the use of large-scale information, once accessible only to researchers, increasingly practical and affordable for forest landscape managers. Forest managers in both the public and private sectors are increasingly gaining access to extensive spatial databases of forest

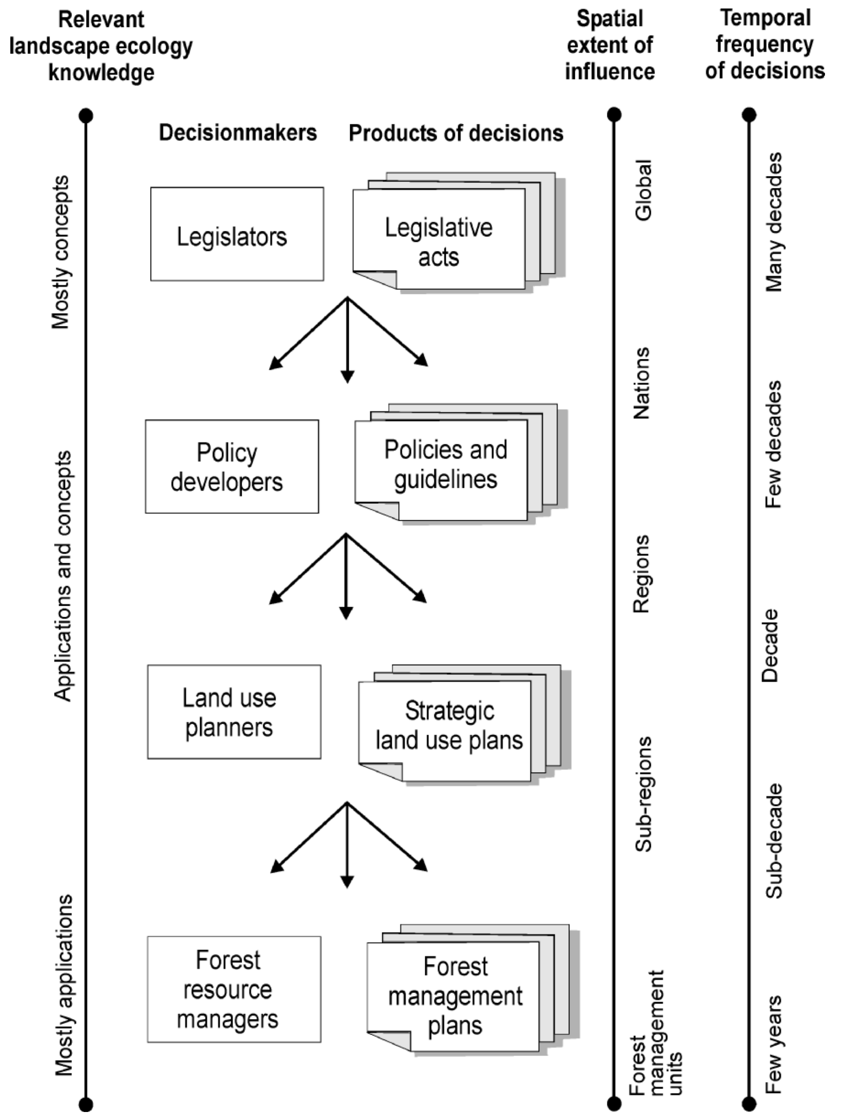

Figure 1.3. An example of the hierarchy of decisionmakers, the level of influence of their decisions in forest management in terms of spatial extent and temporal frequency, and the relevant landscape ecology knowledge.

cover and ancillary information. These databases, regardless of their stage of development, enable forest resource managers to adopt a landscape-level view in their practice, in both a quantitative and a spatially explicit manner. Added to developments in computing and data-acquisition technology is growth in the number of professionals versed in spatial data analysis and computing technology: forest resource management organizations in the public and private sectors are increasingly employing technologists who are adept in using GIS and remotely sensed data in the context of forest management. Therefore, the impact of unavailability and unfamiliarity of spatial data technology, which were considered serious obstacles to applications of forest landscape ecology in the recent past (Perera and Euler 2000; Turner et al. 2002), appears to be diminishing with time.

1.2.5. Barriers to Knowledge Transfer

The factors discussed above can be viewed as a hypothetical source–sink relationship. Accumulating research knowledge is considered to be the source, and the potential application of knowledge is equated to the sink, to which knowledge will be transferred, and the technological and other infrastructure represents the corridor or enabling structure that establishes a link between source and sink and permits the transfer (Figure 1.4). The flow of knowledge depends on the differential between the source and sink and the conductivity of the corridor. Another analog is a supply–demand relationship; that is, demand generated by user applications, the supply of knowledge from research, and a flow of knowledge enabled by the infrastructure that links the two. Both of these analogs of knowledge transfer imply a passive process: because demand is growing, supply is expanding, and the enabling structure is in place, the knowledge is assumed to flow automatically from researchers to practitioners.

The success of such a passive process is predicated on several assumptions about the community of knowledge users. For example, once research knowledge is published, users are assumed to (a) know that knowledge exists, (b) recognize the

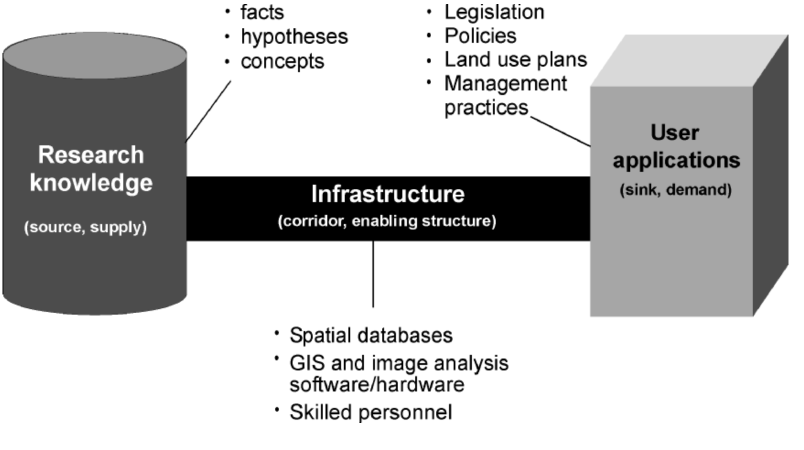

Figure 1.4. An illustration of factors essential for the transfer of forest landscape ecology knowledge and their interlinkages. Some may view knowledge transfer as an automated process analogous to a source–sink or supply–demand relationship. In reality it requires active involvement of knowledge developers and users.

value and relevance of the knowledge, (c) discern the applicability of the knowledge, (d) do the necessary transformation to make knowledge applicable, and (e) if feasible, apply the knowledge appropriately. For these assumptions to be correct, the knowledge developers and the community of users must have a similar philosophical and cultural outlook, similar strategic and tactical goals, and similar scientific and technological environments.

In reality, such similarities rarely exist, invalidating the assumptions about an automated flow of knowledge from developers to users. For example, Turner et al. (2002) identified several generic dissimilarities between the developers of landscape ecology knowledge and managers of natural resources, including incongruity in goals and scales, differences in the nature of the knowledge and data, differences in the training and professional experience of personnel, and differences in institutional culture (Table 1.2).

Furthermore, the forest landscape ecology knowledge generated by developers is innately different from the traditional forest ecology knowledge familiar to forest landscape managers. The resulting differences, some of which are detailed below, may further impede knowledge transfer.

- *Breadth of spatial scale*: Looking beyond the level of forest stands to address forest regions, which are the basis of forest landscape ecology, is not natural to forest managers and planners, and it may not even be accommodated by the present policy and socioeconomic frameworks.
- *Multidisciplinary complexity*: The breadth of the spatial scale results in inevitable social and economic ramifications at the outset of any application of landscape ecology knowledge, and this necessitates broader considerations, often across multiple research disciplines, than has been customary.

Table 1.2. Major differences between landscape ecology researchers and forest managers (adapted from Turner et al. 2002) that prevent an automated knowledge flow from developers to users

	Landscape ecology researchers	Forest managers
Goals	Understand causes and ecological consequences of spatial heterogeneity	Maintain or alter natural resources for societal objectives as guided by local, state, and federal statutes
Scales	Ecologically meaningful scales	Management-oriented scales
Tools/methods	Spatial modeling and analysis, geographic information systems, experiments	Harvest, prescribed fires, wildlife management, restoration, habitat manipulation
Training/experience of personnel	Training in ecology, no management experience	Outdated or little training in ecology, rich management experience
Data	Observation results, simulation results, experimental results, remote sensing data	Observation results, remote sensing data
Institutional culture	Publish or perish	Crisis control and problem-solving

- *Length of temporal scale*: A single forest harvest rotation is the most common planning horizon for forest managers, dictated by economic realities, but forest landscape ecology addresses longer-term planning horizons.
- *Stochasticity in broad landscape processes*: Using traditional knowledge, forest managers often consider determinism to be the de facto status at broad scales, which supports only one trajectory of structure and composition in designing future landscapes, whereas forest landscape ecology may introduce alternative outcomes.
- *Reliance on conceptual models*: Use of predictive and prescriptive models is the norm in forest management, and this makes the more abstract scenario-simulation models and exploratory models that are designed to provide insight and context in landscape ecology unfamiliar to these potential users of the technology.
- *Focus on coarser resolution*: Stand-level and finer resolution of information is the staple input to forest management planning, whereas forest landscape ecology relies on resolutions coarser than this level; as a result, forestry practitioners may question the value of this information.

In addition, forest landscape ecology knowledge may not be readily available to and usable by practitioners. This problem may arise from causes such as the following.

- *Lack of awareness*: Forest landscape managers may not be aware of the accumulating knowledge base, which may be mostly available in journals meant for researchers, and may not understand its relevance to their management practices.
- *Usability of knowledge*: Much of the forest landscape ecology knowledge is still available only in its primary form, such as in complicated models that rely heavily on complex computing technology, rather than in the form of user-friendly tools and applications. This makes direct use of the knowledge difficult for forest managers.
- *Incompatibility with their needs*: Even where applicable knowledge suitable for its intended user is available, it may have been developed without considering the user's specific goals.
- *Incompatibility with existing infrastructure*: Even when applicable knowledge is compatible with the user's needs and goals, users may find that the applications are not compatible with their present suite of applications, databases, and computing technology.

Given these impediments, it is obvious that passive knowledge transfer will not occur in most instances, and that reliance on a solely automatic process of knowledge transfer is likely to widen the disparity between the volume of generated knowledge and the successful application of this knowledge in forest landscape management.

1.3. WHAT CAN FOREST LANDSCAPE ECOLOGISTS DO TO ADVANCE KNOWLEDGE TRANSFER?

All developers of forest landscape ecology knowledge, whether they are academics, researchers, or technologists, have the capability to actively engage in knowledge transfer, albeit to varying degrees. This involvement in knowledge transfer would help ensure that the knowledge they work to generate has an opportunity to be applied appropriately. The broad goal of transfer is to make users aware of the knowledge available and its appropriate application, as well as to impart the technological skills required to apply that knowledge.

1.3.1. Understand the Basics of Knowledge Transfer

Knowledge transfer is an essential step to ensure timely and effective application of knowledge already developed, as well as to identify future needs. The nature of the knowledge to be transferred ranges widely and varies with the circumstances. At one extreme, the principles and concepts of landscape ecology are required for users to understand underlying forest landscape patterns and processes, which provide the context for the necessity and appropriateness of landscape ecological applications. At the other extreme, many skills and technological knowledge are required to understand and use the models, user tools, and spatial data.

Knowledge developers (academics, researchers, or technologists) may transfer knowledge through direct contact with users (legislators, policy developers, land-use planners, forest resource managers, or stakeholders). The specific goal of a transfer activity may range from creating awareness of an emerging concept among users, educating users about the meaning and potential use of a specific research finding, or training users to use a new tool; more than one of these goals may be achieved simultaneously. The intended outcome also ranges widely, from knowing about a concept to understanding the principles and interrelationships with other factors and appropriately applying the new concept or tool. An important aspect of this engagement is that it is reciprocal: users provide feedback to developers about the transfer they received, or initiate transfer and future research by articulating their needs to the knowledge developers. In some instances, professionals trained specifically in knowledge transfer may enter the process and participate in the transfer; these individuals are often referred to as "extension specialists." For the purpose of this chapter, we use the generic term *transfer specialist* for these professionals. Working definitions for relevant transfer-related terms, and commonly used synonyms, are provided in Table 1.3.

As we noted earlier, there are subtle differences between the terms *knowledge transfer*, *technology transfer*, and *extension*. Here, we have used the term *knowledge transfer* to mean the broad group of activities that will increase the understanding of landscape ecology principles, concepts, and specific facts by users, through education, thereby providing a basis for applying the knowledge. Knowledge transfer is

Table 1.3. Working definitions and examples for commonly used knowledge transfer terms

Term	Working definitions	Related terms and examples
Who is involved?		
User	An individual or a group that interacts with developers or transfer specialists to (a) receive knowledge for application and (b) provide feedback on their needs and the applicability of the knowledge	Audience, user, client, stakeholder, forest manager, policymaker, legislator, land-use planner
Developer	An individual or a group that (a) generates knowledge or technology for application by practitioners and (b) receives feedback from practitioners	Academic, researcher, technologist
Transfer specialist	An individual or a group that interacts with developers and practitioners to enhance and expedite the knowledge transfer process	Extension specialist, transfer professional, research liaison, GIS specialist, GIS technologist
What is being transferred?		
Knowledge	Generalized principles, concepts, and specific facts that provide the contextual basis for application	Research findings, models, decision-support systems, methods
Technology	Mechanical means necessary for the application of knowledge	Techniques, user tools, information, data
How accomplished?		
Engagement	Direct interaction among developers, practitioners, and transfer specialists to enable awareness, education, training, and feedback	Involvement, cooperation, collaboration
Awareness	Developers and transfer specialists increasing the practitioner's cognizance of knowledge and technology	Transfer, extension, outreach
Education	Developers and transfer specialists imparting knowledge through activity planned to increase understanding	Transfer, extension, outreach
Training	Developers and transfer specialists helping practitioners to learn a technology or skill through instruction and guided practice	Hands-on exercises, guided practice
Feedback	Developers and transfer specialists receiving practitioner response to transfer activities and becoming more aware of practitioner needs	Evaluation

also a precursor to technology transfer, which encompasses the broad group of activities that increases the users' awareness of applications of knowledge and their skills in using specific tools through training. The chronological progression is from awareness to understanding and finally to applying the knowledge. The overall goal of the suite of transfer activities, commonly referred to as extension, is to help users progress toward the goal of successfully applying landscape ecology knowledge. These principles provide a general overview of the basic elements of knowledge transfer and their interlinkages, and can be applied to both individuals and organizations. The mechanisms of how the various components interact are not addressed here. For more details on these interactions, interested readers are directed to, for example, Argyris and Schön (1978), Reed and Simon-Brown (2006), and Rogers (1995).

In Figure 1.5, we illustrate a hypothetical scenario in which the principles discussed above are put into practice to transfer a landscape ecology model to practitioners. In this example, a spatial research model is converted into an application, an exercise that requires adapting the model to a user-friendly GIS-based tool, while capturing local knowledge. The knowledge transfer process in this instance is com-

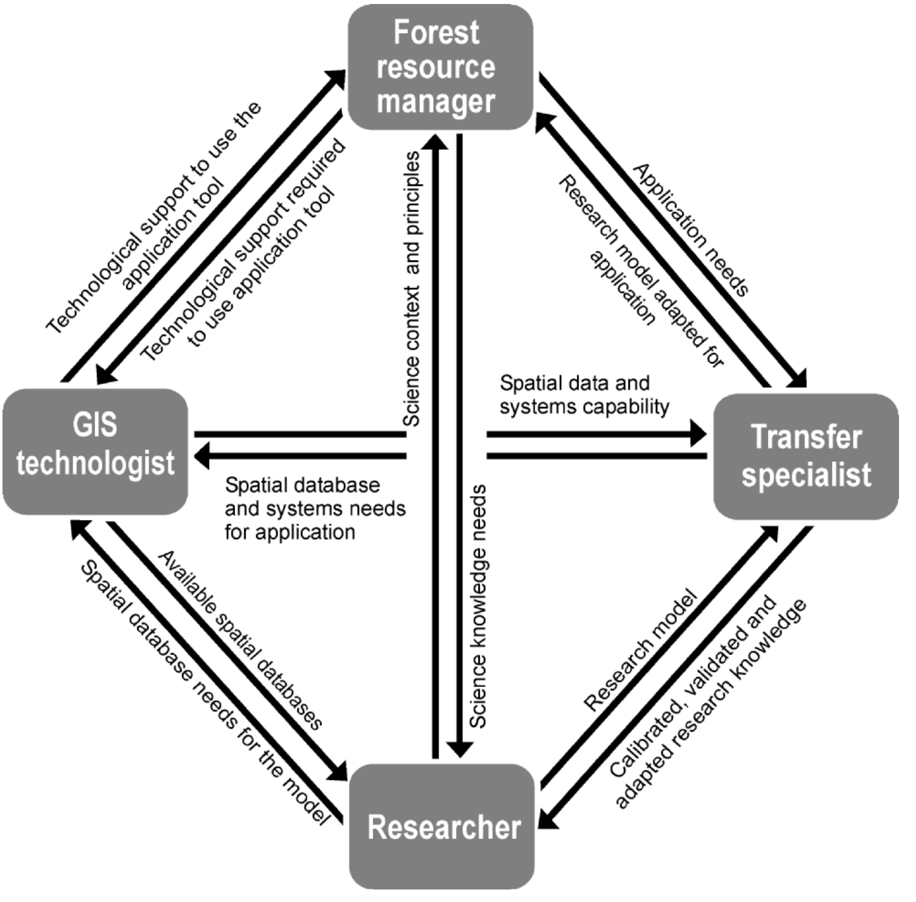

Figure 1.5. A hypothetical scenario in which a landscape ecological model is developed by researchers and converted into a locally adapted application with support from transfer specialists and GIS technologists to meet the needs of forest resource managers. Ideally, all participants engage and interact as a group, rather than in isolated pairs.

plex, and requires both local ecological expertise and GIS technological expertise that goes beyond the developer's understanding of user needs and the user's understanding of scientific principles. The participants are engaged in two-way communication and each plays a vital role in the process. (In practice, the engagements and communications may not occur in pairs: ideally, all participants engage and interact simultaneously as a group). We do not imply that transfer specialists and GIS specialists are absolutely necessary in all cases to transfer knowledge from developers to users; the developers may perform the additional role of transfer specialists and the users the role of GIS specialists.

1.3.2. Play an Active Role

As we noted above, many participants may take part in the process of transferring landscape ecology knowledge. However, a major share of the responsibility for making knowledge transfer an active process rests largely with the developers of knowledge, and they can take on this role by promoting the flow of knowledge between themselves and the users. We recognize three knowledge transfer approaches that account for differences in the role of the knowledge developers. The hypothetical model we presented earlier (Figure 1.4) can be modified to fit these approaches.

First is the supply-driven ("push") transfer approach, in which the developer initiates and powers the knowledge flow. For example, in relation to Figure 1.4, knowledge developers prime the flow of knowledge and drive the knowledge transfer process by proactively creating awareness and educating users. This is analogous to marketing of knowledge. The role landscape ecologists play in this approach must not be confused with environmental advocacy: rather than *advocating* research results and outcomes, the developer *creates awareness* of principles and opportunities. The goal is to make users aware of new scientific concepts, research findings, approaches, methods, and techniques by means that extend beyond publishing in peer-reviewed journals or presenting papers at scientific meetings. We contend that this approach is particularly necessary and effective for broader-level users in the hierarchy in Figure 1.3, who deal with longer-term issues at global, national, and regional scales. There are many examples of this approach in various aspects of ecology, in which scientists have successfully created awareness among legislators, policymakers, and resource managers. Examples such as the emergence of forest landscape management philosophies, including biodiversity conservation, emulating natural disturbance, conserving old-growth forests, and the adoption of practices such as the provision of wildlife corridors and forest patch interior can be attributed to supply-driven transfer.

Second is the demand-driven ("pull") transfer approach, in which users initiate knowledge flow. In relation to Figure 1.4, they prime the knowledge transfer process by recognizing the need for scientific answers to resource management problems. However, the participation of knowledge developers in this approach is no less important than their role in the supply-driven approach. It is analogous to suppliers responding to high demand in a specific market: Knowledge developers must recognize and respond to the specific needs of users, and must provide the necessary science-based solutions, sometimes by means of focused research to solve specific problems identified by the users. Our view is that demand-driven knowledge transfer is effective with users at finer levels of the hierarchy in Figure 1.3—those who plan and manage forest landscapes—mostly in the context of legislation, policies, and other established broader-level directions. Most examples of this transfer approach are models, tools, and decision-support systems developed to meet forest landscape planning or management needs. The popular use of strategic forest landscape planning and harvest-design tools, models of forest succession and disturbance dynamics, tools for assessing landscape patterns, and models of habitat supply and population dynamics can be attributed to demand-driven transfer.

The third approach is more balanced, in which the knowledge flow occurs as a result of both the push from developers and the pull from users—that is, as a result of both the supply of knowledge and demand for its use. This represents a collaborative and iterative approach (Fall et al. 2001, Ruhleder and Twidale 2000), in which the role of landscape ecologists is a continuous engagement in transfer and in developing successive iterations of a product to incorporate the experience and perspectives of everyone involved. The collaborative-iterative approach, in its ideal formation, does not fit the model in Figure 1.4 because there is little separation between developers and users, and no distinct push or pull to prime the process. Principles of adaptive learning, though discussed in the context of natural resource management institutions by Stankey et al. (2005), also may apply here, where knowledge exchange and learning are iterative. Presently, instances of this transfer approach are relatively rare because it (a) requires users to be relatively well versed in landscape ecology knowledge and familiar with the developers and (b) requires developers to be familiar with users and forest landscape management. However, with time, as the transfer process for forest landscape ecology knowledge matures, the collaborative-iterative transfer approach is likely to become increasingly popular.

If landscape ecological knowledge transfer is viewed in terms of an evolutionary process, then the supply-driven transfer approach can be viewed as the most primitive, where knowledge developers initiate the process by creating awareness of landscape ecology knowledge and its potential for applications among users. As landscape ecology knowledge transfer evolves, the user's increasing awareness of the knowledge creates a pull (a demand) for potential applications, leading to a stage in which transfer is initiated by user demand. Once started by either push or pull, the momentum of the transfer process could be driven and maintained by a combination of user demand and knowledge supply. In the final stage of evolution, when knowledge developers and users are mutually familiar with the knowledge and knowledge development capacity and with the applications and user needs, the transfer moves to a collaborative-iterative mode.

1.4. SUMMARY

Forest landscape ecology is maturing as a discipline and its knowledge base is rapidly expanding. A necessary next step is to ensure appropriate application of this accumulating knowledge in forest management. For this to occur, it is imperative that landscape ecologists become familiar with knowledge transfer, which is a process in which developers interact with users, and make them aware of the available knowledge and its appropriate use. As well, developers learn user needs, which promote discovery and iterative improvement of applications.

Knowledge transfer can occur in many different ways; no one standard method is universally suitable. Approaches effective for introducing new landscape ecological concepts may not work as well for encouraging the adoption of new technology. Regardless of the approach, it is evident that developers have an active and leading role in the process. Fulfilling this role requires an understanding of basic knowledge transfer concepts, principles, and practices and the willingness to engage with users.

Although successful transfer is an essential prerequisite, it alone cannot ensure that landscape ecological concepts are appropriately applied for a myriad of practical reasons. Still, the opportunity awaiting researchers to convey their findings to users for application is vast and timely. By considering knowledge transfer as an integral part of their activities, forest landscape ecologists have the opportunity to move their field of study from the abstract to an applied discipline.

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