United States
Department of
Agriculture

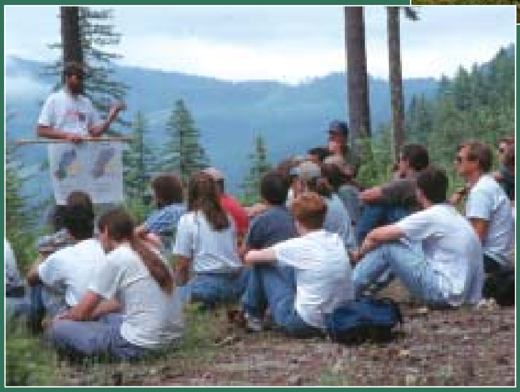
Forest Service

Pacific Northwest
Research Station

General Technical
Report
PNW-GTR-726

August 2007

Proceedings: International Conference on Transfer of Forest Science Knowledge and Technology



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Proceedings: International Conference on Transfer of Forest Science Knowledge and Technology

Cynthia Miner, Ruth Jacobs, Dennis Dykstra, and Becky Bittner, Editors

Troutdale, OR, USA, May 10–13, 2005

Sponsored by:

USDA Forest Service, Pacific Northwest Research Station
U.S. Geological Survey
Oregon State University
University of Washington
IUFRO Working Party 6.06.01—Technology Transfer
IUFRO Research Group 5.12—Sustainable Utilization of Forest Products

U.S. Department of Agriculture
Forest Service
Pacific Northwest Research Station
Portland, Oregon
General Technical Report PNW-GTR-726
August 2007

Abstract

Miner, Cynthia; Jacobs, Ruth; Dykstra, Dennis; Bittner, Becky, eds. 2007. Proceedings: international conference on transfer of forest science knowledge and technology. Gen. Tech. Rep. PNW-GTR-726. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 255 p.

This proceedings compiles papers presented by extensionists, natural resource specialists, scientists, technology transfer specialists, and others at an international conference that examined knowledge and technology transfer theories, methods, and case studies. Theory topics included adult education, applied science, extension, diffusion of innovations, social marketing, technology transfer, and others. Descriptions of methods and case studies collectively covered a wide range of current approaches that include combined digital media, engagement of users and communication specialists in the full cycle of research, integrated forestry applications, Internet-based systems, science writing, training, video conferencing, Web-based encyclopedias, and others. Innovations transferred were best management practices for water quality, forest reforestation practices, a land management system, portable timber bridges, reduced-impact logging, silvicultural practices, urban forestry, and many others. Innovation users included forest-land owners; land managers; logging industry; natural resource professionals; policymakers; public; rural and urban communities—and those in the interface between these two; and others. Technology transfer and related efforts took place in countries throughout the world.

Keywords: Technology transfer, communication, education, forest research, forest management, knowledge management.

Preface

Cynthia Miner[1]

In May 2005, about 100 people met in Troutdale, Oregon, to share information, perspectives, and insights about knowledge and technology transfer. They came from North America, Europe, South America, and Africa. Some were scientists, others professionals working to assure that new concepts, practices, and technologies developed by their institutions are used.

The conference was planned by the International Union of Forest Organization's (IUFRO) Working Party 6.06.01 (Technology Transfer), Research Group 5.12 (Sustainable Utilization of Forest Products), Oregon State University, University of Washington, USDA Forest Service, PNW Research Station, and U.S. Geological Survey. Without the combined efforts of these organizations, the conference would not have been possible.

The question posed by the planning committee was "How can we improve the ability of forest science organizations throughout the world to understand how to successfully influence the adoption of the innovations they generate?" This was an echo of two questions posed by G.H. Moeller and D.T. Seal when they held a conference of an IUFRO subject group established in 1981 to develop methods for the rapid worldwide dissemination and application of results of forestry research. At the conference of 1983 in Edinburgh, Scotland, they asked, "What can ***researchers and their organizations*** do to improve technology transfer in forestry?" and "What can ***research users and their organizations*** do to improve technology transfer in forestry?"

In the conference proceedings, Moeller and Seal[2] stated "Projections indicate that within the next 10 years, the volume of accumulated information will be four to seven times what it is today." The concern was that as the rate of knowledge accumulation increased, the gap of its application would lag. They described the need to increase efficiency through purposeful transfer from research to practice. They suggested this be done by leadership, personal and financial commitment, and creative management of resources by forest science organizations. The conference and the establishment of the working group in the early 1980s marked an increase and formalization of the intent of forest science organizations to assure application.

What has changed over the past two decades? The approach taken by the 1983 conference and the papers in its proceedings reflected a linear, assembly-line definition of technology transfer as a one-way process from producer to user. Many of the papers presented here describe a process very different from one-way transfer and use terms such as multiple channels, back-and-forth exchange, and personalization. And instead of a handoff to the user at the end of the research process, many papers describe the inclusion of users, customers, and community members throughout the research process and present concepts such as customer-relationship management, partnership, and integration. Several papers describe studies and efforts to improve understanding of the people who are potential users of new information.

The 2005 conference papers collectively show a shift from the 1983 view of anticipating information overload to development of systems and methods for managing and making information available through multiple channels. Electronic methods for sharing information have evolved quickly over the last decade so that applications are readily

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[2] Moeller, G.H.; Seal, D.T., eds. 1984. Proceedings of a IUFRO conference. Technology transfer in forestry. Forestry Commission Bulletin No. 61. London, England: Her Majesty's Stationary Office. 113 p.

available and are becoming easy to use. Moreover, managing information and knowledge requires understanding the process of transferring, diffusing, and applying it. Papers here describe related theories, methods, and case studies.

These papers show complex approaches to technology transfer are being developed, new state-of-the-art technology is being applied, and many programs and projects are underway at many institutions. These efforts are being funded by the organizations represented by the authors of these papers. As one author points out, organizations are being held to standards of accountability that require investment toward application of science—and technology transfer in its many forms is the effort to assure this happens.

If the current trends continue, we can anticipate that instead of becoming simpler, the field of technology transfer will become more dynamic and complex—the more we know, the more we realize we don't know. New trends, needs, issues, and people will require new approaches. Technology will continue to provide solutions and methods to help us manage this complexity. Traditional practices such as science writing and hardcopy formats are not going away and are key to assuring understanding of complex science information by broad audiences.

The past decade has seen declines in forest science investment across the world. Those of us working in the area of technology transfer have never had a greater calling to be successful. Critical at this time is working together in scientific study, endeavors to reach mutual users, and sharing knowledge among one another. This proceedings is intended to contribute in a helpful way to each of these aspirations.

Acknowledgments

The International Conference on Transfer of Forest Science Knowledge and Technology was made possible through the contributions of many people and organizations. Participating organizations included the International Union of Forest Research Organization's (IUFRO) Working Party 6.06.01 (Technology Transfer) and Research Group 5.12 (Sustainable Utilization of Forest Products), USDA Forest Service, U.S. Geological Survey, Oregon State University, University of Washington, and Weyerhauser Corporation. Planning committee members included Cynthia Miner, Jamie Barbour, Becky Bittner, Ruth Jacobs, Scott Reed, Larry Mason, Don Hanley, and Tom Wordell. Special thanks to Joe Holmberg and Nathalie Gitt at the Forestry Outreach Education Office, Oregon State University for their help in coordinating the conference, Gary Benson for organizing the poster session, and the Communications and Applications Program, PNW Research Station for their expertise in graphic and Web design. Thanks also to Kristine Cochrane, Charlie Crisafulli, Carolyn Driedger, and Dick Ford for sharing their knowledge of Mount St. Helens on the field trip held on the last day of the conference. And finally, thank you to all who provided thoughtful reviews of each paper and to the authors who revised their contributions based on those reviews. A few papers were rejected and have not been included in these proceedings as a result of the thorough review process.

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From a Social Marketing Perspective: A Proposed Customer Relationship Management Technology Transfer Model

Delton Alderman,[1] Kent Nakamoto,[2] and David Brinberg[3]

Abstract

Technology and knowledge transfer (TKT) is practiced for a plethora of causes, ranging from AIDS prevention to manufacturing competitiveness. The number of government, university, and association TKT efforts is exhausting and fraught with problems; we know anecdotally that the adoption of technology or knowledge is minimal across all contexts. There are a myriad of reasons as to why this phenomenon (i.e., minimal adoption of technology or knowledge) exists, and it is beyond our scope to elucidate on the causes of low-adoption; rather, our intent is to present a theory of TKT based on personalization.

Our personalized TKT model draws from economic, sociology, and social psychology theory constructs, which are couched in the customer relationship management concept. Specifically, we utilize transaction cost economics, social exchange theory, and the constructs of perceived risk and trust to develop a personalized TKT model. We believe that for TKT efforts to be successful, a customer-based approach should be employed rather than the traditional, top-down hierarchical method. One of our objectives is to create a salient "shortcut" in the customer's cognitive schema; whereby a relationship is formed and customers look to TKT providers first for knowledge and/or technology.

Finally, we introduce personalization as a construct. Personalization can be measured and, more importantly, implemented in many forms. For instance, it may include customizing materials, delivery methods, or both; one-to-one interactions including at intermediary sites; or transfer and subsequent adoption may be a function of visit frequency. Traditional TKT approaches are primarily top down (i.e., hierarchal); our premise is that personalizing TKT, a bottom-up market-driven (i.e., tailored) tactical approach, may ameliorate risk for risk-averse actors and augment trust among TKT providers and ultimately the adoption of technology, knowledge, or both. The ultimate value of personalization is beneficial because personalization can hasten adoption of TKT. Exploration of the impact of personalization also can help us to understand the mechanisms that affect the success of TKT and ultimately the adoption of technology or knowledge.

Keywords: Social marketing, trust, perceived risk, customer relationship marketing, and personalization.

Introduction

Technology and knowledge transfer (TKT) is practiced for a plethora of causes, ranging from AIDS prevention to manufacturing competitiveness. The number of government, university, and association TKT efforts is exhausting and fraught with problems; we know anecdotally that the adoption of technology or knowledge is minimal across all contexts. The reality of TKT rarely lives up to expectations or perceptions of its potential,

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even when competitive emulation is not a serious threat (Galbraith 1990, Gupta et al. 2000, Ruggles 1998). There are a myriad of reasons as to why this phenomenon (i.e., minimal adoption of technology or knowledge) exists, and it is beyond our scope to elucidate the causes of low adoption.

Traditional views of innovation adoption focus on organizational demographics and innovation characteristics as being the primary predictors of adoption (Rogers 1995). Technology and knowledge transfer assets are fundamental sources of competitive advantage in open economies; consequently the long-term prosperity of firms operating in open economies is increasingly predicated on their ability to identify technology and knowledge assets and to properly exploit them before they are emulated by competitors (Argote and Ingram 2000, Eisenhardt and Martin 2000). Clearly, one goal of TKT is to foster competitiveness and sustainability.

Customer preferences can be revealed by fostering a learning relationship as personalization concentrates on providing services or products to one customer at a time by identifying and then satisfying their individual needs. Personalization then aspires to repeat this several times with each customer, so that enduring relationships are developed (Peppers and Rogers 1997). Taylor (1998) reported that a service-type relationship with customers has benefited many businesses. Hence, appreciation of the human component guides us from myopic actions, rather than perceiving of TKT as only an exchange from point "A" to point "B." To be more precise, consider transfer as an interactive process with back-and-forth exchange between you and your customer for an extended period (Gibson and Smilor 1991).

Social Marketing

Kotler and Zaltman (1971) originally defined social marketing (SM) as "…the design, implementation and control of programs calculated to influence the acceptability of social ideas and involving consideration of product planning, pricing, communication, distribution and marketing research." Another useful characterization is, "…the planning and implementation of programs *designed to bring about change* using concepts from traditional marketing" (Social Marketing Institute 2005). Shrum et al. 1994 operationalized the SM four-P's as: **product**—what is being offered to the target consumer; **price**—the cost(s) of employing the technology; **promotion**—integrated communication using different strategies and channels to reach the target audience; and **place** (distribution) defined in two different manners, both of which are relevant to us: (1) the means to accomplish a given behavior (i.e., where the actor participates) and (2) providing adequate and compatible response channels for our customers. A proposed fifth-P also may be relevant: **positioning**, which "involves the location of the product relative to other products and activities with which it competes" (Alcalay and Bell 2000).

Customer Relationship Management

The American Marketing Association (2005) defined customer relationship management (CRM) as seeking to create more meaningful one-on-one communications with the customer via customization (i.e., the tailoring of a product to the special and unique needs of the customer). However, this is rather ascetic; Gummesson (1998) proffered CRM as an association requiring a long-term view, one of mutual respect, and "…the acceptance of the customer as a partner and coproducer of value and not just a passive recipient...". We agree with this conceptualization; as TKT providers we should strive to understand not only the characteristics of the customer, but of how the technology or knowledge "fits" and its potential "effects" on our customers.

With "fit" and "effect" in mind, our view also includes **transaction cost economics**, expenditures that determine transaction viability. Expenditures include the costs associated with intermediate governance structures (IGSs) (Parkhe 1993) such as alliances, the stability or longevity of relationships, and commitment of the actors involved. The IGSs are used to form long-term relationships and include transaction-specific assets (TSAs)—assets that have little or minimal value outside of the exchange relationship (Williamson 1985). These assets include specialized training, experience, and with regards to personalized TKT, source credibility, predictability (i.e., consistency of relationship), dependability (i.e., is it in the client's best interest?), and longevity (i.e., length of relationship). Actors invest in TSAs for three reasons: (1) efficiency and effectiveness, (2) to signal honorable intentions for the relationship, and (3) as a requirement of exchange (Brown et al. 2000).

Social exchange theory affords us the opportunity to expand TSAs and suggests that two discrete constructs are influential in understanding relationships among partners: (1) **Trust** between the partners has a positive impact on the long-term relationship, particularly when environmental forces predicate changes and (2) **dependence** on a partner is important in influencing the longevity of the exchange relationship. Trust also has been found to affect the adoption of new technologies (Fukuyama 1995). We also believe that **perceived risk** must be recognized, as it is a driver of the antecedents of trust and trust also moderates some antecedents of perceived risk.

Trust (fig. 1) has several definitions. Here we use Moorman et al.'s (1992), "the willingness to rely on the exchange partner in whom one has confidence" and Dodgson's (1993), "trust is one's disposition, an expectation held by one partner about another that they will behave in an acceptable manner." Zaltman and Moorman's (1988) research indicated that personal trust is potentially the most vital behavioral factor affecting the use of knowledge. According to them, trust is important to knowledge utilization because it ameliorates

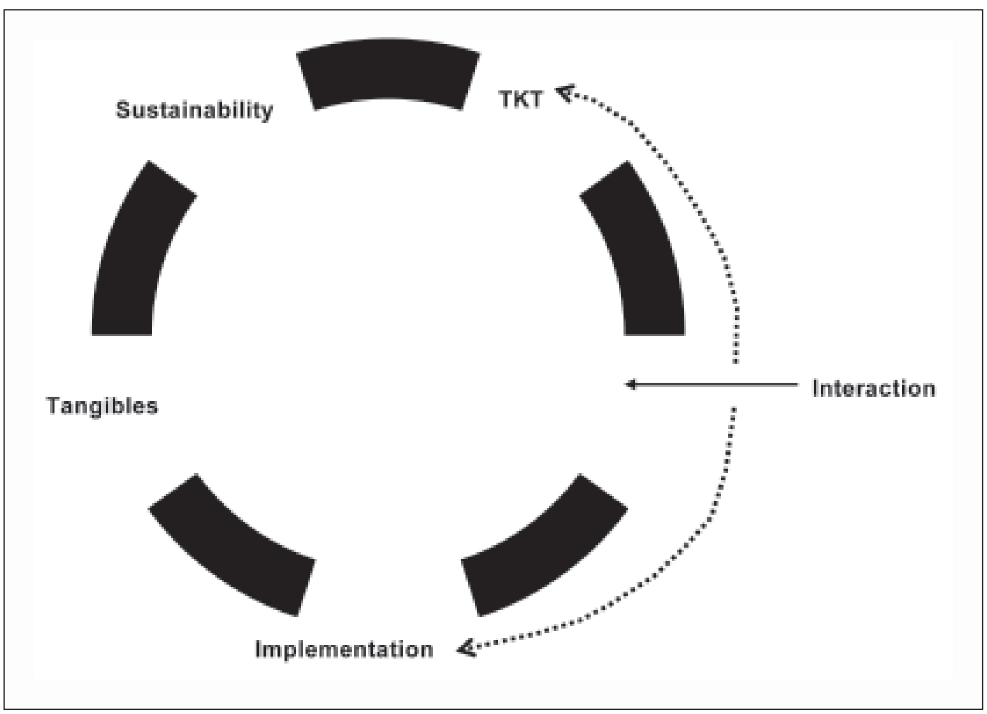

Figure 1—Customized customer relationship management—technology and knowledge transfer (TKT) Model.

perceived uncertainty and consequently perceived vulnerability. Ultimately, trust implies a willingness to accept vulnerability, with the expectation and confidence that an actor can rely on the other party. Trust can change over time, evolving through stages of development, augmentation, and decay (Fukuyama 1995, Rousseau et al. 1998). In our proposed model, antecedents (note that there can be additional antecedents) of trust include (1) source credibility—can include both the transfer source and TKT attributes and assets; however, our emphasis is on the source; (2) dependability—is it in the client's best interest; is the transfer source dependable? (3) predictability—consistency of the relationship; and (4) longevity—length of relationship; Will the TKT provider be there during the long haul?

Perceived risk (fig. 2) is typically defined in a consumer context as perceptions of uncertainty and the adverse consequences of buying a product or service (i.e., an implicit assumption is that the probability and outcome of the product purchase are uncertain) (Dowling and Staelin 1994). In a TKT context, this is transitive, where trust is defined as the "uncertainty and disadvantageous consequences of adopting a technology or knowledge." In our model, perceived risk has four antecedents (again, note that there can be additional antecedents) that can result in desirable or undesirable

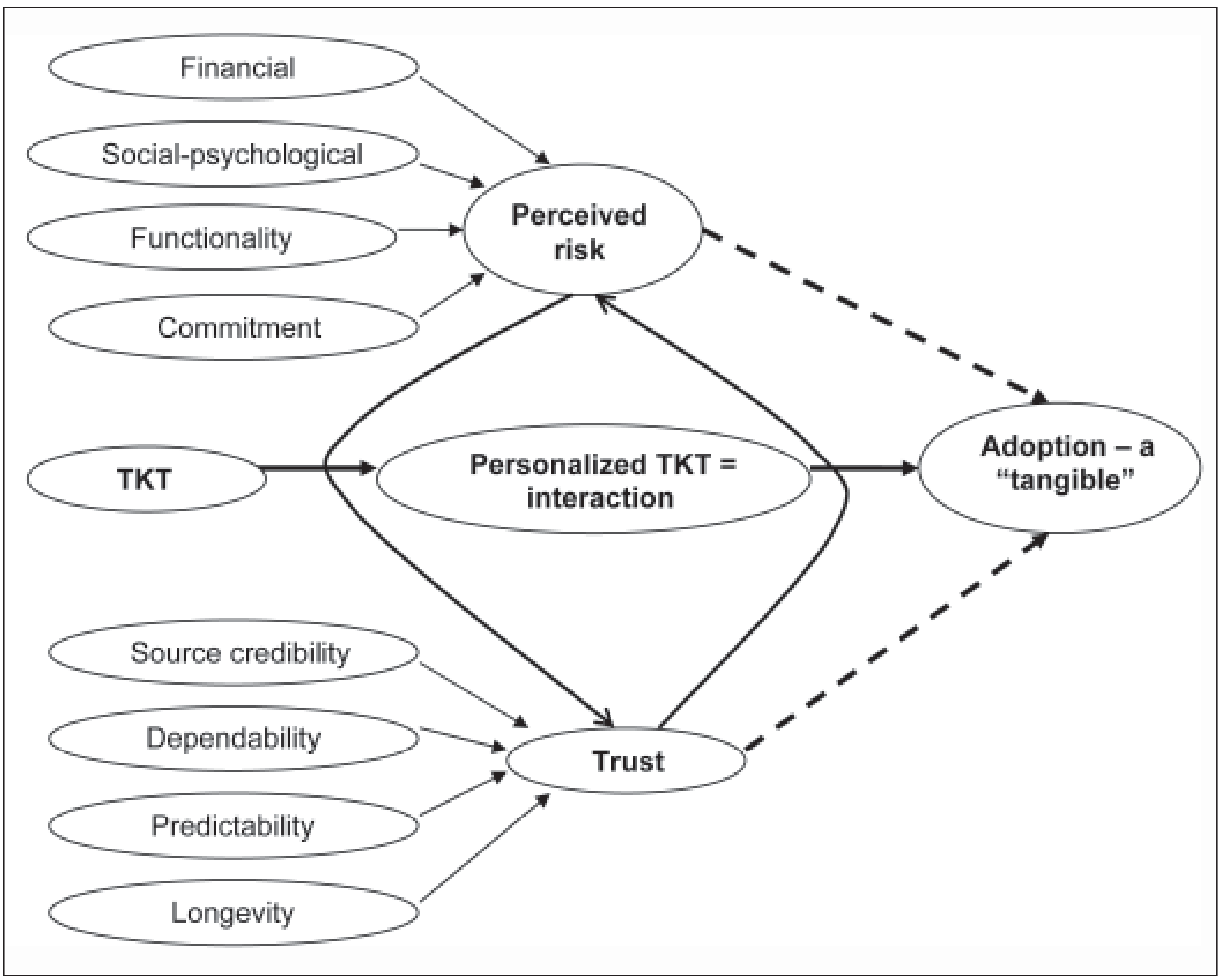

Figure 2—Personalized interaction-technology and knowledge transfer (TKT) constructs.

consequences for our customers: (1) **financial**—does the risk reward outweigh the actual costs or potential deleterious effects; (2) **social-psychological**—social norms, technology anxiety (substantial levels may lead to TKT avoidance), or need for interaction (substantial levels may decrease the need or the desire to try or learn) (Meuter et al. 2005); (3) **functionality**—is this TKT going to work? and (4) **commitment**—both personal and from the TKT provider. As TKT providers, we must recognize that the more revolutionary the technology, the greater the incumbent risks of TKT adoption.

Trust and perceived risk must be addressed if we are to improve exchange relationships and ultimately the adoption of technology or knowledge. Perceived risk may moderate and at the very least mediate trust. For example, the financial and functionality antecedents of perceived risk might directly influence trust (fig. 2). Specifically, increased (and most probably unacceptable) risk perceptions regarding financial costs and of perceived functionality (i.e., it will not work) might lead the customer to have low levels of trust for both the TKT and the transfer source. Conversely, a perception of overall trust in the TKT provider may possibly decrease the perceived risk of the TKT.

There are other factors that affect adoption; some were previously discussed and are not included in the following discourse. We present these for thought and as assessment items. First, TKT **innovation characteristics**: compatibility, relative advantage, complexity, observability, and trialability; secondly, **individual differences** in our customers: inertia (may limit efforts to learn) and previous experience (experienced users may be more likely to try), and customer demographics. Finally, **customer readiness** includes motivation (extrinsic—motivated by self-interests; intrinsic—trying new things or feelings of accomplishment) and ability (having necessary skills and confidence) (Meuter et al. 2005). An understanding of the actor's worldview affords us the opportunity to "position" TKT in order to maximize the perceived benefits and minimize the perceived costs.

Personalization

Personalization or "markets of one" is the premise of our model. The personalization types of TKT developed for each customer "moderates" the TKT process, and by personal tailoring we envision trust levels increasing and perceived risks to be ameliorated. The TKT provider's value-added goals should include developing long-term relationships with our customer, customer satisfaction, and adoption of TKT by our customers at some level. This also will necessitate a behavioral change in us, the TKT provider, as it includes an implicit disposition that the customer is a copartner and a coproducer of value.

Personalization includes the following (and more): inquisitive and active listening personnel, the means and methods by which our customers acquire and use TKT, and accordingly, a personalization of the TKT delivery mechanism—making it unique for each individual consumer. At the crux of personalization is the nontrivial action employed to achieve personalization with our customers: **discerning** the consumer's preference for "who" delivers the TKT, what types of TKT they are interested in, and *"how"* they prefer for TKT to be delivered. Is TKT delivered via mail, personal interactions (in-house), webcasts, virtual simulations, site visits (in-place), or company representatives, etc.? Personalization, in the form of individually tailored marketing communications, should be more effective than mass communication efforts (Peppers and Rogers 1993).

At the core of personalization is genuine discourse with our customers to gain their input before, during, and after TKT delivery. Without their essential information and partnering, we believe that most forms of TKT will fail to be adopted, including personalization-based efforts. We are striving for an exchange model of communication, a heterarchical relationship, with an egalitarian connotation. That is, we do not speak with our customers as strangers; rather, we speak to our customers as with our close friends. In this manner, we are exchanging communication, we are exchanging information, and we are not giving a lecture—a transmission model of exchange. While this appears to be intuitive, it is not. We must always be cognizant of the fact that transfer processes that work for one customer may not be applicable to others. The ultimate value of personalization is that it is beneficial because individual tailoring can hasten the adoption of TKT; exploring the impact of personalization also can help us understand the mechanisms that affect the adoption of TKT.

Customer Relationship Management Implementation

The model is very simple (fig. 1); initially the TKT product is conceived by us or others and relationships are developed. The "interaction" phase is next, this is where our market research should be employed, as the personalization of the TKT process should afford us the knowledge and ability to successfully deliver the product to our customer. Next, is the implementation of the TKT by our client, which is a tangible TKT adoption. Finally, as this is envisioned as an iterative process, our continual interaction with our customers should result in a sustainable relationship with the customer—a "Win-Win" for all.

Conclusion

Every customer and organization has its own goals and culture; there is not a single TKT or TKT process that will "fit" all occasions and customers. This knowledge "opens the door" for us to develop and improve TKT delivery methods. Our argument is that developing personalized TKT results in understanding our customers at the most critical and basic levels. We gain knowledge of their concerns and develop long-term relationships, which should, in turn, foster trust in us. Finally, our customers adopt TKT that allows them to successfully compete in open economies.

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Getting Technology Into Practice: Using Pre- and Posttraining Activities

Ralph R. Johnson[1] and Gary E. Dixon[2]

Abstract

The traditional methods of transferring knowledge and technology are publication in journals, symposia, and field trips. Transfer of knowledge and technology is not complete until the receiver accepts and applies the material, or rejects it as inappropriate or inaccurate. In this presentation, theories of adult learning and technology are reviewed and applied to forest science. Emphasized in this presentation are the importance of application by peers and the relevance of the new knowledge and technology to job-related problems. Examples will be presented for the Forest Vegetation Simulator, which illustrates multiple methods of technology transfer.

Keywords: Technology transfer, adult education, vegetation simulation.

Introduction

Innovators of new information and technologies use various techniques to get their products into use. Frequently, the technology transfer process either fails or takes longer than desired. Understanding some key concepts behind adult learning and technology transfer theory can help explain possible reasons behind technology transfer successes and failures. In this symposium you are likely to hear many stories about successful technology transfer. Perhaps you can relate some of the concepts discussed in this paper to those stories to help explain why those technology transfer efforts were a success. A better understanding of these theories can also shed light on why "one shot" technology transfer efforts are often not successful.

Adult Education

Successful technology transfer has a strong adult education component. Individuals involved in technology transfer need to be informed of new adult education theories sufficiently so they truly understand what is involved and how they might benefit. Knowles (1990) suggested a series of characteristics that need to be considered when teaching adults. These may seem like common sense, but they are often overlooked when designing a technology transfer program. Knowles spelled out the following:

- Adults have a general need to be self-directing.
- People have an ever-increasing base of experience, which they should use in making meaning of the new topic they are learning.
- People are ready to learn when they have a need to learn.
- Education is viewed as a process to be more competent.
- Adults are motivated to learn by intrinsic factors.
- Adults need to know why the technology may be useful to them.

If you're promoting a new product or idea, addressing the above characteristics can factor into your marketing. In the area of forest yield projections, the 1960s and 1970s foresters had a wealth of experience using published yield tables. For the Pacific Northwest, the classic

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publication was Bulletin 201 (McArdle 1961). When the first computerized yield processors like DFSIM (Curtis et al. 1981) were produced, users of this technology had personal experiences, either in school or on the job, in the use of the published yield tables. Getting potential users to implement this new technology into practice was most successful with those who had the most to gain. Perhaps their experiences indicated that paper methods took too long and did not allow for sufficient complexity. At any rate, there was a motivating reason for potential users to try the new technology.

If your technology transfer methodology has traditionally consisted of training sessions, literature reviews indicate successful long-term change is generally poor (Baldwin and Ford 1988). In studies where training was successful, the trainees personally valued the training, attended on their own initiative, had precourse discussions about the training, or there was a favorable organizational climate back at the job site for implementation. So again the trainees were motivated to try the new technology.

Technology Transfer

One of the classic references in technology transfer science is that of Rogers (2003). He suggested there are classes of innovators as follows:

- Innovators
- Early adopters
- Early majority
- Late majority
- Laggards

We liken these to personality types but tempered by the application. If you're really excited about something, you might be an innovator; if you're cautious you might be an early adopter, trying the technology only after some of the innovators have tried it and succeeded; if you are a pessimist you might be a late majority, trying the technology only after it is in common use elsewhere; if you are apathetic, you might be a laggard. In short, there is a connection between a personality type and the kind of innovator you are for a specific technology transfer activity. But, a concept that Rogers' presents that is equally related to the adoption of innovations is something he refers to as phases of adoption. These are:

- Knowledge
- Persuasion
- Decision
- Implementation
- Confirmation

Many, if not most, technology transfer programs stop at the persuasion stage. For example, the typical technology transfer consists of a short workshop on a Saturday, a flyer distributed in the mail, or an article in a magazine. The real work in technology transfer is getting people to decide to use your new technology or information and implement it. Moving from persuasion to confirmation may take many steps such as field days, visits to peer professionals, or more training even if there is a commitment to implement. The confirmation step may seem unnecessary to the person passing on the technology. However, this step can provide valuable feedback to the developer. Users might adapt part, all, or modify your idea to make it work in their situation. In some instances they may choose to reject it as inappropriate or decide it is no better than what they are currently doing. All of these things would be valuable for you to know.

Although Rogers' work forms the core of many technology transfer activities, the real world presents complexities. Stock and Tatikonda (2000) present the idea of complexity and maturity of concept. Stock and Tatikonda refer to complexity, novelty, and tacitness as the metrics to describe complexity and maturity. These ideas are especially true for new software. Think of the differences between the purchase of a new upgrade to your Windows© operating system or your first venture into forestry cruising software. Or, how often have you installed the newly upgraded version of a software product, only to find bugs; or worse, the new version breaks something that was previously working fine. In Stock and Tatikonda's view, highly complex and immature products need a different kind of technology transfer effort. Rarely would a journal article or symposium suffice for getting ideas into practice for complex items.

Stock and Tatikonda described four technology process types. These are:

- Arms-length purchase
- Facilitated purchase
- Collaborative handoff
- Codevelopment

Suggested Models for Application and Examples

Terez (2003) made some positive suggestions for implementing research findings in adult education and technology transfer. He stated:

> Perhaps there's some worthwhile prep work that attendees can do—a simple assignment that requires them to get input from their colleagues. This is a great way to heighten interest. During the session, participants can work with the information. And in a post-session assignment, they can report the findings at a staff meeting, using the opportunity to share ideas and get people involved in next steps.

A useful learning model that has wonderful application to the field of technology transfer is that of peer learning. As the name implies, individuals learn from their peers. It's the old "two heads are better than one" in action. Plus, for the cautious or pessimistic types, there is comfort in company, when applying new technologies.

Early technology transfer theorists studied the transfer of hybrid seed corn from new product to implementation. Once the bulk of the corn producers could see for themselves how the new seed worked, they were more likely to try it themselves. Farmers observed their neighbor's fields planted with the new hybrid seed. Noting that it seemed to work, they tried a small plot on their farm. Note that very few people converted their whole operation over to the new seed. Once they were convinced it was better by doing it themselves, then they converted. You can expect similar results getting your technologies adopted. Ottoson (1994) summarized the actions you might take to increase the likelihood that your technology transfer efforts will be successful (fig. 1). This work was targeted at continuing education of professionals, and it has direct application of technology transfer activities.

Our experiences with numerous technology transfer activities, lead us to make a strong recommendation that there are advantages to having a technically competent third party actually engage in the transfer activities. We have often seen the need to "de-jargon" publications to make them understandable to the potential user group. Although innovators might like technical descriptions, other groups may find this step unnecessary. In production applications of new technology, this third party also serves to note technical deficiencies and suggest solutions to the developer. Users might be more likely to give honest feedback to a third party.

Examples of Technology Transfer Using the Forest Vegetation Simulator

The Forest Vegetation Simulator (FVS) (Dixon 2002) is a collection of computer modules that assist forest land managers looking at alternative management scenarios. The staff supporting FVS designed their technology transfer efforts around the adult education and technology transfer ideas noted above. In addition, various forest scientists have embedded highly complex concepts into the FVS system.

This is an example of the basic technology being developed by one group, Forest Service research, and implemented by a third party specializing in technology transfer. The staff supporting FVS was recognized with the Chief's award for excellence in technology transfer in

Strategies to facilitate the transfer of learning before, during, and after adult education programs

	Before	During	After
EDUCATOR	• Don't assume transfer. • Plan with learner and sponsor. • Understand reason for participation. • Identify "what" is to transfer. • Understand application context. • Include transfer component in program design. • Market program with transfer intent. • Negotiate meaning of transfer success.	• Link general principles to real world examples. • Explore relevance, advantages, and feasibility of "what" is to transfer. • Use methods that enhance transfer: practice, feedback, discussion, and critical reflection. • Honor learner plan for barriers to transfer. • Help learner plan for barriers to transfer. • Provide materials to aid transfer. • Suggest transfer resources.	• Provide followup assistance. • Link learners with each other. • Link learners with educator. • Evaluate transfer process and effect. • Use evaluation results in future planning.
LEARNER	• Clarify "what" is to transfer. • Reflect in expectation of self and others for transfer. • Clarify transfer-related reasons for participation. • Translate application context to planners. • Help define what constitutes transfer success.	• Actively participate in learning. • Link educational experience to own application context. • Explore potential to adapt "what" is to transfer. • Critically reflect on transfer process. • Anticipate supports and barriers to transfer. • Develop transfer plan.	• Look for opportunities to transfer. • Implement transfer plan. • Adapt "what" transferred to context. • Use transfer resources. • Seek support for transfer. • Provide evaluation feedback on transfer process and effects.
SPONSOR	• Support learner preparation for educational program. • Participate in program planning. • Help identify "what" is to transfer. • Endorse "what" is to transfer. • Help define what constitutes transfer success.	• Anticipate learner's return. • Identify transfer facilitator. • Participate in development of transfer plan.	• Seek learner feedback on educational experience. • Facilitate implementation of transfer plan. • Provide required resources • Support learner. • Provide opportunity for transfer • Provide learner with coach or mentor. • Participate in evaluation of transfer success.

Figure 1—Strategies to facilitate the transfer of learning before, during, and after adult education programs. (source: Ottoson 1994)

1991 and 1993, and the Secretary of Agriculture Superior Service Award in 2001. The success of the FVS program in technology transfer lends credence to the ideas presented above.

Training Sessions

Forest Vegetation Simulator instructors are encouraged to:

- Learn about their students prior to the training session.
- Adapt course content to meet the needs of the students.
- Use relevant examples in the course.
- Relate course topics to students problems.
- Allow time for students to reflect on content and suggest application.
- Make themselves available before and after sessions for assistance.
- Use teaching methods that link peers in small groups.

Students are encouraged to:

- Bring a work-related problem with them.
- Apply the concepts shortly on returning to work.
- Make peer contacts for help in postsession activities.
- Ask the instructor to adapt course content to their specific problems.

Embedding Highly Complex Technology

As noted by Stock and Tatikonda, complex technology requires special efforts. In forest mensuration, there has been a transition from direct volume estimators to stem profile models to calculate tree volumes. Recently, the Inland Northwest Growth and Yield Cooperative developed a full suite of taper models for commercial conifer species. There is really little need for field foresters to understand the mathematical equations, and it would be extremely difficult for most individuals to do the math. The resulting equations may be more accurate than those they are currently using, but they might reject the project because it is far more difficult to use and understand than what they are currently doing. The staff supporting FVS embedded the models into the FVS modeling system that many field foresters already understand. To the FVS user, the transfer of taper function technology was simple and transparent, even though the taper technology itself is very complex.

Transferring Evolving Technology

The Joint Fire Sciences Program recently produced an extension to FVS for use in assessing the impact of fire on forest management actions. The initial computer code, although “tested” for bugs, had not been used in production situations. It is also an example of developers planning from the beginning to use a third party for technology transfer. With this technology, the FVS staff took its technical support staff out to field sites. Working with resource professionals, the technical experts assisted with the technology transfer operation. When bugs surfaced, the FVS staff worked with the developers to find solutions. Even for field staff, who Rogers would have labeled innovators, the likelihood of moving from knowledge to implementation would have been small without this technology transfer effort.

Based on my experiences with FVS in the technology transfer field, we would add a recommendation for developers of complex and unstable technologies to work closely with the technology innovators throughout the development process. In the event things do not work out, development can be modified, or in extreme cases halted, and there won’t be a sour taste with the broader set of users. Innovators are happy to assist in this role and are not adversely affected when things do not go as planned.

Parting Comments

We hope you consider the following after you leave this conference:

- When using training sessions to pass on your technologies, keep the topics relevant to the students.

- When you have complex technologies, start first by passing them on to the innovators. Don't stop until the early adopters have bought in. Then peer interaction will help with the transfer.
- When you have complex technologies, use an intermediary to assist the transfer.
- When you have complex technologies, find existing processes to embed them in (making for a transparent transfer).
- Remember most potential recipients have a process they are already using. What you are offering has to be better, faster, or easier.
- Technology transfer will be much easier if the recipients are in need of your technology.
- Each evening of this conference review your notes and the abstracts to reinforce the material presented.
- Within 1 week of leaving this conference, review the abstracts and your notes and plan how you will apply at least one concept presented.

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Applied Science and Technology Transfer for Avoided Costs and Protected Forest Values

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Abstract

Applied science and technology transfer in support of healthy forests and rural communities includes more than the training of individuals to use the latest equipment or software products. Success will ultimately be measured not in user adoption statistics but in the degree to which forest practices and public expectations are aligned over the long term. Public expectations are focused on many nonmarket values like clean air, water, and habitat protection. Therefore, those in the business of forest science and technology transfer assume certain responsibilities for providing the best scientific information available in a form that supports the empowerment of interested publics, professionals, and policymakers to achieve the greatest good. First, we must contribute to the development of a common understanding of the present circumstances. Secondly, we must assist with knowledge and tools needed to develop decision-support systems at appropriate scales of temporal and spatial complexity. A successful society must be served by scientific knowledge, understanding, and predictive ability such that informed decisions can be made that evaluate alternatives and tradeoffs.[4] In this paper, we will present a sample of nonmarket valuation methods for forest and forest product attributes as examples of how interdisciplinary applied science and technology is critical both to the valuation process and the decision-support context. The goal is to demonstrate how technology can be used to help analyze the complexities of management choices associated with the sustainable management of multiple values.

Keywords: Forestry technology transfer, applied science, nonmarket values, avoided costs, environmental services, cost/benefit analysis, forest fires, sustainability.

The Importance of Understanding Values Created by Forest Management

Forests provide a number of market and nonmarket values that benefit both consumers and the general public. Market benefits include products and services that can be bought and sold, such as timber and nontimber forest products. These market benefits are determined by public demand and can be relatively easily assessed for comparable value by using existing market price data. Nonmarket benefits include essential environmental services such as clean air and water, carbon sequestration, aesthetics, habitat, biodiversity protection, fire avoidance, and others.

However, pricing nonmarket benefits and services supplied by forests, although very much in public demand, can be problematic owing to their nontraded nature. Nonetheless, nonmarket values can be quite high as evidenced by policies to protect nontraded resources such as air, water, and wildlife habitat. Integrating the benefits of nonmarket values and market values inevitably changes the definition and selection of best management practices.

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[4] Kimmins et al. 2005, Guldin et al. 2005

For example, if the avoided cost of fighting fires were available in the market as an offset to the cost of removing overly dense ladder fuels, more fire-prone forests would be thinned thus reducing fire risk while also contributing to the public understanding and support for such investments (Mason et al. 2006). Providing incentives to produce forest aesthetic and biodiversity attributes that the public values would motivate different management pathways other than short rotations (Lippke et al. 1999). Constructing buildings to the public's high environmental standards would require different product purchases and processing investments; in many cases, wood products would be selected for having higher overall environmental performance (Lippke et al. 2004).

This paper examines several areas where nonmarket values are important and discusses public demand for such benefits and services with the objective of revealing the importance of these values in decisionmaking and the critical integration role for applied science and technology transfer.

What Do Markets Pay For?

It is generally understood that markets facilitate the buying and selling of goods and services at market-established prices. Members of the public are well acquainted with supply and demand. Schumpeter (1954) told us that market signals or "positive" economics explain relative value by establishing price. Market goods from forests include timber and fiber used for building products, paper, cardboard, industrial chemicals, and biofuel for renewable energy products. Nontimber products such as natural foods and flora as well as recreational amenities derived from the forest may also be bought and sold for commercial purposes. In addition to direct production costs, prices established for timber and nontimber products should include all other ancillary costs associated with ownership and management incurred as a result of regulatory compliance, liability risk avoidance, or other factors. For example, modern forest management costs might include insurance to reduce the risk of damage as a result of litigation in courts or additional staffing with relevant expertise to reduce the risk of (perceived or real) negative impacts on surrounding neighbors or the public. Another example might be higher costs associated with alternative, lower impact harvesting practices or forest certification audits. In the market, cost/benefit relationships are dynamic. When factors of production fail to earn marginal profit, the product ceases to be made available. Conversely, if demand (i.e., market price) increases then so does the quantity of products supplied.

What Do Markets Not Pay For?

Forest product prices do not include the value of the numerous public benefits that forests provide such as clean air and water, habitat protection and biodiversity, recreation and aesthetics. Nor do they include the benefits derived from avoiding the high public cost of forest fires associated with fire suppression, fatalities, habitat and facility destruction, and postfire restoration. Forests are often managed to provide opportunities for recreational activities and public enjoyment of forest aesthetics and scenic beauty that (aside from nominal user fees) may not be captured as market prices reflective of intrinsic value (Garber-Yonts et al. 2004, Laband 2003, Pagiola et al. 2004). Life cycle analysis has shown that products made of wood are renewable and are more environmentally-friendly than building products such as steel studs or concrete walls (Lippke et al. 2004); however, the market currently delivers no premium for this environmental contribution, which is also generally not revealed to the public. Such forest "products" are not sold through organized markets, yet there is strong public demand for their environmental attributes. Schumpeter (1954) told us that such deliverables fall into the realm of "welfare" economics, which prescribe rather than explain value. As the complexity and disagreement surrounding forest management (especially on public lands) increases, it is apparent that better agreement on valuation methodologies and cost/benefit relationships that include a broad view of public values could be helpful.

Recognizing Avoided Costs of Fire Suppression as Public Value

Although “welfare” economics may not be explained by market prices, there are nonetheless real costs associated. Suppression of forest fires, for example, can be quite expensive. Added to risk to public resources are forest fire threats to human life, wildlife, and habitat. It has been shown that there is a public willingness to pay (WTP) for fire hazard reduction (Winter and Fried 2001), yet no value for fire hazard reduction has been adopted into the market even though there are readily available cost estimates for at least some of the costs that result from not reducing fire risk. It is estimated that for the period 1999 through 2002, the average cost of firefighting for the Washington State Department of Natural Resources was approximately $2,000 per acre (Washington State DNR 2004). A study of federal forests in Washington and Oregon found the average cost of fire suppression for the Forest Service to be over $1,000 per acre (Mason et al. 2003). The severity and incidence of fighting fires can be reduced by management treatments (Rummer et al. 2002), yet associated avoided costs are not included in cost/benefit analysis of investments in fuel reduction treatments. Better understanding of such relationships could lead to healthier forests and public savings with applied science and technology transfer as the critical agents to produce the required information. The valuation of fire risk reduction is developed here as an example that can be extended to other nonmarket value benefits.

Nonmarket Benefits of Reduced Fire Risk

Removal of small-diameter trees to reduce hazardous fuel conditions is known to be costly. Large trees can be removed for their lumber and other product values as reflected in the market; however, the market value for smaller logs is often less than the harvest and hauling charges. As a tradeoff, failure to remove small-diameter trees results in the retention of fuels that support the transfer of ground fire to crown fire and aggravate negative wildfire impacts to the landscape (Omi and Martinson 2002, Peterson et al. 2005). Unfortunately, the market does not automatically reflect the value of negative environmental consequences that result from crown fires. If the negative impacts that result from crown fires were fully reflected in the market, there would be much higher motivation to avoid them, providing the necessary incentive to remove high fuel loads in spite of the cost.

Land management decisions aimed at reducing the risk of fire can have a high benefit-to-cost ratio, if all market and nonmarket costs and benefits are included. First, the cost of fighting fire could and should be considered a cost of not removing high fuel loads. Mason et al. 2003 developed a parametric approach to assist interested publics and policymakers in quick estimation of relative costs and benefits associated with fuel reduction treatments. A look-up table was developed to estimate the present value of avoided future costs at an assumed discount rate. The independent variable is time-to-fire. With this table, users can estimate costs for a particular event at a predicted time or, by choosing as the temporal target the midpoint of an equal probability distribution, the cumulative cost exposure for a landscape can be approximated where each acre is expected to burn at some time over a designated period.

Mason et al. (2003) demonstrated this methodology for the present value of the public savings associated with fire risk avoidance on federal forests. By using recent experience on firefighting costs of $1,000 per acre and high-hazard forests (those likely to burn within 30 years) and moderate-hazard forests (those likely to burn within 60 years) an estimate of the magnitude of the resulting public liability exposure can be readily developed. The resulting estimated present values of future fire suppression costs are $481 per acre for a high-risk forest (with 15 years as the distribution midpoint) and $231 per acre for a moderate-risk forest (with 30 years as the distribution midpoint). Fuel reduction treatments such as thinning the smaller trees while leaving a basal area of 40 to 60 square feet per acre have been shown to reduce the ladder fuels that trigger crown fires and produce some log revenue (Fiedler et al. 2001). When we add the present value of estimated fire suppression cost avoidance to net return from sale of harvested merchantable logs, we have successfully characterized a combined market (positive economics) and nonmarket (welfare economics) public cost/benefit analysis. Such a framework is essential for integrated evaluation of forest management alternatives.

There are many other nonmarket values associated with the reduction of fire risk important to forest owners and to society at large (Pfilf et al. 2002). For example, there is a financial value of avoiding facility losses and human fatalities. Communities value a lower fire risk and reduced smoke. Habitats for threatened and endangered species that are valued by many publics may be lost to wildfires. Fires reduce the carbon stored in the forest and the opportunity to produce long-lasting pools of carbon stored in products. Fires consume biomass that might otherwise be used for energy conversion and green energy credits. Regeneration after fires can be problematic and costs are high. Postfire rehabilitation may be needed to avoid serious erosion, water contamination from excessive sediment, and invasion of exotic species. If there are harmful impacts from thinning treatments they can be incorporated as well.

Where future costs (losses) can be identified for these and other values, then cumulative present-value liability estimates can be approximated and the relative costs and benefits of management alternatives better understood. Mason et al. (2003) created an accounting ledger for cost/benefit analysis of fuels reduction investments per acre on federal forests to demonstrate how avoided costs and nonmarket values might be better considered as real returns on management investments. Although management costs of $580 per acre are charged for fuel reductions and no net market returns are credited from log sales, the magnitude of protected values and avoided costs they estimated was large, $1,402 over the investment cost of thinning on high-risk stands and $606 net on moderate-risk stands. An alternative way to view the investment is as a payback time to breakeven chart (fig. 1). Considering only the avoided firefighting cost, it takes about 10 years to break even with the initial investment in fire risk reduction, but as other avoided costs (or values) are included, the payback is much quicker.

However, under current market mechanisms (that exclude nonmarket values), forest owners/managers may not adequately benefit from forestry investments to avoid costs as they absorb all the market costs while the nonmarket values flow to other stakeholders. The effective result is a disincentive for sustainable forest management based in an irreconcilable tension between what the public pays versus what the public desires.

Other Examples of Nonmarket Tradeoffs

Although WTP studies may overestimate actual consumer behavior, experimental choice surveys, a specialized form of Contingent Valuation Analysis (CVA), provide a means of allowing survey respondents to choose the best among many different treatments, thereby demonstrating a means of ranking different environmental attributes (Green and Srinivasan 1990). For example, a mail survey conducted in Washington state asked rural and urban families to select the best of different forest management alternatives that altered forest attributes. Respondents selected from different tradeoffs of biodiversity and habitat, aesthetics, rural jobs, cost, and a brand label for the treatments (Xu et al. 2003). The result showed a substantial WTP for biodiversity/habitat and aesthetics restoration, as well as a willingness to accept a level of cost and job losses to achieve these benefits. A WTP of more than $100 per year per family for aesthetics and habitat restoration was not uncommon with the amount sensitive to the location of the family (urban/rural) and their income.

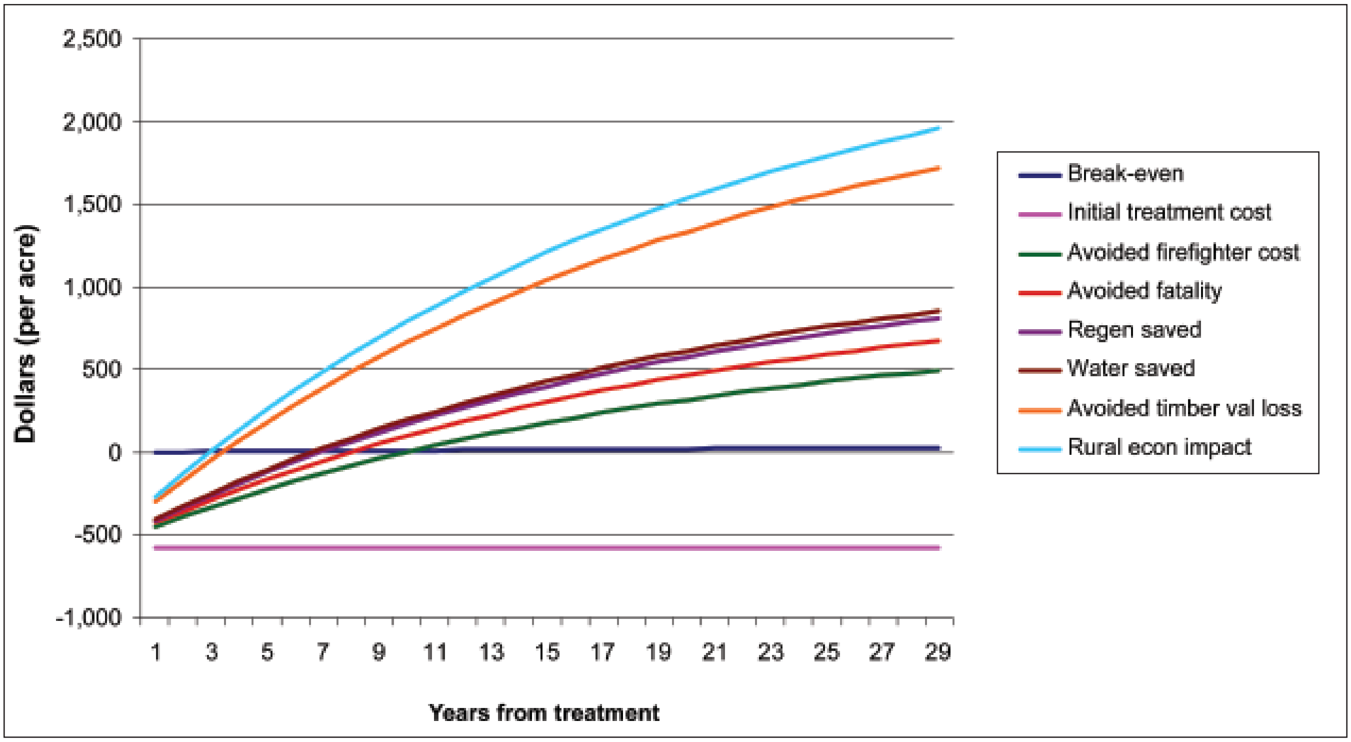

Figure 1—Buildup of nonmarket values from thinning treatment to reduce fire risk.

Another example is a recent study that used results from life cycle assessments (Lippke et al. 2004) and a choice-based, stated preference approach and basic consumer demand theory, to analyze household preferences for reductions in environmental emissions from building products (Robbins and Perez-Garcia 2005). By means of a national mail survey, respondents were asked to assess a set of goods with different levels of emissions and price attributes; they were then asked to choose their most preferred alternative. Four price levels, four environmental levels (including a baseline no-change scenario) for four environmental attributes (greenhouse gas emissions, solid wastes, clean water, and air particulates) were included in each of the 15 choice sets. The results of this survey suggest that consumers are sensitive to differences in the amounts and favor building materials with lower greenhouse gas emissions and other environmental burdens over those resulting in higher burdens.

These types of experimental choice studies can help demonstrate specific public preferences and values in order to improve targeted educational and training programs. Management can be geared to provide or improve values such as those described above (aesthetics, biodiversity, or reduced greenhouse gas emissions); marketing can be directed to improve public information so consumers have a better understanding of the true costs of their purchasing decisions.

Technology Development and Transfer

Integrated approaches to modern forest management require the support of software products with the capability to test treatment alternatives and project results forward in time with growth and yield models. Interested members of the lay public as well as forestry professionals and policymakers must be informed of present conditions and future possibilities such that choices for action are not confusing and subject to distrust. Effectiveness will depend on egalitarian availability and transparency of forest modeling technologies. Both formal and informal delivery partnerships are evolving.

For example, the USDA Forest Service has spent years developing and refining the Forest Vegetation Simulator (FVS) as a publicly available growth-and-yield model with variants for most areas in North America (Dixon 2003). The Fire and Fuels Extension (FFE) has also been developed by the USDA Forest Service for use with FVS to assess risk, behavior, and impact of fire in forest ecosystems (Reinhardt and Crookston 2003).

On a parallel track, has been development of the user-friendly Landscape Management System (LMS) at the University of Washington (McCarter 2001). Because these systems project tree list responses, they are especially important tools for quantifying forest structure attributes important to many environmental values, such as habitat suitability, fire, and aesthetics. The Rural Technology Initiative (RTI) at the University of Washington and Washington State University provides workshops and training sessions to help the public learn how to use forestry software products such as FVS, FFE, and LMS.

When these public domain software products are brought together and made available through public training programs such as those described above, the resulting technology and applied science transfer empowers local participation in fuel reduction planning. For people concerned about forests but not inclined to use software, process empowerment also occurs when scientific findings are made available and linked to transparent and replicable methodologies including visual displays and templates.

Conclusions

The challenge of developing long-term strategies to reduce wildfire risks across tens of millions of acres of inland West forest, to enhance the public's understanding of the existing tradeoffs between biodiversity protection while eliminating jobs, and to improve consumer product information, is daunting. The body of information to be considered is huge, and the planning process may be formidable. Infrastructure is limited, funding is scarce, costs high, and conflicts rampant (USDA Forest Service 2002). Strategies to help professionals, publics, and policymakers gain better understanding of the present circumstances and the future possibilities of adjustment would be helpful. New technology applications are providing the definition of variables needed to estimate many nonmarket values and the benefits that can be gained by including them in management decisions. It is important to understand the value of these benefits and to integrate them with the other needs of consumers and forest managers. Ignoring these values because they may be more difficult to quantify, results in poor management practices and unintended consequences.

As an example, for Washington state alone, we could expect that close to $1 billion in potential firefighting costs could be avoided with implementation of publicly supported proactive fuel reduction treatments (Washington State DNR 2004). There are additional nonmarket benefits associated with targeted forest biomass removals like green energy, protecting habitat, aesthetics, and reduced smoke. In terms of aesthetics and biodiversity, the analysis indicates that public valuation of forests could be increased by $1 to $2 billion per year by motivating more alternative management practices (Lippke et al. 1999). This net benefit includes the value for increasing biodiversity and aesthetics less the value lost from lower employment and higher costs accumulated across all residents of the state as measured in the survey described above.

The Nation's investment in just residential construction is $750 billion per year (USDI Bureau of Economic Analysis 2006); integrating consumer demand for green building products can lead to a significant change in the distribution of market share if accompanied by changes in perceived public value. Decisions to build and buy houses that do not consider environmental burdens misdirect purchases to products that are fossil fuel intensive instead of using renewable resources for buildings and green energy. As a result, even as the movement to curb carbon emissions gains momentum, such emissions will, in fact, continue to increase. Purchasing standards could better reflect recent scientific findings by using labels to identify products with lighter environmental burdens. This would enable nonmarket values to be internalized into consumer decisions.

Applied science and technology transfer toward building a better understanding of value tradeoffs will help the public, policymakers, and forestry professionals develop a common understanding of management options. Without such assistance, the complexity of disparate valuation systems against a backdrop of broad landscapes and extended timeframes will leave us arguing about what is out there today rather than developing a vision for how we could manage forests tomorrow.

Metric Equivalents

1 acre = 0.405 hectares

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Best Practices: Theories From the Field

Viviane Simon-Brown[1] and A. Scott Reed[2]

Abstract

What constitutes "best practices" in knowledge transfer programs? This paper acknowledges the contributions of practitioners to the body of knowledge transfer theoretical concepts, and synthesizes their ideas into three fundamental attributes: learner-centric, credible research-based information, and rigorous evaluation. Essential steps in developing learner-centric education programming are conducting ongoing needs identification, creating positive learner environments, incorporating various teaching modalities to accommodate different learning styles, adapting to the independent self-directing nature of adult learners, adopting a "less is more" philosophy, and documenting personal and group achievements.

Credible research-based programs are not prescriptive. Rather, they offer audiences a continuum of alternatives with their consequences and the diagnostic tools to distinguish the plus/minus values of the choices and make wise decisions. Rigorous evaluation helps to make programs more effective, refine activities and delivery methods to achieve better results, assess the extent of usage by the audience, and answer the question: Is my program making a difference? Adding a fair-open-honest teaching philosophy changes a typical knowledge-transfer situation into a transformative knowledge exchange.

Keywords: Knowledge-transfer practices, learner-centric, research-based information, evaluation, fair-open-honest philosophy.

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Introduction

What constitutes "best practices" in a knowledge transfer program? What contributions have knowledge transfer practitioners made to the body of knowledge transfer theories? This paper first acknowledges the work of several extension practitioners who have successfully worked with adult learners, modified existing theories to meet immediate needs, and when necessary, created their own theories to explain why some techniques work and others fail. It then illustrates how combining their concepts into knowledge-transfer programming design creates cohesive and balanced adult education.

The practitioners include:

- Eric Norland and Jim Johnson for their parallel work in identifying best practices in forestry extension, and Norland's work on evaluation methods for extension.
- Bill Hubbard for his work in understanding and overcoming forestry technology transfer barriers in the United States.
- Tony Faast for his fair-open-honest public policy concept.
- David deYoe for his analysis of the roles within the knowledge exchange system.
- John Garland and Paul Adams for their work on determining the credibility of research-based information.
- Scott Reed for adapting current knowledge transfer theory to the needs of landscape ecologists.

Learner-Centric Education

Effective knowledge-transfer programs do not focus not on what the educator wants to teach! (Norland 2003).

They focus on what the learner needs in order to develop knowledge, skills, attitudes, and behaviors. The best programs happen when the audience and the knowledge-transfer professional freely exchange information, experiences, and problemsolving insights.

Essential steps in developing learner-centric education programming are:

- Conduct ongoing needs identification.
- Create positive learner environments.
- Incorporate various teaching modalities to accommodate learning styles.
- Adapt to the independent, self-directing nature of adult learners both in methodologies and technologies.
- Adopt "less-is-more" philosophy.
- Document personal and group achievements.

Conduct Ongoing Needs Identification

Excellent knowledge-transfer programming begins with issues identification (deYoe and Hollstedt 2003). Program topics come from stakeholders, policymakers, researchers, and the knowledge-transfer professionals themselves. Informal ways of garnering information include individual telephone calls, unplanned encounters, or unsolicited emails from clients. Focus groups, interviews, and surveys constitute more formal inquiry methods.

With traditional audiences, stakeholders should be involved in the entire program design process from needs assessment through implementation and evaluation (Johnson 2003). This approach works well with known audiences. It is far more difficult to connect with potential new audiences. Identifying and contacting interest groups, corporations, professional and nonprofit organizations, resource users, community and political leaders, and other education professionals within the same arena are effective means of expanding beyond the traditional client base.

Create Positive Learner Environments

Creating a safe and motivating intellectual environment for thoughtful exploration of knowledge is key to personalizing learning. Physical well-being is similarly important. If the audience is attending after-work classes, then comfortable seating, access to refreshments, not too long nor too short classes, all become important components of the knowledge transfer. Meeting the spirit as well as the law of the Americans with Disabilities Act (ADA) is also crucial (Simon-Brown 1999).

Adult learners arrive with broad and diverse sets of values, beliefs, and life experiences—both positive and negative—that impact their ability to learn (Norland 2003). For many adults, a teacher lecturing in front of a classroom is intimidating. The positioning implies that the knowledge is being transferred in only one way—from teacher to student. Successful adult programming takes into consideration the participants' practical knowledge. Discussing at the beginning of a program what the participants know about the topic creates an exchange of knowledge, which recognizes their contributions to the process; and enables the knowledge-transfer professional to adapt the programming based on what was said. This enriches the learning experience for all.

Incorporate Learning Styles Methods

People perceive and process information in different ways. Understanding these differences and incorporating learning style methodologies enhances knowledge transfer. In the United States, lecture remains the dominant teaching method, even though approximately one-half of the U.S. population does not process information verbally (Simon-Brown 1999). To overcome this deficiency and to stimulate retention, knowledge-transfer professionals incorporate a variety of techniques in each session. These include hands-on activities; varying individual, small group, and larger group work; practicing active listening; offering both practical and conceptual information; conducting field trips; encouraging journaling and role-playing; and creating problemsolving teams.

Adapt to the Independent, Self-Directing Nature of Adult Learners

Adult learners are problemsolvers (Reed 1999). Learning concepts only work if it's clear to the learners that the concept is a necessary step toward solving the problem. Knowing information for information's sake is not the norm; the information must be meaningful to them in their present situation. Motivated adult learners incorporate new information into what they already know for action-oriented solutions.

Electronic technologies enhance knowledge-transfer professionals' capacity to accommodate these "just-in-time" learner needs. Tools of the trade can be synchronous or asynchronous. Synchronous—or simultaneous—tools include teleconferencing, real-time World Wide Web work, and satellite linkages. Asynchronous—not simultaneous—approaches such as the Web, video-streaming, email listservs, virtual field trips, video-conferencing, cable TV, CDs, and DVDs, can also be effective; with the caveat that the best practices critical to successful knowledge transfer are included in the package.

Adopt "Less-Is-More" Philosophy

One of the most difficult techniques for knowledge-transfer professionals to master is "less is more." It is more useful to learners to cover less information and to explore the meaning of that information than it is to rush through a large amount of material (Norland 2003). Teaching the major concepts and then providing students with the "how-to" tools to locate the specific information they need is one way to overcome the need to "tell all." Providing a myriad of optional indepth background materials is another way to minimize nonessential instruction. Modeling is a third way. In modeling, the knowledge-transfer professional through his or her actions, demonstrates the planning, organizational, and decisionmaking strategies that are being taught.

Document Personal and Group Achievements

Effective knowledge transfer acknowledges, formally and informally, learning milestones. Documenting learning by using certificates or credentialing is valued, both within the educational setting and by the larger external community. Although participants acquire a sense of accomplishment, credentials reinforce the value of and legitimize the knowledge-transfer experience.

Credible Research-Based Information

Facts are verifiable and socially agreed-upon truths.[3] Accurately communicating research information in ways that meet learner needs—without changing the fundamental nature of the information—is the crux of the knowledge-transfer challenge.

It is often difficult for practitioners to distinguish legitimate science from value-laden pseudo-science; however, to maintain legitimacy and trust, knowledge-transfer professionals must scrutinize the education materials for credibility. Materials that are formally and rigorously reviewed by peers, referees, and panels of scientists can generally be recommended. Scanning the literature is another technique; it provides a better grasp of the contextual framework for the issue (Adams and Hairston 1994).

Credible research-based knowledge-transfer programs are not prescriptive. Rather, they offer audiences,

[3] Smith, C.; Gilden, J. 2000. Values: the lens through which we view reality. 12 p. Unpublished. On file with: Courtland Smith, Oregon State University, Corvallis, OR 97331.

first, a continuum of alternatives with their consequences; and second, the diagnostic tools to distinguish the plus/minus values of the choices, and to make wise decisions. They do not espouse one practice over another. This key characteristic distinguishes education from advocacy.

Garland (1997) states that participants should be able to trust and act upon the information they receive to:

- Learn about the available portfolio of options and their consequences
- Identify relevant facts for each option
- Distinguish the differences among values, myths, opinions, and facts
- Identify personal values involved
- Identify unknowns and variables
- Use data to analyze individual situations
- Define what success would look like for them

Rigorous Evaluation

Evaluation helps answer the questions:

- Are my knowledge-transfer efforts actually making a difference?
- What would have made my program more effective?
- How can I refine my future knowledge-transfer activities to achieve better results?
- To what extent is my audience using the information?

Evaluation has various definitions. We use the term to describe the systematic collection, analysis, and reporting of information that can be used to improve a project or program. It also can be described as a continuous process of inquiry—a process of asking questions about social, economic, and environmental conditions and circumstances within which knowledge transfer occurs.

A quick Web search identifies dozens of evaluation methods for evaluating knowledge-transfer program effectiveness. Two standard tools for planning and assessing impacts are logic models (W.K. Kellogg 2000) and variations of Bennett's Hierarchy (Bennett 1975).

A logic model visually displays the sequence of actions that describe what the program is and what it will accomplish (Norland 2003). It shows the connections between available resources, activities carried out with program audiences, units of service delivered, and intended results, as well as the long-term goal to which the program contributes.

Bennett's Hierarchy describes a series of staircase levels of evidence of program impacts. A newer version called Targeting Outcomes of Programs includes a hierarchy of targeting outcomes, tracking progress toward achieving targets, and evaluating the degree to which programs impact targeted social, economic, and environmental conditions.[4]

Fair-Open-Honest Teaching Philosophy

The fair-open-honest public process philosophy adapts well to knowledge-transfer situations. Incorporating its criteria in formal and informal interactions strengthens programming as well as connections with clientele (Faast and Simon-Brown 1996).

Fair

Fair means providing opportunities for people to participate in ways that work well for them. Providing everyone with the same information at the same time, and making sure the people affected by a decision help to make that decision are elements of fairness.

Open

The essence of open is the question: Are you really listening? An open knowledge-transfer process ensures that programming is designed to accommodate and use

[4] Bennett, C.; Rockwell, K. 1995. Targeting outcomes of programs (TOP): an integrated approach to planning and evaluation. Unpublished manuscript. On file with: University of Nebraska, Lincoln, NE 68508. http://citnews.unl.edu/TOP/english/overviewf.html. (July 2005).

information from a variety of sources; that participants understand their roles; and the process is straightforward, understandable, and clearly explained.

Honest

Honest means not withholding information or assuming the information is too complex for the audience to understand. It also means acknowledging that some issues are simply so value-laden that group effort cannot fix them. And it means being realistic about what can be delivered, whether it's a report, a policy, or an outcome.

Conclusion

There are almost as many theories about educational best practices as there are practitioners in the field. Clearly, this paper does not address the full range of available options. However it is useful to look at what well-respected practitioners choose to use in their knowledge-transfer programming. The three fundamental attributes—learner-centric, credible research-based information, and rigorous evaluation—espoused by all the practitioners discussed in this paper, contribute greatly to the success of knowledge transfer.

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In Search of the Science Integration Keystone

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Abstract

The federal government has had a long-standing interest in effective technology transfer (e.g., President's Science Advisory Committee 1963; U.S. Public Laws 96-408, 99-502; Presidential Executive Order 12591). Federal land management agencies and their partners have embraced this responsibility. Why then, in spite of 40-plus years of effort are we still pondering how to improve technology transfer?

Through a brief exploration of historical technology transfer efforts, human motivation theory, recent media opinions, and informal discourse with others in the federal and academic arenas, I've learned that technology transfer is far more complicated than it used to be when success was simply measured by publishing new information. To measure successful technology transfer in modern terms means providing for the integration of new scientific findings and technology-based tools in a measurably relevant socioeconomic context. This paradigm has been described as bridging or boundary spanning *(*Sanchez 2000*)* because it is multidimensional, requires new infrastructure, navigation models and mechanisms, and progress requires special communication skills between communities of people that are separated by a gulf of differences in perceptions, values, and language.

In this paper, I discuss three critical operating challenges of the modern technology transfer paradigm that need more attention, compile and interpret problem-solving concepts, and propose a science integration bridge-building framework dependent on eight capacity-building blocks. I also propose that the science integration keystone is "executive leadership" as defined by the U.S. Office of Personnel Management (OPM 2005), because coordinated capacity building depends on committed leaders who possess the courage, vision, business acumen, and human resource management reengineering skills necessary to construct and institutionalize a modern technology transfer, or more accurately, a **science integration** paradigm.

Keywords: Science integration, technology transfer, capacity building, human motivation theory, boundary spanner.

Background and Challenges

Science and technology have vastly improved the quality of our lives as individuals and as a society. Nevertheless, knowledge comes at a cost, so the investment value of science and technology is constantly questioned. Public and government interest in the use of scientific findings in federally controlled decisions is essential and discretionary depending on the socio-political context (U.S. Public Law 106-554) and the degree of scientific certainty that may be claimed. The USDI 2003 Strategic Plan recognizes that "[p]olitical leaders, policymakers, and the public have never had a greater need for accurate and timely science-based information than today."

In recognition of the need for improved science-based information access, delivery, and communications, the Bureau of Land Management realigned its National Science and Technology Center to focus on capacity building. In April 2004, as chief of a new "Science

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Integration" division, I scanned the technology transfer[2] and related social science "adoption of innovations" literature, monitored opinions in the national media, attended formal meetings and workshops, participated in ad hoc discussion forums, and solicited personal perspectives pertinent to the need to improve science integration. I asked questions such as: Why do some science and technology integration efforts work? Is it the nature of the science delivered, or does it have something to do with a special relationship that the science consumer has with the science provider, or is it both and more? My purpose here is to share pertinent discoveries resulting from this brief, nonscientific scoping effort.

What Has Worked?

Making scientific information and products available and useful is extremely challenging and time consuming under almost any condition. Scientific information comes in many languages, scales, and formats, which makes it difficult to synthesize. In spite of this, some organizations have enabled the adoption of science by targeted science consumers. The USDA Extension Program was often mentioned in discussions and presentations as having been successful with rural clients. Another effort that has clear sustained utility is the widespread use of Rothermel's (1983) Fire Spread Equation for a growing series of fire behavior and spread prediction tools and applications.

What Has Not Worked?

In 1973, Forest Service fire managers developed a "seven-step process" designed to synthesize and disseminate 20 years of accumulated research results that had been reported in over 150 technical publications. The 1973 Forest Service technology transfer plan specified a target audience, creation of illustrated booklets, and active marketing. In a Forest Service report (Marx and Moeller 1984), the project was deemed successful because "the technology was transferred to the target audiences and evidence showed that it was being used." (Note that this "evidence" was not disclosed in the report.)

Based on the 1973 Forest Service report, it would appear that the 1973 Forest Service information synthesis and technology transfer effort took significant leadership support and employee effort. That commitment does not appear to have been sustained, however, because in 1994, Forest Service fire directors again posed the question of how to integrate research results into fire management activities and an "eight-step process" was developed (USDA 1994). A team of Forest Service staff investigated how well the 1994 eight-step process worked and reported that although some issues/problems were transformed into products, the follow-through and commitment to transforming the relevant problems into a research framework was insufficient because of a change in leadership interest.[3]

Why Is There a Problem?

In my search to understand the science integration challenge, I found three basic operating principles that contribute to the problem: (1) insufficient capacity to assimilate an exponentially growing body of data, information, tools, and knowledge; (2) our lack of capability to deliver knowledge in a format that ensures maximum access and utility; and (3) a general lack of ability to communicate effectively because of multiple obstacles. The most challenging of the three operating principles appears to be the inability to effectively communicate.

[2] Note: The terms modern technology transfer and science delivery, applications, and integration are used interchangeably in this paper to mean a joint problemsolving process that links science providers, tool builders, investigators, decisionmakers (land managers and their staff), and science user communities together to prioritize, produce, deliver, and sustain relevant science and technology applications. Persons who facilitate the linking process are called science integrators or boundary spanners (Sanchez 2000).

[3] Cook, W. 2004. Personal communication. Technology Transfer Specialist, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Missoula Fire Lab, 5775 US West Highway 10, Missoula, MT 59808.

This is probably because catalyzing change in human values, conditioning, and behaviors to enable improved communications is far more elusive than mechanistically resolving an assimilation problem (Snowden 2002).

The Forest Service 1973 seven-step and 1994 eight-step technology transfer processes mentioned previously are examples of how ad hoc efforts to improve on technology transfer effectiveness is insufficient. Why is this? In my search for an answer, I discovered that generally the relationship void between science providers and science consumers might be the result of years of reinforcing bad behaviors and low expectations. Therefore, I believe that we need to invest in answering the following behavior-driven issues to truly understand the science integration problem:

- Why is it difficult for decisionmakers to transform resource management issues into a publicly accepted science framework? What is needed to simplify and speed up the task?
- Is it possible to determine the research questions that will contribute effectively to management's problemsolving process. If so, how?
- Why do so many scientists resist directed research and the extra effort to transform the results into management applications? Can this resistance be overcome and if so, how?
- What is necessary to enable sustained performance when these issues are addressed?

Science providers and federal land managers usually operate in physically and intellectually separated communities that reinforce certain behaviors. To change behaviors in these communities, we need to understand their inherent or predominant perspectives.

The Perspective Challenge

Others have suggested that we need to make a fundamental shift in how natural resource scientists perceive their role in management (Herman 2002), are perceived by managers (Limerick and Puska 2003), and participate in the decision/policymaking process (Clark et al. 1998).

A scientist perspective: Many scientists have historically viewed themselves as having fulfilled their technology transfer responsibility when their findings are published. They view the process transfer trajectory as one-way (e.g, passive rather than interactive) with a clear end point. Evidence of this perspective can be found in a 1984 Forestry Commission Bulletin article by Marx and Moeller (1984) describing the technology transfer planning process as **"beginning when a scientist or his superior informs top management that there are research results ready for transfer to users."** This perception of the technology transfer process has apparently dominated the federal lands management science delivery system for at least 40 years (President's Science Advisory Committee 1963). The presumption is that the only legitimate facts are those that result from independently derived scientific investigations and analyses.

In the federal land management context, many scientists perceive themselves in unwelcome territory for a variety of reasons, many of which are valid (Sellars 1997). Thomas Kuhn, an internationally known historian of science, philosopher, and author of *The Structure of Scientific Revolutions* (1962), described the nature of scientific change and the challenges that scientists face as follows: "In science, novelty emerges only with difficulty, manifested by resistance, against a background provided by expectations." These perspectives are evidence of long-standing and deep-seated frustrations in the science provider community. They also reveal some work components that science providers value and suggest opportunities for improvements.

In general, the scientist is rewarded (and therefore conditioned to respond) when their findings are found to be credible (statistically certain) through the labor and time-intensive data collection, analysis, interpretation, retesting, and peer-reviewed publication process. Sometimes the insistence on certainty can have adverse consequences. Albert Einstein, for example, tried to prove that the universe evolved in a finite, predictable manner. Decades of experimentation have confirmed otherwise. Reality actually consists of a haze of possibilities. Einstein's rejection of uncertainty resulted in his losing touch with mainstream physics for most of his career (Greene 2005). In the federal land management context, the consequence of withholding scientific information until there is greater certainty means that decisions are often made without an opportunity to consider the current state of knowledge.

A resource manager or decisionmaker perspective: Decisionmakers usually must make their decisions relatively quickly in spite of uncertainty and poorly defined and/or complex goals and objectives. Managers often take calculated risks because of public or organizational pressure and a system that demands and rewards short-term successes rather than long-term, potentially better outcomes. Federal land managers facing intense pressure to act, and negative consequence if they don't, sometimes choose to ignore or even suppress science-based information in their perception of an imperative to act. For example, the Forest Service reaction to disastrous wildfires that took place in 1910 was to implement an aggressive fire suppression policy in spite of scientific evidence and debate over the use of fire as a critical resource management tool (Pyne et al. 1996). The long-term ecological and socioeconomic consequences of ignoring that scientific information have been very costly as is evident in present day increases in unprecedented wildfire behavior in many fire-adapted ecosystems.

Unfortunately, it often takes a crisis, like the 1910 fires, to catalyze a change in the decisionmakers' perspectives. This is as true today as it was at the turn of the 20th century. One federal resource manager/decisionmaker I interviewed (who wishes to remain anonymous) believes that the Healthy Forest Act and supporting directives (HFA/HFRI) have set in motion a potential crisis when public expectations of a safe wildland-urban interface (WUI) and reality collide. He believes that "too many decisions in the forest health world are being driven by ecologists." He has a degree in the environmental sciences so I was surprised by his negative reaction to an ecologically driven decision framework. I asked him to explain this paradox. He said that the public land management mission directs us to focus on multiple public values. For example, the HFA/HFRI directs federal land managers "to restore forest ecosystem health and to protect public values." Forest ecosystem health is now measured by an ecology-based metric called the "condition class." Decisionmaker performance, therefore, is measured by how many acres are successfully converted from one condition class to another. The public, however, does not relate well to this metric or its value. What the public expects is that many more homes in the rapidly growing WUI will be protected. If federal land manager performance is rewarded principally on the basis of acres converted (regardless of location), why take the personal risk or absorb the higher costs associated with treating the most difficult but socioeconomically valued acres where homes are located? This resource manager/decisionmaker views the science community as driving the ecologic values approach (which focuses on landscapes) because "it fits their program agenda, not the larger social priorities agenda which is protection of homes." He believes that a paradigm shift would reframe the performance metrics to reward the decisionmaker for taking risks to treat the most difficult, high-priority WUI areas (and thereby satisfy certain socioeconomic priorities), and also reward those scientists who enabled the manager to take calculated risks in these areas successfully.

This discussion about differing perspectives is not meant to imply that scientists can't produce when there is uncertainty nor that decisionmakers are inherently impulsive. Perspectives are personal, complex, and they evolve. For example, an emerging, socially cognizant perspective is evident in a letter by Bazzaz et al. (1998), which states that

> "good science used to involve doing first-rate research and publishing it in the scientific literature. Now, however, [a group of eminent ecologists] note a third necessary activity:

> informing the general public (and especially taxpayers) of the relevance and importance of our work. We are convinced that this applies to even the most esoteric of 'basic' research, because understanding how the world works is fundamental to both satisfying natural human curiosity and solving the human predicament."

This statement from an academic scientist suggests that an evolution toward revised, perhaps converging perspectives is taking place.

Operating Challenges

Why, in spite of explosive growth of science-based knowledge, is there a perception that land management and resource allocation decisions are increasingly made by federal judges and not by professionally trained and experienced resource managers? The answer is, at least in part, that litigants often demonstrate they have a better mastery of relevant scientific knowledge than federal resource staff specialists and decisionmakers. Why haven't federal specialists and decisionmakers mastered the most current and relevant scientific knowledge? According to Sherwood L. Boehlert, Chairman of the House Science Committee, "What we need is for some agency or some organization…to synthesize all the various information that's available to us. We don't lack information; we just lack consolidation of information." Whether we agree or not with the entirety of his position (that we don't need more information), I think we can agree that federal land management agencies do not currently reap the full benefit of our national investments in science and technology because of lack of coordinated direction, synthesis, and dissemination of temporally and spatially relevant natural resource management data, information, and knowledge. A cursory look at this subject revealed that the operating challenges to science integration appear to be:

Our Capacity to Assimilate

Knowledge is increasing faster than it can be assimilated (Empson 2001; Lubchenco 1998; Naisbitt 1982, Naisbitt and Aburdeen 1990; RUC 2000, 2003). Many new findings, models, and tools are produced annually by research efforts, but the vast majority of these products are not being coordinated, synthesized, and adopted by end users (Ford 2000, MacKendrick 2001, Marx and Moeller 1984, Pringle and Collins 2004). In addition, free access to all relevant information is limited by laws and regulations (Bodard 2003).

Our Capability to Effectively Deliver

Mechanisms to ensure efficient and effective delivery and application of evolving science information and technology are grossly inadequate (MacKendrick 2001, Marx and Moeller 1984, Pringle and Collins 2004), localized, or merely embryonic. Individuals working to correct infrastructural capacity issues are scattered and not engaged strategically (NRC 1993). Efforts to be responsive to and effectively benefit from the explosion of published and unpublished knowledge, predictive models, and decision-support tools are not coordinated between individual scientists, technology specialists, end users, programs, and agencies (NRC 1993, USGS and ESA 1998). Insufficient business attention and research dollars have been given to building the concomitant infrastructure, human, and organizational capabilities to fully realize the benefits of the Nation's past and ongoing research investments (NRC 1993).

Our Ability to Appropriately Communicate

Understanding and response to needs is not sufficiently accomplished because of language, process, perception, and value differences between science and technology providers and potential end users (e.g., decisionmakers, policymakers, staff specialists, practitioners, and the public). A consistent and effective approach to science and technology integration in a modern context is needed (AAAS 2005, Bensaude-Vincent 2001, Evans 2005, Ford 2000, Lubchenco 1998, MacKendrick 2001, NAPA 2002, NRC 1993, Rothman and Robinson 1997, USDA FS 2004a, USGS and ESA 1998). Finding relevant Web-based information and tools takes an extraordinary amount of patience, skill, and time. Additionally, the capacity to facilitate complex, interdisciplinary problem-solving across multiple spatial and temporal scales in a socially responsive manner is insufficient (Benda et al. 2002, Clark and Fujimura 1992, Herrick 2000, Lubchenco 1998, NRC 1993, USGS and ESA 1998).

These capacity, capability, and ability deficits lead to ineffective application of science information, duplication of efforts, and ultimately (in some instances) to poor decisions (NRC 1993) and loss of public confidence. The result is that managers and policymakers rarely have the "best" possible information and tools to evaluate their options and to predict or communicate the effects of their actions (Clark and Fujimura 1992, Feick 2003, Ford 2000, Hines 2001, Lubchenco 1998, NAS 1986, NRC 1993). In spite of at least four decades of effort, the science integration gap appears to be widening in key scientific arenas, particularly those relevant to public lands stewardship.

Proposed Solution

Useful published and unpublished information exists on the uneasy relationship between scientists and operational decisionmakers (potential science consumers). There is also a body of knowledge on how to motivate humans to change within an organizational context. I have selectively mined this knowledge to propose a metaphorical bridge-building solution to the science integration challenge. My hypothesis is that the way to engineer this bridge is to build multifaceted capacity through eight building blocks strategically constructed, balanced, and connected by the keystone of executive leadership.

Block 1. Understand Contextual Success and Create a Learning Clearinghouse

The federal government and suborganizations, such as the U.S. Department of the Interior, develop and implement business processes that are responsive to the mission and culture of their organizations. People in these organizations are influenced and make choices based on individual and organizational values. A thorough examination of what has worked and what has not worked given current and historical organizational values and technology to facilitate science integration in each federal land management culture/agency should be conducted. The lessons learned should be synthesized and delivered to a centralized clearinghouse so that information and ideas on what works and what doesn't, given an array of cultures and conditions, can be easily accessed by interested entities, particularly leaders of these agencies and their staff responsible for development or use of science-derived products and services.

Block 2. Recognize and Respond to Human Connection Opportunities

To design and reengineer a science integration bridge, we need to recognize and respond to at least three areas of opportunity to span gaps in human connections: those between scientists, between scientists and decision-makers who are science consumers, and within federal organizations.

Connections within science communities— According to some social science researchers, collaboration between scientists working in different disciplines is lacking. This collaboration is important because the human/natural environment nexus is very complicated, involving multiple lexicons, and temporal and spatial scales. Benda et al. (2002) identified **four obstacles** to scientists collaborating:

- Lack of a common language between disciplines.
- Existing scientific knowledge may reflect outdated contexts that are ill suited to current environmental problems and questions.

- Mismatches in time and space, in forms of knowledge, and in levels of precision and accuracy.
- Scientists are influenced by worldviews and nonscientific values that favor certain assumptions.

Although there are undoubtedly additional collaboration obstacles facing scientists, we should consider addressing at least these four now that they have been systematically identified by a group of social scientists.

Connections between science providers and decisionmakers—
Weber and Word in a 2001 article asked "is it possible… for scientific information to make sense in similar ways for nonscientists and for scientists?" The authors came to three conclusions:

- Scientists and nonscientists would benefit by seeing science communication as a process as well as a product.
- Frame of reference matters because information is understood through both general and local contexts.
- Scientists must accept that objectivity is not neutrality. Once an apparently objective body of information is placed in a public context, it will inevitably be evaluated and used to evaluate other information.

Again, by acknowledging that these findings (and many others in the literature) may have merit, and brainstorming and testing solutions, we can frame and implement several remedies.

Connections in a modern organizational context—
It is critical to understand the individual science provider's and decisionmaker's needs in an organizational context. Every worker has four personal and social needs: mastery, contribution, self-respect, and acceptance. These needs generally push people forward but, because the future is always unknown, they may also hold people back because of fear of failure, insignificance, being judged, and rejection (Hultman and Gellermann 2002). By hiring federal social scientists to study and test these findings and organizational management theories (e.g., Burke 1982) on the federal land management and science provider communities, we stand an improved chance of making organizationally sustainable connections.

Block 3. Cultivate Behaviors That Enable Science Integration

Biologist Michael Soule once said: "An instant of honesty and compassion is more important than an hour of logical argumentation." People often argue when they misunderstand or disagree with another's values. Disagreeing is part of the scientific process, but it is often viewed as alienating because the perpetrator is "not being a team player" in the management arena. According to Hultman and Gellermann (2002), once embraced, values become our standards of importance. The outcome of valuing—that is applying standards of importance—is that decisions are made. Value often means "a good deal, well worth the money." Psychologically, values are conceptions about what is important in life. They also serve as criteria for making decisions and setting priorities, and are behind the explanations and justifications we give for our actions.

Recent research reveals that values such as "economics, personal/subjective factors, and politics" have the greatest influence on land use decisions (Feick 2003). Scientific or technical information was third in terms of considerations. Individuals and organizations are driven by a range of influences. Therefore, in the modern world we must consciously strive to align individual, societal, environmental, and organizational values that enable the integration of science and technology. Successful realignment of values at this scale absolutely depends on strong leadership commitment to understanding the values and needs of resource management staffs, decisionmakers, and science providers. Developing this understanding will require investment in more social scientists charged with studying the behaviors and drivers of federal lands management decisionmakers and their science providers. Some preliminary thoughts on the basic actions that we need to take to cultivate desired behaviors follow.

Understand resource manager and decisionmaker behaviors—
Resource managers and decisionmakers regularly engage in risk management. The challenge for federal land resource managers is to optimize the management of multiple resources, while minimizing negative impacts on conflicting environmental, socioeconomic, organizational, and personal values. Therefore, science providers who routinely adapt their communications style and research to address socially relevant and risky management issues are far more likely to create products and services that will be used by resource managers and decisionmakers. Perhaps we need to challenge academia to include more relationship-building and risk-assessment communications training in their science and technology core curricula.

Understand science provider behaviors—
Science and technology providers are motivated by fears and desires just like any other person. They share values and expectations that shape their sense of personal and social competency and integrity (Ford 2000). Imagine going to work every day presuming that, "Any action that environmental scientists take in the project called 'restoration' is almost sure to get them applauded, condemned, questioned, congratulated, and criticized for going too far and for not going far enough" (Limerick and Puska 2003). Why should the "environmental scientist" bother to go to work if they believe that they can't be effective? Science and technology providers face challenges that are often unrecognized by the land use decisionmakers. For example, a scientist's professional credibility (and sense of personal worth) could be challenged when their findings are applied outside of their original research context, but the decisionmaker chooses to violate the context stipulation because it's the "best available science" they have. The science provider can't prevent this from happening (Ford 2000).

Another powerful driver of science provider behavior is compensation. Federally employed scientists are financially rewarded more for their contributions to "advancing science" within their field of expertise than for enabling science integration (Wright 2006). Naturally, the federal decisionmaker often interprets a scientist's primary focus on doing what is necessary to publish as "self-serving." The federal decisionmaker has limited time to wait for the publication so their interest in communicating with federal scientists wanes.

Helping the scientist to understand the federal decisionmaker's need for getting any information, even incomplete information, could alter the relationship and behavior of science provider communities. Helping the federal decisionmaker appreciate that compromises made by the science provider potentially compromise their professional standing and earning power could alter decisionmakers choices for applications of incomplete scientific findings.

Take action to cultivate desired behaviors and outcomes—
Warner Burke (1982) identified five values for a growth-oriented organization to cultivate: human development, fairness, openness, choice, and balance of autonomy and constraint. Respect and recognition should be added to this list in my opinion. There are ample opportunities for individuals and organizations to engage in practical activities that will cultivate a change in science provider and science consumer (e.g., decisionmaker) behaviors. For example, the federal government can support more relationship-building forums, such as hiring more place-based scientists and hosting more scientist and decisionmaker driven, question-and-answer workshops.

Block 4. Invest in the Right People; Recognize the Science Integrator Role

A majority of potential science consumers in federal land management agencies do not have the time or expertise required to filter mountains of specialized, sometimes contradictory scientific knowledge and rapidly evolving technology. Many potential science users are so swamped by competing interests that they may not even realize they need information or how to use it once they get it. It is not reasonable to mandate that decisionmakers abandon their driving need to be responsive in a timely manner to their stakeholders. It is equally unreasonable to expect scientists to reshape the scientific process to suit decisionmaker needs, values, and behaviors at the expense of the scientists' professional integrity. Special skills, therefore, are needed to span the science integration bridge. Science integrators (also known as boundary spanners) must respect the values and cultures of the resource management staff specialist, the decisionmaker, and the science provider. Boundary spanners are needed to facilitate transformation of the technical into the pragmatic. These special people must have a passion for service, excellent relationship-building skills, and be entrepreneurial and patient. It is time for higher education institutions and federal leaders to invest in developing and maintaining a cadre of professional science integrators to "corporately" bridge the science integration gap.

Block 5. Recalibrate Performance Expectations

To be successful, science integration must be viewed as an essential and shared responsibility. Potential science consumers must try to understand the implications and ramifications of the scientific information available to them.

The federal research-grade evaluation system does not work well for the federal land management agencies; it should be altered to equally reward federal scientists who enable successful science outreach, education, technical assistance, and applications.

All federal land management science providers need to understand that although drafting publications and posting information on Web sites (often the principal action proposed in the Internet age) has value, those activities do not meet the needs of the intended science consumers. Modern technology transfer cannot be accomplished by periodic one-way deposits of information in books, journals, conference posters, and papers. It is essential that scientists gain the capacity to collaborate effectively with practitioners and decisionmakers to help them identify and frame the right science questions, recognize environmental constraints and opportunities, and understand potential consequences when certain choices are made.

We also need to recalibrate our expectations of staff specialists who plan for and manage human, natural, and cultural resources and advise decisionmakers. Federal land and resource management specialists are overextended. They are expected to be expert advisors in multiple technical disciplines; uphold federal mandates, regulations, and policies; personally oversee data collection; synthesize and report relevant information by using advanced technologies; and practice "collaborative conservation." They often do not have the time to seek out and synthesize existing and emerging science and technology. Resource specialists and decisionmakers would greatly benefit from accurate, readily accessible, timely, and relevant science-based information and tools.

Block 6. Adopt Relevant Operating Frameworks and Processes

At present, there is no consistent leadership or coordinated approach within, or between, agencies to support long-term scientific research on federal lands. Pringle and Collins (2004) made the case for a "unified infrastructure" or "network of networks" on a continental scale that is capable of making connections between different types of federal land ecosystems, management issues, and question-driven ecological research. Unfortunately, the tasks required to construct a "unified infrastructure" capable of making these connections were not provided in the publication. Nevertheless, we need to design and implement a sensible connection strategy to optimize and define inter- and intraagency working relationships between science providers and federal land management science consumers. Implementing a suitable operating framework and processes will not be easy even if a strategic framework were available. There are vested interests within each agency for whom change will be viewed as threatening or prohibitively expensive. Committed leadership, therefore, is key to breaking down resistance and enabling change.

This science integration operating framework and processes should be designed to motivate appropriate and timely science provider and consumer interactions. There are times when scientific independence is crucial (e.g., during analysis and interpretation of research results) and other times where collaboration is essential (e.g., to inform the public and translate issues into research questions). The strategy must accommodate the need for basic research to identify management issues, selection of the "best available science" support of the planning and National Environmental Policy Act (U.S. Public Law 91-190) process, and performance accountability between organizations. A strategic adaptive-management model, such as shown in figures 1 and 2, illustrates how science and technology could be integrated into the land and resource management process while simultaneously preserving scientific integrity. This multidimensional model suggests a credible information processing and decision path to sort through a body of issue-specific knowledge to make science-based, defensible resource management decisions. This model also enables certain science consumers to let science providers know what data are missing so that targeted end users get what they ask for.

Shared strategic frameworks and processes could significantly improve potential federal science consumers' ability to assimilate relevant science and technology, and science providers' ability to deliver useful tools and information. It would establish a common language, reduce wasted efforts and associated costs, enable accountability within and between organizations, and facilitate adaptive management relevant to federal lands issues.

Block 7. Develop and Maintain Coordinated Information Synthesis and Decision-Support Tools

There are tremendous opportunities to access knowledge, but the intended science consumer is generally not able to access useful information because of time constraints or lack of expertise to make sense of an avalanche of data and information. Fortunately, information synthesis tools are emerging such as NatureServe, Google Scholar, and the National Biological Information Infrastructure. However, it's not clear whether these types of tools are meeting the needs of decisionmakers because few federal land managers have the time to access and learn to use the tools. My sense is that we need better coordination of our growing national investment in science-based information synthesis and decision-support tools. Perhaps institutionalization of an interagency science-based information clearinghouse or consortium for land managers at multiple organizational levels could effectively focus resources on high-priority management issues and long-term change concerns. In the absence of such a body, we will continue to develop ad hoc and competing solutions to the information synthesis challenge and engage in stressful and costly unresolved science debates.

Block 8. Organizational and Individual Commitment

Organizations can thrive when shared values are clearly established and modeled by their leaders (Burke 1982, Hultman and Gellermann 2002). There is a great deal of effort given to science integration, but there appears to be no consistent leadership within, or between, federal land management agencies to measure and report on what works and to demonstrate sustainable commitment for science integration.

I found many ideas about how to engender "common will" for organizational and individual capacity and capability building in science integration. Foremost on the

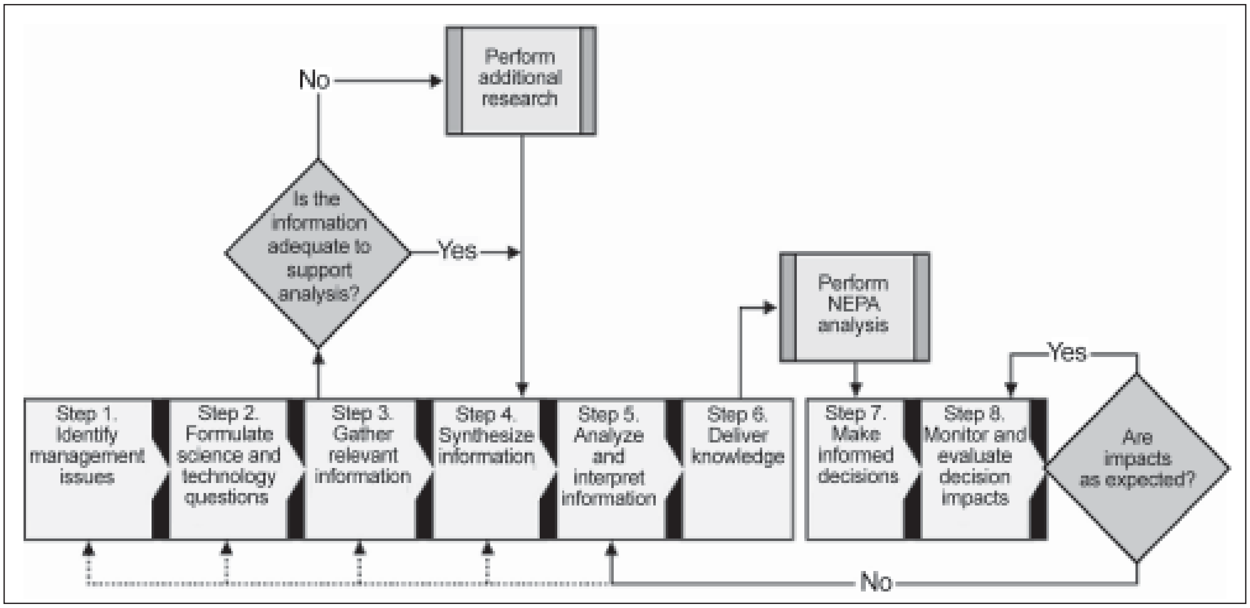

Figure 1—A science-based adaptive management model.

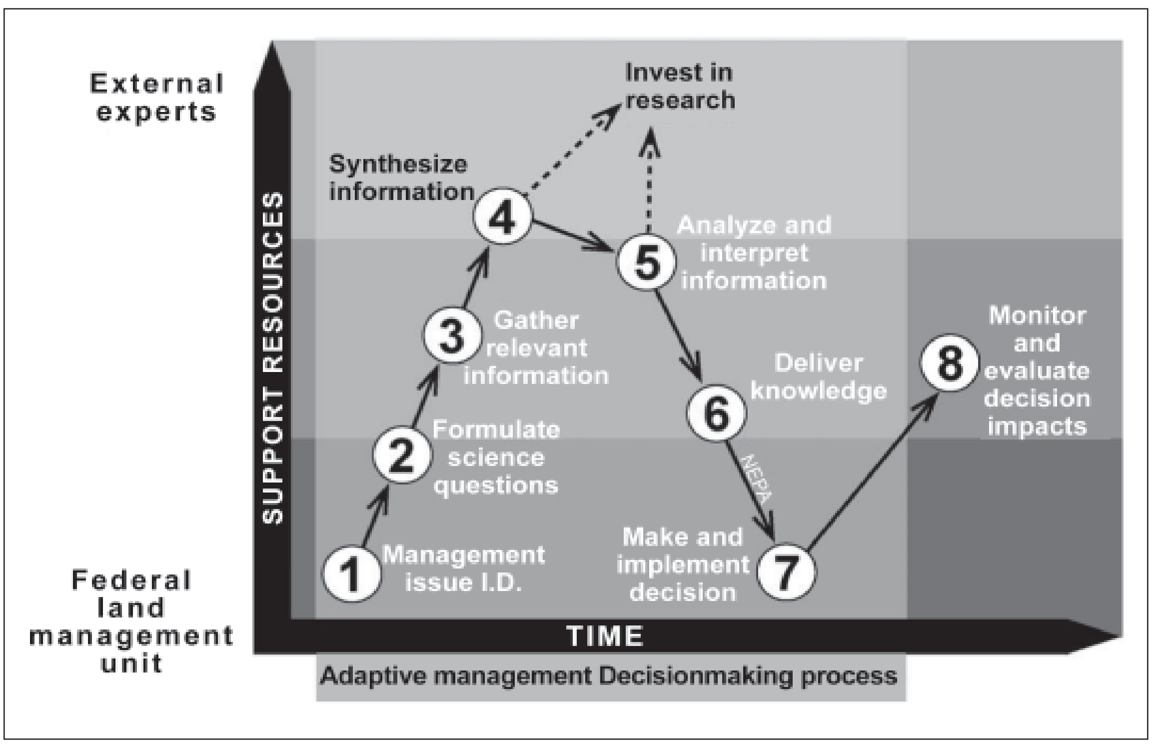

Figure 2—The relationship between decisionmaking, implementation, and available resources. The decisionmaking process takes place over time, and the need for support resources relates to the process. In the diagram, it can be seen that additional support resources may be needed as early as step 2 and peaks at the assessment and analysis step. The greatest involvement occurs if additional research is required. At this point, the federal land manager should not be involved. As the process proceeds, the staff resource manager and then the decisionmaker becomes reengaged until at step 7, the decision is made by the manager.

list is the need for leaders throughout the organization who demonstrate their commitment to the desired outcomes. Other organizational operating principles include:

- Adopt a business framework that plausibly compels successful science integration.
- Cultivate and reward "growth-oriented" team approaches.
- Seek out and leverage common values.
- Engage in bidirectional, iterative dialog.
- Invest sufficient time and energy to understand and frame needs in the "right language."
- Create and deliver timely, relevant, and easy-to-use information.
- Be flexible and adaptable—it is no longer acceptable to say "we can't do 'X' that way because we've always done 'X' this way."

These organizational operating principles foster creativity, synergy, and a productive working environment committed to an organization's mission.

Keystone to Success

The science integration bridge cannot be simply constructed because, as I've shown in this brief exploration of technology transfer efforts and human motivation theory, there are many "competing forces" and structural elements required. In the absence of a strategically placed and appropriately crafted keystone, a bridge will inevitably collapse. The purpose of the bridge keystone is to distribute competing forces so that no one structurally important block is destabilized resulting in bridge failure. The keystone metaphor seems to me to be an apt description of the purpose or role and function of our federal executive leaders. The OPM identified 27 performance "competencies" for the federal executive leader, such as courage, vision, business acumen, technical know-how, and human resource management skills. All of these skills or competencies are required to build a sustainable science integration bridge.

Conclusion

The federal government has had a long-standing interest in effective technology transfer. Federal land management agencies and their partners have embraced this responsibility, but in spite of decades of effort, we don't have very many examples of successful science integration programs. The federal government needs to systematically examine what has worked well, define what the outcomes of the technology transfer process should be, and invest in an improved, much more viable technology transfer (e.g., science integration) "bridge."

Using values-based problemsolving concepts identified in the social sciences literature, several published articles, and stories and observations from federal land management science providers, resource management specialists, and decisionmakers, I have discovered many opportunities for constructing a viable science integration bridge. These opportunities were briefly explored and connected by eight conceptual building blocks. Each building block requires improved understanding at multiple scales, a commitment of new resources or reconfiguration of existing resources, and changes in models, perspectives, and culture. None of these things can be accomplished in the absence of committed and consistent executive sponsorship. I conclude, therefore, that executive leadership is the keystone to enabling and sustaining effective science integration—at least in the federal land management arena.

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Organizing Information for Natural Resource Management

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Abstract

Two cultures, management and science, have different visions about resource management because of their respective responsibilities. In each culture, people come to terms with reality based on experiences within their own language system and consider the respective assumptions to be self-evident. Facilitating technology transfer requires leaving behind some ideas about science as the only source of truth and knowledge while still recognizing that scientists and managers have their respective world visions. A management knowledge structure is presented that looks at information as a process that leads to ways of addressing a manager's controllable natural resource elements. One way is to provide turn-key products that address a specific area of the knowledge structure.

Keywords: Management elements, science and technology transfer, culture of science and management.

Introduction

Two individuals, a research scientist and a forest manager are talking about new research results.

Mgr: I heard that you have some new and exciting research results.

Sci: That's right, these findings are a real advancement in understanding ecosystem dynamics.

Mgr: How good are these findings?

Sci: They are significant.

Mgr: Really! Then production will become higher than in the past.

Sci: Yes it will.

Mgr: How much higher?

Sci: We were able to measure with certainty, a fraction of 1 percent change.

Mgr: So how is that going to help me meet the management goals?

Here is a conversation where an exchange of thoughts and opinions was not taking place. These people are talking past each other. The manager is thinking that significant means something is important and influential, whereas the scientist is saying that a difference exists. These individuals, or groups as the case may be, are both sincerely trying to improve the outcome of forest management, even though they seem to have different thoughts about the same topic.

Objective and value-free orthodox science presents fragmented perception of the world as it investigates small details of large systems. On the other hand, management deals with a whole system; therefore, information for managers must bridge the fragments of knowledge produced through scientific pursuits.

This paper looks at how natural resource managers develop and use information. I present a framework that can be used to target and inject new findings into a management environment. I end with a short discussion about how the science community can address management concerns. My approach presents some human responses associated with technology transfer that affect a land manager's use of controllable management elements.

Using concepts from philosophy is an exercise in reason, where the ideas that come out on top have the best reasons supporting them. Reason is the web of inferential relationships among propositions. Reasoning

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involves propositions standing in logical or evidential relationships with each other, and thus forming evidentiary structures. These structured relationships are roots of value systems that guide human social and environmental interactions.

I will be addressing public land management, primarily the Forest Service, because that is where I worked. However, there are parallels to other agencies that have a responsibility for managing some of this planet's natural resources. In the private sector, natural resource management deals with the same opportunities and constraints although they march to a different drummer.

Organizational Culture

Science and management are two unique cultures where there are distinctive procedural techniques and characteristic products. Each practitioner takes their own culture for granted and considers that their assumptions are self-evident (Wagner 1995). All too often this leads to the false assumption that information developed at one level will meet everyone's needs.

One reason is that each party has unique responsibilities and therefore has different ideas about which components of information are most important. Neither one is wrong because each perspective comes from traits and products of the social environment where they apply their skills (Krippner and Winkler 1995). Each has its own language structure.

Language and Learning

Linguists Edward Sapir and Benjamin Whorf (Anderson 1995) claimed that languages don't simply serve as neutral tools that people use to report what's "out there"—but rather that they set the ground rules for what people see, understand, and talk about. Every language is its own set of blueprints for constructing reality, deciding what will be noticed and what will be overlooked, and establishing the rules for communication. In learning a language, they said, a person "channels his reasoning and builds the house of his consciousness."

For example, as a Peace Corps volunteer in Honduras, Central America, I exchanged ideas in both Spanish and English. In time, I found that by using the Spanish language rather than English, one was likely to reach a different, but not wrong, conclusion regarding some questions. Until I understood that the structure and words in each language were leading in different directions, there were many times when a "grand idea" for a project led to very different concepts for a solution—theirs and mine. In a similar way, the languages of science and management often lead in different directions.

Krippner and Winkler (1995) said this very succinctly; "People in each culture construct experience in terms of the categories provided by their own linguistic system, coming to terms with a 'reality' that has been filtered through their language."

A person sees what they have learned to see. In the 18th century, empiricists were impressed by the power of mathematical techniques, which opened vast new realms of knowledge in the natural sciences (Berlin 1995). They asked themselves, like Socrates, why the same methods should not succeed in establishing similar irrefutable laws in all areas of human affairs. This was the beginning of the search for a science-based explanation for all questions.

For a long time, a science-based approach led to many important advances in the acquisition of knowledge about the physical and biological world. However, situations developed where people were required to adapt their behavior to accommodate the new technologies, even when it did not seem to be a natural way of doing something. But science produces facts that apply only to the situation that was observed to arrive at conclusions.

There is an inherent weakness in using only facts because, facts alone do not, cannot, determine what is right from what is wrong. People must decide how to use the information to keep society functioning. We are going from seeing science as the source of absolute and final truth, to accepting it as a continuously changing body of ideas without losing confidence in scientific facts (Anderson 1995: 2) such as, water still continues to run downhill because of gravity.

Philosopher Thomas Kuhn (1995: 190) told us that transformations to new visions are usually gradual and almost always irreversible. For example, a student looking at a contour map for the first time sees only lines on paper. After enough tries at transforming his vision, the student becomes an inhabitant of the cartographer's world and sees a picture of the terrain. Also, natural resource managers and scientists have their respective world visions, which I consider to be subcategories of the scientific-rational worldview (Anderson 1995: 110-116). Following is a vision describing a knowledge structure in the natural resource management world.

Resource Management

Natural resource management is about directing chaos by merging physical, biological, and behavioral traits in an interactive, multivariate approach that stresses the importance of defining patterns, form, self-organization, and adaptive qualities of complex processes (Krippner and Winkler 1995: 166).

Managers such as forest supervisors and their respective resource staffs in range, watershed, etc., along with technical specialists for soils, hydrology, forestry, etc., all work together to create management information. These decisionmakers and support personnel are responsible for overall operations through their choices to implement or approve land use activities or assessments or affect policy and direction.

Staff members work with information about the forest resources to create ways of obtaining resource outputs. Ultimately, all forest activities must address management information needs. How management information is used depends on the goals of an organization.

Goals—Respond to Public Values and Create Economic Efficiency

In the private sector, economic returns on an investment are the driving force because businesses exist to make money for their owners. A corollary to the money-making process is not spending it needlessly. Successful businesses differentiate between expenses that are needed to stay in business and those characterized as moral obligations. To do otherwise would have companies operating as charities, which would violate their responsibility to their shareholders (Diamond 2005: 37-38). Costs not directly supporting the primary outputs are externalized unless there are statutory requirements to account for them.

In the public sector, economic returns are not the only drivers. Concerns of present and future stakeholders, the public, are more likely to be addressed. Organizational objectives are for public natural resource management to provide goods and services from the land without impairing productivity or degrading water quality.

Organizing Information

There are three basic premises: (1) information is a resource just as are land, water, vegetation, and wildlife: (2) information requires a knowledge structure for effective use by management; and (3) managers respond by using information to direct their controllable elements.

The natural resource knowledge structure (fig. 1) has three general levels: (1) data about individual facts obtained from investigations, (2) interpretations to project responses, and (3) management information that is the integration of multiple resource responses.

Knowledge Structure

The words "knowledge" and "information" are used to describe communication as it relates to natural resource

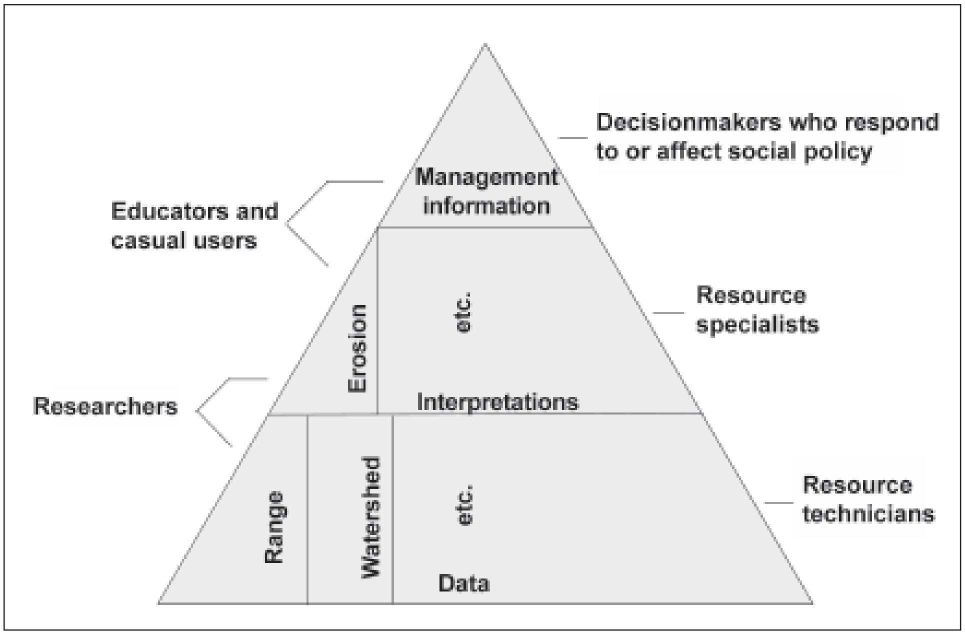

Figure 1—Knowledge structure with management levels, examples of data and interpretations, and potential information users at each level.

management. These familiar terms are often used interchangeably. However, in this context I attempt to give each word a meaning that is built on popular definitions.

The categories or levels of **information** start with the basic data collected during inventory work. Basic data form the foundation data on interpretations about potential resource responses to changing environmental conditions. An example is how soil erosion might be affected by a management action. Management information is created from interpretations about multiple resources along with social considerations.

This end product, management information, is used to manipulate a set of controllable elements. These elements are the natural resource management tools used to respond to social values, legal requirements, environmental dynamics, economics, and technological capabilities.

Knowledge is organizing what is known about a topic, like natural resources, into a relationship that characterizes information content and flow. Overall, knowledge is the familiarity, awareness, and understanding gained through experience and study in the broadest sense.

Communication as a Method

Communications as a method involves moving thoughts, ideas, and experiences between and among people by using speech, writing, behavior, and signals.

Information as a Process

The process entails organizing details about the knowledge a natural resource manager can use to control a set of management elements. This is a collection of facts and data about specific events or situations for one or more ecosystem or social functions.

Management Information

Management information includes an understanding of the opportunities and constraints on forest resources that can be used to meet a multitude of needs and desires. This information is used to guide the application of natural resource management tools when responding to social values, legal requirements, environmental dynamics, economics, and technological capabilities.

Management Tools

The key to planning for management practices is knowing which natural resource elements can be controlled. These are properties a manager can manipulate through a decision, to achieve the desired outcome (Warrington et al. 1989). Here the focus is on quantity, quality, location, timing, and mix of outputs. There are other elements, like weather, that cannot be controlled even though they have to be accounted for in the decisionmaking process.

Controllable Natural Resource Elements

Following are five controllable natural resource elements:

- **Quantity** of outputs produced (e.g., board feet, animal unit months, etc.) or inputs used (such as tree planting, range improvements, etc.).
- **Quality** is the goal toward which the methods used to implement the management practices are aimed (Pirsig 1974). It is expressed through the effects of chosen management practices on the functioning and productivity of affected watersheds. This includes the areal extent of disturbances, the magnitude of disturbance, and the duration of the effects of a disturbance.
- **Location** is where the practice occurs on the ground.
- **Timing** of practices through the sequencing of entries into a watershed or the season of operation.
- **Mix of outputs** is only available to natural resource managers for long-term management. This element is more often used in agriculture than in forestry or range management because crops can be changed in a shorter period than is practical for forests or rangelands.

Crossing the Divide

The usual science publication is written by scientists to communicate with scientists. Transferring knowledge, information, and technology from science to land managers revolves around social as well as technical processes. Effective communication with land managers requires interdisciplinary information. Successful communication also requires carefully focused efforts to keep the process from following a trajectory similar to that described by the second law of thermodynamics, where everything moves toward the lowest energy state.

Back in the old days, the members of the Watershed Systems Development Group were discouraged from going to regional meetings for the purpose of discussing how to use the information in a publication. The rationale was that forest management specialists were educated people who could read and understand the document. This approach ignored, at a minimum, that readers were only going to see things through their own cultural point of view.

Matching Research to Management

Research results need to be targeted on the appropriate part of the management knowledge structure. Results from individual research projects are usually only a piece of the management puzzle. For example, a computerized soil water model, REGIM4 (Warrington and Weathered 1983), used in **real time** for tree planting, requires results from a number of studies, including one that identifies a soil water stress level for Douglas-fir seedlings. This step alone is crucial to meeting “quality” expectations from tree planting contracts. REGIM4 works well, with a correlation between predicted and measured soil water content of around 80 percent. But this model was not widely used because potential users did not inhabit the model developer’s world, or have the modeler’s associated visions about evaluating soil water content.

Turn-Key Applications

Only the most motivated users will occasionally attempt to do the implementation step for new procedures. This is a weakness in the final REGIME4 publication. At that time, reviewers didn't think implementation steps were appropriate information to include with the discussion about the model because it was assumed that users would know how to go about applying the tool on the ground. By providing complete and ready-to-use solutions, scientists, and developers will create more acceptance than when end users must devise, design, or create ways to implement a tool or finding.

Addressing Project Managers

An executive summary **is not** an abstract. An abstract is a brief description about the content of a publication. An executive summary helps the project manager understand how the research findings can improve management and indicates how these findings can be applied in a management context. For example, presentations for users should be made in a format displaying controllable environmental elements that can be readily evaluated in relation to economic, social, and legal concerns. Attribute charts and maps that combine multiple concerns are very valuable at this level.

Managers want to know about research results. They assume that the process of getting these results has been properly reviewed within the science community. I recommend organizing management publications so that the conclusions and applications are immediately apparent to the reader at the beginning of the document. Then move to ever-increasing detail about the role of supporting information, so it is available if needed. This provides reading options that make the best use of a manager's time.

Technology Transfer Specialists

Ideally these individuals should have training and experience in both research and management. They will often be in the position of using reasoned judgement when adapting research results to management needs. Critics will be quick to find fault with almost everything they are doing.

The untested assumptions used to link various technology elements together will be low-hanging fruit for the science community. Scoping out management needs is important given the ecological and sociological diversity that exists. Each user entity will see only a narrow solution as being in their best interest, but all want the product. Technology extension specialists will have a unique and difficult communication responsibility.

Working Together

Leaving behind a cherished past of hard-earned life experiences is both frightening and exciting. This applies to children growing up and adults shifting to new visions of a seemingly chaotic world. These shifts are due to the introduction of new tools or a new way of using the old tools. The world didn't change, only our description changed with the changed perspective. I see a creative interaction between human minds and the cosmos not only as the source of scientific facts but also society's beliefs, personal perceptions about our surroundings, and social interactions.

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Communication Barriers to Applying Federal Research in Support of Land Management in the United States

Vita Wright[1]

Abstract

Barriers to effective communication between researchers and managers can ultimately result in barriers to the application of scientific knowledge and technology for land management. Both individual and organizational barriers are important in terms of how they affect the first three stages of the innovation-decision process: (1) knowledge, where an individual is exposed to innovation and develops an understanding of how it works; (2) evaluation, where an individual evaluates advantages and disadvantages and forms a favorable or unfavorable attitude toward innovation; and (3) decision, where an individual engages in activities that lead to a choice to either adopt or reject the innovation. Communication studies provides insight into potential influences to the communication and use of research results by federal land managers. Effective communication refers to the development of a common understanding between the research communicator and the manager or practitioner about both the existence and utility of an innovation. Communication research reveals that people frequently report leaving the same encounter with different perceptions of that encounter. So, it is not surprising that a scientist presents results in what they perceive to be clear terms and then the land manager returns to their daily tasks with a modified perspective of what the scientist intended to communicate, with continued uncertainty, or with lack of interest that leads to passive rejection of innovations. By understanding contextual influences to communication within target audiences, research communicators may be able to plan for and minimize potential causes of misunderstanding within different target management audiences. Recognizing that science delivery and application approaches are often developed on an ad hoc basis, this paper emphasizes the need to understand specific influences to the communication process within these audiences. Understanding influences to communication within target audiences will help applied researchers, research application specialists, and upper level managers prioritize limited delivery and application resources and increase the likelihood that these efforts result in application.

Keywords: Innovation-decision, science communication, research application, diffusion.

Introduction

A federal research scientist (researcher), charged with developing knowledge to support federal land management, develops a new tool to help land managers accomplish their objectives. To make the tool relevant and useful to managers, the researcher works closely with managers throughout all stages of development. The managers she interacts with not only demonstrate enthusiasm for the new approach, but also identify additional ways in which it will be useful. After the tool is developed, the researcher publishes a manuscript and gives several presentations at conferences and workshops about how it works. With the exception of answering specific requests for additional information, the researcher then switches to focus on developing other potentially useful knowledge and techniques. If this tool,

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which represents many hours of labor and creative thought by both researchers and managers, is like many innovations, it will be used locally by the few managers who contributed to its development and by some of their colleagues. Other managers who happen to see the publication or hear a talk about the innovation might think it sounds like a good idea but continue to do their jobs without using it. An astute observer questions, "What keeps federal land managers from using many of the scientific innovations that will either make their jobs easier or increase the likelihood that they'll achieve desired outcomes?"

Why Focus on Federal Research and Land Management?

In the United States, federal land managers are required to base decisions such as those that affect fire, fuels, wildlife habitat, and invasive plants on the best available science. The U.S. Departments of Agriculture and the Interior regularly allocate funding toward developing and delivering scientific knowledge and tools in support of this mandate. However, the U.S. Office of Management and Budget recently expressed concern about whether the full benefit of this investment is being reached. This funding, and subsequently the scientific information available for land management, may be jeopardized if the federal research and management agencies cannot demonstrate that managers are both aware of and using federally funded research.

The goals of federal management and research programs can be achieved only if scientific knowledge and tools are effectively transferred to land managers. Many researchers in U.S. federal agencies work closely with managers during an iterative process that identifies research needs and ensures results are relevant. Once research results are complete and tools are developed, researchers make them available by publishing results, hosting information on Web sites, and giving presentations to management audiences. In addition, U.S. agencies work to improve the awareness of and access to completed research by offering online publication distribution (e.g., http://www.treesearch.fs.fed.us), library and document delivery services (e.g., http://www.nal.usda.gov/digitop; http://library.doi.gov/ill.html), and searchable Web syntheses (e.g., http://www.fs.fed.us/database/feis; http://forestencyclopedia.net).

Most of these approaches improve access for managers who actively search for scientific knowledge and tools. However, the adoption and use of innovations by land managers is dependent on more than information accessibility. In British Columbia, Hollstedt and Swift (2000) identified the following categories of barriers to the communication and adoption of scientific research into forest policy and management: information sources (not knowing what information is available), information access (not knowing where to find the information), cultural differences (between researchers and research users), technology (limited access or incentives), and capacity (time, money, skills, desire). Kearns and Wright[2] found similar personal, organizational, and external barriers among USDA Forest Service fire, range, and recreation managers. Additionally, during a Forest Service Roundtable on science-policy integration that was sponsored by Deputy Chiefs for Research and the National Forest System, prominent research scientists and agency decisionmakers also acknowledged barriers posed by different cultures and perspectives of researchers and managers (USDA Forest Service 1995). Finally, recent interviews of field-level researchers and managers in the Forest Service's Rocky Mountain Region noted that communication problems arise from managers' and

[2] Kearns, S.A.; Wright, V. 2002. Barriers to the use of science: USFS case study on fire, weed, and recreation management in wilderness. Unpublished report. On file with: Aldo Leopold Wilderness Research Institute, 790 E Beckwith Avenue, Missoula, MT 59801.

researchers' perceptions of each other, ineffective use of communication channels, and a paucity of time, awareness, interest, and mutual understanding.[3]

Although each of these efforts identified individual and social barriers to the communication and use of research results, none of them drew upon the existing body of knowledge from communication studies to help improve understanding of or develop strategies for reducing these barriers. Additionally, established efforts, such as the aforementioned Web sites, that aim to make information accessible do not generally address many of the contextual barriers to the communication of research results. Drawing from the communication literature, this paper introduces potential influences on the effectiveness of communication between managers and researchers and on practitioners' decisions about whether to adopt scientific knowledge and tools. It does not address the preferred information sources or methods that managers use to access information.

Innovation—Decision Process

The *Diffusion of Innovations* theory (Rogers 1995, Wright 2004) describes what happens once an individual gains initial knowledge of new ideas (i.e., innovations) such as those presented by the scientific community. This can be either a passive process where a person is exposed to new information through any of a variety of communication channels, such as face-to-face, written, and mass communication, or an active process where the individual searches for innovations to meet their needs. If a person's interest is piqued by exposure to the innovation, the individual actively begins the "innovation-decision" process by gathering information. According to the theory, an individual initially works toward understanding how the innovation works. Then the individual gathers information to weigh the potential advantages and disadvantages of using the innovation and uses this to develop either a favorable or an unfavorable attitude toward it. If uncertainty is reduced to a tolerable level and a person develops a favorable attitude, the individual decides to try incorporating the innovation into ongoing practices.

This overarching theory, often used to understand or facilitate social change, recognizes that it takes time for individuals, and communities, to incorporate innovative concepts and techniques into established approaches and practices. The amount of time depends in part on individual characteristics of the potential adopters, social values and expectations, and communication networks. The innovation-decision process is distinguished from other types of decisionmaking based on the inherent uncertainty associated with deciding whether to use new ideas or to stick with existing, known, practices. Individuals have different levels of comfort with uncertainty that affect how they obtain their information and how quickly they adopt new ideas. They are also influenced by the culture and norms of the communities in which they work. Rogers (1995) reminds us that communities function as social systems, with interrelated units, communication networks, and established social norms. Federal researchers can use a better understanding of land managers, including individual and social influences on the innovation-decision process in different management communities, to reduce barriers to the use of scientific innovations.

The discussion here focuses on communication barriers that are likely to influence the first three stages of the innovation-decision process as described by Rogers (1995): (1) knowledge, where an individual is exposed to innovation and gains an understanding of how it works; (2) evaluation, where an individual evaluates advantages and disadvantages and forms a favorable or unfavorable attitude toward innovation; and (3) decision, where an individual engages in activities

[3] Lundquist, J. 2004. Communicating fire science research between the Rocky Mountain Research Station and national forests within Region 2. Unpublished report. On file with: USDA Forest Service, Rocky Mountain Research Station, 240 West Prospect Road, Fort Collins, CO 80526-2098.

that lead to a choice to either adopt or reject the innovation. These stages occur along a continuum rather than as separate stages.

Effective Communication

Communication, as both the cooperative construction and exchange of ideas, is fundamental to how individuals navigate through the innovation-decision process. Managers obtain information that increases their awareness of and ability to evaluate innovations by communicating with researchers, technology transfer or application specialists hired to communicate results, and other managers. Face-to-face communication among researchers and managers takes place in a variety of venues. Research is commonly presented at professional conferences and symposia, where results are communicated both during professional presentations and during formal and informal interactions outside presentations. Additionally, research results are communicated at smaller workshops, meetings, and training courses focused on specific management issues. Finally, once managers are aware of and interested in innovations, researchers participate in onsite or phone consultations with individual management units to answer questions about the relevance of research results to specific units and their management issues.

From the researcher perspective, effective communication about innovations leads to their use by land managers. In fact, researchers often express frustration that managers do not incorporate research results into management decisions and practices, even after they hear about them. Rogers (1995) explained that rejection of an innovation can occur at each stage in the innovation-decision process, and that many innovations are rejected passively despite exposure to the innovation (i.e., use of the innovation is never really considered).

From the perspective of land managers, effective communication with researchers reduces uncertainty about how to use innovations to achieve their goals (Rogers 1995). This includes two types of uncertainty: general uncertainty about the best approach for achieving their goals, and uncertainty regarding specific messages conveyed about an innovation during communication with a researcher or research application specialist. For instance, uncertainty can exist about what the innovation is, how it works, and why it works. According to *Diffusion of Innovations* theory, once individuals become aware of and interested in innovations, they spend the evaluation stage actively seeking information that reduces uncertainty about the advantages and disadvantages of using those innovations (Rogers 1995).

Overcoming different primary communication goals, effective communication leads to the development of a common understanding between the research communicator and the manager about the existence and utility of an innovation. Knowledge from communication studies offers insight into how face-to-face communication between researchers and managers occurs and what influences the outcome of communicative interactions about innovations (e.g., whether managers pursue the use of research to which they are exposed). In sum, the outcome of communicative interactions depends on the individual and social contexts in which they occur.

Potential Misunderstanding

Ambiguity

Communication research reveals that people frequently report leaving the same encounter with different perceptions of that encounter. So it is not surprising that a researcher presents results in what they perceive to be clear terms and then the land manager returns to their daily tasks with a modified perspective of what the researcher intended to communicate, with continued uncertainty, or with lack of interest that leads to passive rejection of innovations.

Traditionally, communication refers to the process of transferring information from a sender to a receiver. Communication scholars refer to this as the transmission, or conduit, model of communication. It is a simplistic model where people understand each other by encoding and decoding messages based on shared language rules (Jacobs 2002, Roberts and Bavelas 1996). However, most communication researchers subscribe to a different model, called the inferential model, which acknowledges that a speaker's intended meaning cannot be entirely understood through language rules (Jacobs 2002). Further, meanings can evolve and conversations can lead to shared meaning that is created during the course of conversation that goes beyond a communicator's original intent. In this view, the meaning of a conversation is negotiated between communicators (Roberts and Bavelas 1996). Regardless of the communication model one subscribes to, communication researchers agree that ambiguity exists and misunderstanding is likely pervasive.[4]

Sillars (2002) defined misunderstanding as "intentions, meanings, thoughts or feelings" attributed to a speaker that are different from those intended by the speaker. There are a variety of factors that contribute to misunderstanding during communication. For instance, people generally understand messages based in part on shared language rules; however, these rules are often incomplete, and messages can incorporate the rules in an infinite number of ways. As a result, there is always some degree of ambiguity that requires inference when interpreting verbal or written messages (Jacobs 2002). Inference results from the "layered knowledge beneath, behind, or within" sentences that can lead speakers and listeners to understand messages in different ways (Duck 2002). Additionally, inference is necessary because people often use language unconsciously, both when conveying and when interpreting messages, and so people are not always aware of their communication choices. Finally, communicators can have multiple goals, which leads to the ambiguity of underlying, implicit messages that are inadvertently expressed (for instance, through nonverbal cues) and sometimes contradict explicit verbal messages. Inferences about a speaker's goals are likely to influence the understanding of that speaker's messages (Berger 1997).

Selective Attention and Context

Misunderstanding can also result from selective attention. All people are selective about the messages they hear for a variety of reasons. The "cognitive miser" metaphor used by social psychologists suggests that people strive to achieve "the greatest possible cognitive effect for the smallest possible processing effort" (Sillars and Vangelisti 2006). In other words, people conserve mental resources by being extremely selective about the signals to which they attend. This reduces mental stimuli to the point where individuals can feasibly process them; the consequence is that it also creates the potential for different individuals to pay attention to different signals.

People are more likely to pay attention to messages about scientific findings and products if they perceive the messages to be relevant to their goals or needs. Managers are often driven to learn about innovations as a result of dissatisfaction with current approaches; however, it is also possible for needs to develop once a person is exposed to an innovation. Rogers (1995) used the example of a new clothing fashion, where a person decides they need fashionable clothing only after being exposed to it, to demonstrate that needs are not always identified in advance. Part of the lack of understanding between researchers and managers may stem from a problem or need that is perceived by the researcher but not the manager. This situation is reflected in the following statement, "We may want food and not need it. And we may need vitamins and minerals and fail to want them" (Edgar Dale quoted in Rogers 1995). In other

[4] Sillars, A.L. 2002. For better or worse: re-thinking the role of "misperception" and communication in close relationships and families. 17th annual B. Aubrey Fisher Memorial Lecture, University of Utah.

words, researchers and physicians who study how the human body works know that people need vitamins, but someone working outside these professions may not identify vitamins as a priority. As a result, people in the latter group may not pay attention to messages about how to incorporate vitamins into their daily routines.

Perception is also important in determining the outcome of communication events. Perception refers to the way individuals interpret messages and provide order and meaning to their environments (Bowditch and Buono 2005). Humans have a natural tendency for long-established perceptions to become ingrained, which means they often hear what they expect to hear rather than what the speaker conveys. This can be especially true when there are stereotypes (e.g., conventional beliefs about the "typical" researcher or the "typical" manager). Furthermore, people can be motivated to maintain inaccurate impressions despite explicit information that contradicts these impressions (Sillars and Vangelisti 2006). For example, people tend to interpret information so it is congruent with existing beliefs and attitudes because hearing messages that are incompatible with existing beliefs can lead to cognitive dissonance, or internal conflict, which is troubling (Rogers 1995). By hearing what they expect to hear, people can protect their worldviews and identities and reduce the stress associated with changing deep-rooted views.

According to the *Diffusion of Innovations* theory, individuals are most likely to interact with others who they perceive to hold similar personal and social characteristics (e.g., personal or cultural beliefs, education, work experience, social status). Communication among such individuals, described as homophilous, is more comfortable and more effective because these individuals share common understandings and subcultural language. In contrast, heterophilous individuals are perceived to differ in these social characteristics (Rogers 1995). Researchers and managers are often heterophilous. In addition to increased technical understanding of an innovation, researchers often have different levels of education and are motivated by different priorities than many of the managers who are responsible for adopting and implementing innovations. According to Rogers (1995), communication among heterophilous individuals can be problematic when it causes internal conflict for those who find messages to be inconsistent with the beliefs or the environments in which they are used to operating. Such differences can result in misunderstandings (Rogers 1995).

Much of the understanding gained during interactions depends on the individual and social contexts in which communication occurs. Individual contexts that are likely to influence the communication and adoption of research results include a person's prior knowledge, beliefs, attitudes, and comfort with risk/uncertainty. Sillars and Vangelisti (2006) note that social, cultural, and historical factors also influence the ways people interpret messages. This includes social norms such as an agency or administrative unit's organizational values, assumptions, and expectations. Messages can also have different meanings when conveyed in different social and institutional settings or by different messengers (e.g., a supervisor, well-respected peer, disrespected peer, friend, or spouse) (Knapp et al. 2002). Bateson (1978) went so far as to say, "Without context, words and actions have no meaning at all." According to this view, messages about research results can only be interpreted, and meaning can only be generated, in relation to the context in which they are delivered (Duck 2002, Knapp et al. 2002); research communicators will be more effective if they understand this context.

In summary, which signals are selected depends in part on the context created by background knowledge and beliefs that exist as a result of the message interpreter's history. These can change as communication patterns between people evolve over time and as relationships develop. A longer history of communicating together, or of participating in the same cultural environment, is likely to lead to shared knowledge, memories, and principles of inference that can either enhance understanding during an interaction or result in patterns of continued misunderstandings (Duck 2002, Sillars and Vangelisti 2006). Duck (2002) noted that, "No one talks without reference to things that they believe to be commonly understood," because references to shared notions facilitate the development of common understanding.

Conclusion

Much of the communication about innovations is initiated by researchers and research application specialists (e.g., during presentations at professional conferences or workshops). With so much potential for misunderstanding owing to the inherent ambiguity of communication, inference, and selective attention, researchers and others who strive to communicate research results need to understand contextual influences to the outcome of communication between researchers and managers. Researchers, research application specialists, and upper level managers can use knowledge of potential influences of misunderstanding to develop strategies aimed at achieving greater mutual understanding between these two groups. In fact, Berger (1997) discussed the need to predict the beliefs and actions of message recipients in order to produce effective messages. He suggested some uncertainty about these can be reduced in advance by acquiring information about message recipients as well as the social context in which messages are likely to be received. In summary, by understanding contextual influences on communication within target audiences, researchers and others who communicate research results may be able to plan for or minimize potential causes of misunderstanding with these audiences. Reducing misunderstanding will ultimately increase the effectiveness of communication about innovative knowledge and tools.

Acknowledgments

I appreciate Alan Sillars' insights and comments on the discussion of communication and misunderstanding. Thanks also to David Parsons for his thoughtful review. Research presented in this paper is part of a project supported by the USDA Forest Service: Aldo Leopold Wilderness Research Institute, Rocky Mountain Research Station, Pacific Northwest Research Station, National Fire Plan, and Washington Office—Fire and Aviation Management; the Joint Fire Science Program; the BLM National Science and Technology Center; and the National Center for Landscape Fire Analysis.

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Methods

Video-Teleconferencing: A Powerful Tool For Technology Transfer

Robert E. Bardon[1] and Susan E. Moore[2]

Abstract

Administrative demands and legislative edicts for cost containment and cost accountability pressure universities to move beyond the traditional means of technology transfer between researchers and the public. Cost-effective solutions are needed to facilitate technology transfer. Multipoint video teleconferencing is an option that offers simultaneous video and audio for communication between researchers and practitioners and allows the two groups the opportunity to interact in real time.

Through the 1990s, North Carolina invested heavily in electronic communication to ensure information access and equity for all citizens of the state. This investment resulted in the North Carolina Research and Education Network and North Carolina Information Highway. These networks offer the opportunity for information delivery to multiple sites in multiple states via video-teleconferencing through the microwave standard system, the H.320 system and Internet protocol. Based on the need for accessible face-to-face training and using the information exchange opportunities provided by the information networks, North Carolina State University Extension Forestry developed the Forestry Issues Series.

The Forestry Issues Series, co-administered by the Forestry Educational Outreach Program, is a multistate conference series delivered via multipoint video-teleconferencing. The program was developed to provide an economical means of continuing education for natural resource professionals while meeting the administrative demands and legislative edicts for cost containment and cost accountability that challenge the traditional means of engagement facilitated by extension. Each year, the series offers 6 to 10 topics ranging from technical and policy aspects of forestry to traditional forest management issues and practices. The program has been instrumental in providing educational opportunities at a reasonable cost to participants. The ability of participants to interact with researchers and other professionals, save money on the cost of attending conferences, and meet work schedule responsibilities has been key to the success of the program. The authors analyze 4 years of evaluation data to determine participants' time and cost savings, level of satisfaction, increase in knowledge, and applicability to their professional forestry work.

Keywords: Technology transfer, continuing education, distance learning, video-teleconferencing.

Introduction

The North Carolina State University Department of Forestry and Environmental Resources extension and outreach programs developed and implemented the Forestry Issues Series, a conference series delivered via multipoint video-teleconferencing. The program was developed to provide an economical means of continuing education for natural resource professionals while meeting the administrative demands and legislative edicts for cost containment and cost accountability that challenge the traditional means of engagement facilitated by extension. Each year, the series topics range from technical and policy aspects of forest management

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to traditional forest management issues. This is a statewide program that targets private and public sector natural resource professionals.

The driving force behind natural-resource-based continuing education in North Carolina has been the need for continuing education credits in order to maintain registration as a forester with the State of North Carolina. Prior to 1999, the predominant methods for obtaining continuing education credits included field days, short courses, workshops, and conferences delivered on site to participants. These have been effective methods in reaching traditional Extension audiences (Harmon and Jones 1997, Londo and Monaghon 2002, Prestemon 1986) and are still an integral part of the outreach program within the department.

Through the 1990s North Carolina invested heavily in electronic communication to ensure information access and equity for all citizens of the state. This investment resulted in the North Carolina Research and Education Network and North Carolina Information Highway. These networks offer an opportunity for information delivery to multiple sites in multiple states via video-teleconferencing through the microwave standard system, the H.320 system and Internet protocol.

Research has shown that multipoint video-teleconferencing can be a cost-effective method for technology transfer (Kelsey and Mincemoyer 2001, Kolomeychuck and Peltz 1992), while maintaining the ability of two-way interaction, which is essential to effective communications (Fulford and Zhang 1993). The client's need for continuing education credits and an inexpensive means of obtaining the credits, the administrative demand for cost containment, cost-efficiency, and cost accountability, and the creation of a technology transfer system prompted the development of the video-conference series.

Methods

The Forestry Issues Series operates as a fee-based program to provide program sustainability. The series originates from North Carolina State University and is broadcast live via analog to as many as 12 sites. Sites are capable of both broadcasting and receiving and are located at community colleges, universities, or extension centers. Sites are traditional classrooms or conference rooms that have been upgraded with cameras, televisions, and microphones. Equipment used to broadcast is also a part of the facility. Extension specialists and continuing education professionals are responsible for planning, coordinating, and implementing the series. The annual series, which began in the fall of 2000, ranges from 6 to 10 conferences, scheduled to correspond with the fall and spring semesters. Summer break is used for planning and preparation of the annual series. Con-ferences have been offered in the broad areas of environmental stewardship, forest management, innovative technologies, and professional development.

Conferences are 3 hours long and are presented in a traditional conference style with speakers presenting the information followed by question-and-answer sessions. Each site is provided an opportunity to ask questions, with the conference facilitator at the originating site and the host at each remote site acting as facilitators. The conference facilitator is either an extension specialist or the director of the Forestry Educational Outreach Program. Site hosts are registrants who have their registration fee waived in return for hosting the site. In addition to facilitating questions and answers, site hosts assist with handouts, evaluations, and registrations.

Extension specialists, research faculty, and invited instructors (from public and private sector) serve as presenters. Guidelines for the preparation of presentations are provided to each presenter to assist with the development of materials that will be broadcast across the network. These guidelines assure that the materials, which are viewed on televisions, are readable by the participants.

Targeted audiences include natural resource professionals both in the public and private sectors. Several means of marketing are used to promote the series to these audiences. They include:

- Direct mailing
- Email distribution
- Web posting
- Posting to list servers
- Notification of government agencies and organizations

Evaluation data is collected at the end of each conference and used in assessing program impact. Since 2000, evaluations have been used to assess:

- Individual cost savings
- Program quality
- Willingness to attend similar traditional conferences versus teleconferences
- Primary reason for attending
- Benefits of attending the video-conference, e.g., save money, meet work schedule responsibilities
- Level of satisfaction
- Suggestions for improvements
- Suggestions for topics

Results and Discussion

Thus far, 31 workshops have been offered, in which 2,600 registrants from North Carolina and bordering states have participated. Registrations have increased from 595 registrants the first season to 671 registrants the fourth season, with a peak registration of 704 during the third season (table 1). Even though there was a decrease in the number of conferences offered, the number of registrants per conference was greater during the last two conference seasons than the first two conference seasons (table 1). Beginning with the second conference season, participants were asked in the evaluation at the end of each conference what was their primary reason for attending the teleconference. Over 60 percent of the participants in each season have indicated that obtaining continuing education credits is the primary reason they attend the teleconference series (table 2). Over 7,000 continuing education credits have been awarded. The increase in registrations and the need for continuing education credits as the primary reason for attending the teleconference indicates that participants in the teleconference series find this to be an acceptable delivery method in meeting their continuing education needs.

The ability of a participant to attend a conference and return to work the same day is a major benefit of the teleconference series (fig. 1). Traditional conferences often are held in one location with participants having to travel long distances to attend. Based on evaluations, the average one-way distance traveled by participants if they were to attend a similar conference in Raleigh or Charlotte, North Carolina, is 235 miles (378.19 km). This travel often results in long hours away from other work responsibilities and costs for lodging, meals, and mileage. The average one-way distance a participant traveled to attend a teleconference in North Carolina is approximately 36 miles (57.94 km). For every dollar invested (registration cost) by participants, participants perceive individual cost savings of approximately $25 in the 00-01 season, $19 in the 01-02 season, $18 in the 02-03 season, and $15 in the 03-04 season (table 3). The decrease in cost savings between the first and second season and the third and fourth seasons is due to the increase in the registration fees during those seasons. The cost savings are savings in the cost of time and travel expenses (table 3). This translates into an economic cost savings for participants at over $1 million for all conferences to date. The majority of cost savings were in time savings (fig. 2), the time that an employee is able to meet other work responsibilities and not be at a traditional conference. The ability of participants to save money on the cost of attending conferences and the ability to meet work responsibilities have been key to the success of the program.

Cost of the video-teleconference series has been nominal for participants because of the minimal direct operating cost in running the program (table 4). These

Table 1—Number of conferences, number of registrations, and average number of registrations per conference season

Conference	Conferences	Registrations	Registrations per conference season
	– – – – – – Number – – – – – –		*Average number*
2000-01	9	595	66.11
2001-02	9	630	70.00
2002-03	7	704	100.57
2003-04	6	671	111.80

Table 2—Primary reason for attending a teleconference. Participants were asked at the end of each conference "What is your primary reason for attending this teleconference?"

	Conference season		
Primary reason	2001-02	2002-03	2003-04
		Percent	
To earn continuing education credit	61	61	65
Subject matter content	22	20	21
Personal enrichment	11	13	10
Advancement in current job or career	5	5	4
Other	1	1	0

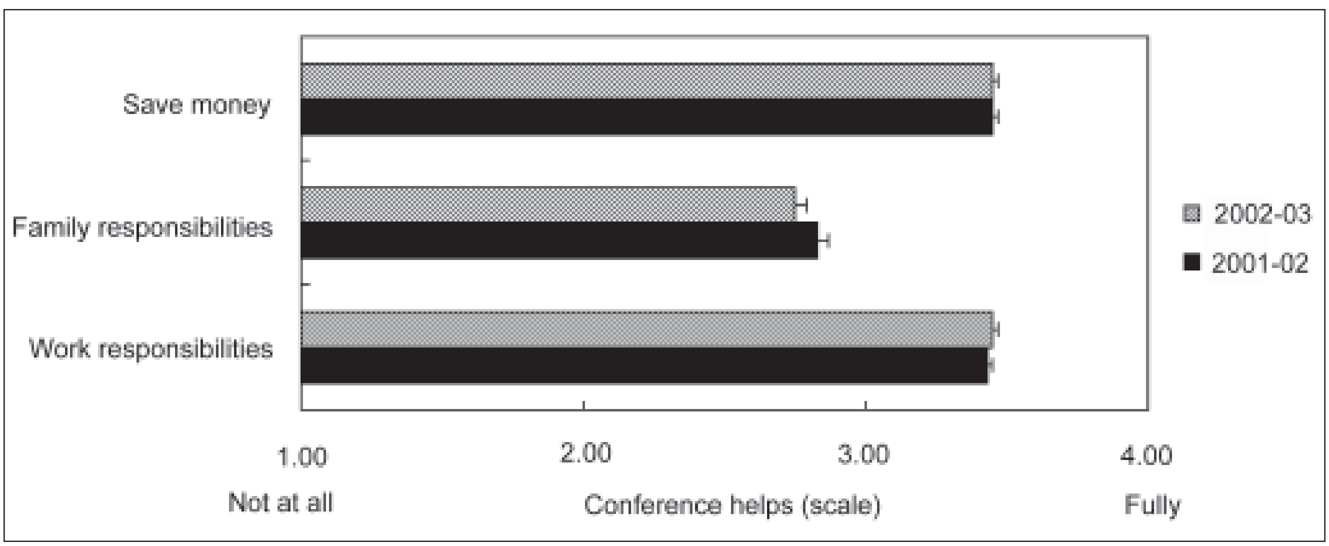

Figure 1—Ways video-teleconferencing technology helps the user based on evaluation data collected during the 2001–2002 and 2002–2003 seasons. Rated based on the scale of 1—does not help at all to 4—fully helps.

Table 3—Cost savings per dollar invested, per conference season, for time, mileage, meals, and lodging

	Conference season			
	2000–01	**2001–02**	**2002–03**	**2003–04**
	Dollars			
Time away from work	17.45	12.59	12.81	10.91
Mileage	3.67	2.62	4.44	3.44
Meals	1.51	1.65	1.31	0.52
Lodging	2.39	2.53	0.10	0.28
Total	25.03	19.39	18.66	15.15

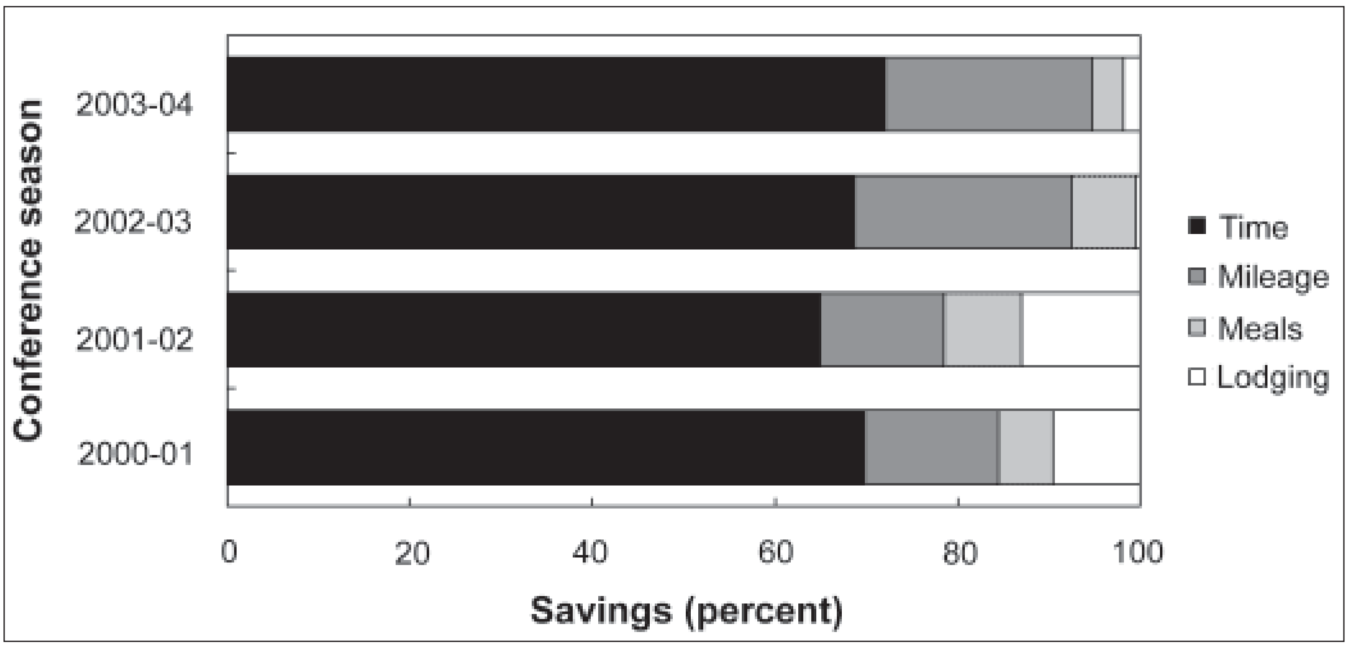

Figure 2—Percentage of savings per dollar invested, per conference season, for time, mileage, meals, and lodging.

Table 4—Cost to conduct one conference

Expense type	**Cost**
	Dollars
Administration	703
Supplies and materials	660
Printing/mailing/copying	703
Total cost	2,066

operating costs are similar to what it cost to deliver a traditional program of like content. Registration fees cover this nominal cost. Costs associated with broadcasting and receiving, which includes facility fees, line charges, and charges for broadcast and receiving services, have been covered by sources other than registration fees. If these costs were not covered, costs associated with broadcasting and receiving would range from $50 to $100 per hour depending on the site and would be approximately $3,000 per conference. To date, receiving sites have covered the fees associated with the facility and line charges. Because all of the conferences originate from the College of Natural Resources facility, broadcasting fees are currently covered by the College of Natural Resources at North Carolina State University. If the site fees were not covered by other sources, the registration costs would double from $30 to $60. Other costs that could raise the registration fee include costs associated with bringing in speakers and site hosts.

In 2003, a postevaluation was mailed to participants 6 months to 1 year after the conference season. The survey was used to gather data related to application of information received and impact on job skills. Review of the data indicates:

- 99 percent of the participants had an increase in their understanding of the subject matter.
- 98 percent of the participants applied information they received during the teleconference.
- 77 percent of the participants enhanced their job skills by attending the teleconference.

A word of caution though: the postevaluation is based on one season's worth of data and is a measure of short-term success; it is not a measure of the long-term impact the program has had on preserving or enhancing the client's well-being and long-term interest. Further evaluation is needed to understand the long-term impact outreach and extension programs delivered through distance education technology will have on the client's well-being and long-term interest.

Other benefits attributed by those involved in the forest issues series include:

- Providing a direct link between researchers and professionals who then put the research findings to work.
- Providing researchers the opportunity to receive direct feedback on findings, and the practicality of proposed new methods, and to obtain ideas for further research.
- Providing greater cooperation between faculty, governmental agencies, and external stakeholders.

Conclusion

The extension and outreach programs within the Department of Forestry and Environmental Resources have found the use of video-conferencing to be a cost-effective means of providing continuing education. The Forestry Issues Series has added another powerful tool to meet the demands of continuing education for natural resource professionals. The program has been instrumental in providing educational opportunities at a reasonable cost to participants. With participation in each video-conference continuing to rise and the administrative demands and legislative edicts for cost containment, cost-efficiency, and cost accountability continuing to grow, extension programs delivered through multipoint video-conference technology will continue to be used to meet future demands for continuing education.

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Challenges and Opportunities in Forest Restoration Outreach: The Example of Southwestern Ponderosa Pine Forests

Peter Friederici[1]

Abstract

The majority of forest managers, informed policymakers, and educated members of the public agree that restoration of dry, fire-adapted forests of western North America is a critical ecological and social need. A large body of scientific research documents how forests that were once open and parklike have grown dense with small trees, resulting in significant increases in fire hazards and declines in ecological values.

It has been difficult, though, to convert even detailed scientific understanding into effective results on the ground. Reasons include numerous economic and social hurdles, but also difficulties in translating research results into tactics applicable in the field. Ecologists often require many years before they are willing to identify causal relationships between specific restoration treatments and identifiable ecological results. Managers often demand immediate answers to ecological questions so that they can make pressing real-time decisions. Policymakers and the public are often unwilling to wait for peer-reviewed scientific results and want to know quickly whether economic, political, and social investments in restoration work are warranted.

This paper uses the example of the Ecological Restoration Institute's (ERI) outreach program to assess the difficulties and opportunities inherent in translating science into action. The ERI maintains a broad effort aimed at publicizing timely yet scientifically rigorous information about the restoration of Southwestern ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) forests. Through an ever-evolving combination of print and electronic publications, public outreach activities, and land manager workshops, we attempt to keep varied audiences abreast of the latest developments in the science and application of restoration work. This paper outlines a broad restoration outreach strategy and discusses challenges encountered as those working to improve the health of public-lands forests continue to expand the audience for their work.

Keywords: Forest restoration, ponderosa pine, Southwestern United States, outreach.

Introduction: The Complexities of Restoration

Ecological restoration is a fast-growing approach to the management of forests and many other ecosystem types in North America, and throughout the world (Arno and Fiedler 2005, Jordan 2003). Restoration, according to the Society for Ecological Restoration International (SERI), is "an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability. . . . Restoration attempts to return an ecosystem to its historic trajectory" (SERI 2004). Restoration can simultaneously return ecosystems to greater ecological health, make a positive contribution to the human economy, and enable people to actively participate in the management of natural areas near their homes. Yet, it is also a complex and often contentious endeavor (Jordan 2003).

Restoration is complex for several reasons. The scientific information on which it is based is always incomplete. Restoration is largely an effort to guide

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future management through knowledge of past conditions. Although researchers have many tools for plumbing the ecological past, our understanding of that past is always partial and often biased by preconceptions (Egan and Howell 2001, Landres et al. 1999). Even our understanding of how ecosystems work in the present moment is always incomplete. Managers seldom know as much as they would like to know about interactions among plants, animals, climate, geology, human activities, and other factors that affect ecological circumstances and, hence, their management decisions.

Restoration also is not a matter solely for scientists and for professional land managers. Rather, it engages broad segments of the public who are interested in conservation, recreation, resource-based industries, even the safety of their homes and neighborhoods (Cortner 2003). That breadth of interest can bring wide support to restoration projects but also instill a great deal of controversy when forest managers propose such actions as mechanical thinning or prescribed burning (Allen et al. 2002, Cortner 2003, Friederici 2003). The social landscape in which restoration takes place is often as complex as the ecological landscape. Restoration touches on questions of policy, economics, decision-making processes, and ultimately on the deep-seated values that people perceive in forests and other landscapes (Jordan 2003, Oelschlaeger 2003). For these reasons, restoration advocates cannot work in isolation; rather, they have a critical need to focus on outreach to the varied audiences and many people who are interested in the topic.

Case Study: Southwestern Ponderosa Pine Forests

In no landscape ought it to be easier to engage residents in the process of restoration than in the dry, fire-adapted forests of western North America, and especially in the ponderosa pine (*Pinus ponderosa* Dougl. ex Laws) forests of the Southwest (Arizona, New Mexico, and southern Colorado and Utah). Many lines of historical evidence have shown that these forests were once subject to frequent low-severity fires that maintained an open forest structure and a diverse understory of grasses, forbs, and shrubs (Allen et al. 2002, Covington and Moore 1994, Swetnam and Baisan 1996). With the advent of intensive livestock grazing, logging, and fire suppression in the late 19th and early 20th centuries, the regular cycle of frequent fires was broken. Fires vanished from many parts of the forest landscape for decades.

As a result, many of these forests grew dense with thickets of small trees. Today these stands and their associated large trees are at risk of severe stand-replacing crown fire that threatens human communities and the ecological integrity of the forest. They also are subject to severe bark beetle (*Dendroctonus ponderosae)* attacks. Other ecological values are at risk, too. Overly dense stands lose much of their herbaceous understory and, with it, the wildlife species that rely on it (Covington 2003). When dense ponderosa pine forests burn, stands are often replaced across hundreds or thousands of acres, causing erosion, loss of soils and wildlife habitats, and possibly long-term changes of vegetation type (Savage and Mast 2005).

Restoring these forests is, on the one hand, quite simple. They are still forests. Unlike the tallgrass prairies of the Midwest, to cite one example, most of them have not undergone a type conversion. Although some nonnative, invasive plants are a problem, most of these forests are still dominated by native species. Development connected with the region's quickly growing population is a concern, but vast acreages of dry forest will remain in public ownership and will likely continue as open space in the long term. Most Americans recognize their value for lumber production, for livestock grazing, for healthy watersheds, for recreation, for aesthetics, and perhaps, above all, for local economies that are increasingly based on natural amenities.

In addition, scientific understanding of the past structure of these forests is remarkably robust. These forests were settled relatively late in the history of the

United States. Good records—written and photographic—exist of their condition prior to alterations by novel land-use practices in the 19th century. In addition, the region's dry climate has preserved a great deal of physical evidence—such as stumps, fallen logs, living trees, and soil phytoliths—that documents historical forest conditions (Covington 2003, Fulé et al. 1997).

The management techniques required to return contemporary forests to conditions similar to those of the past are also relatively well understood. More, of course, always remains to be learned, but the effects of the two most commonly implemented restoration treatments—prescribed fire and mechanical thinning—have been heavily studied for years.

Perhaps most important, restoration of these forests is quite consonant with human needs and desires. Unhealthy dry forests are prone to enormous and dangerous crown fires that are detrimental to both ecological and human values. Healthy ponderosa pine forests burn frequently, but they burn at a low level of intensity that typically does not threaten human lives or property or such ecological values as the healthy functioning of watersheds. In addition, research on aesthetic preferences has shown that people tend to like the open-structured, spacious appearance of ponderosa pine forests resembling those that preceded the Euro-American settlement of the West (Daniel and Boster 1976, Ulrich 1993).

This fortuitous coincidence means that managers of ponderosa pine forests can shape the landscape into what most people want to see even as they improve its ecological health. Managers of western landscapes with very different fire regimes, such as lodgepole pine (*Pinus contorta* Dougl. ex Loud) forests or California chaparral, are not so fortunate. In such places, where severe, stand-replacing fires are naturally evolved, managers may need to make difficult choices between ecological integrity and public safety.

Despite the widely agreed-upon need for restoration, and despite the identification of enormous acreages of dry forest in need of restoration in the interior West (GAO 1999), the pace of work done has been slow. Why is this? Some of the most significant reasons for that failure are matters of policy and economics. Studies have shown that investing relatively small amounts of money in restoration can avert the spending of much larger amounts of money on fire suppression (Romme et al. 2003, Snider et al. 2003). But the federal government, which manages most of these forests, has generally been loath to invest federal funding in the precautionary restoration of forests before they burn, and indeed has at times taken money from fuels reduction projects that might contribute toward restoration and used them for fire suppression (GAO 2004).

As a result, restoration work has generally been completed only when some grant funding is available (as, e.g., through New Mexico's Collaborative Forest Restoration Program) or when private contractors are able to remove enough products of value from the forest (especially larger trees that can be turned into lumber) to compensate for the time they spend in removing the large numbers of small-diameter trees that make up the primary fire threat but are generally unmerchantable. The logging of larger trees almost inevitably stirs public controversy. In many places, as in Arizona, infrastructure is insufficient in the form of logging companies and mills to accomplish restoration work at even a slow pace.

But the slow progress of restoration can also be ascribed in part to shortcomings in education. The term "restoration" has entered the language of forest management and is often used to describe any activity that reduces wildfire danger or improves forest health—even if it does not truly restore natural conditions. As a result, managers often fail to take steps—such as seeding native grasses or conducting regular maintenance burns—that contribute to holistic restoration and can lower fire danger in the long term. Many homeowners who live adjacent to public forest tracts, assuming that the responsibility for avoiding fire lies entirely with public land managers, neglect simple steps that can contribute to the reduction of fire danger on their own property.

Policymakers who must try to balance manifold demands for attention and limited resources are seldom sufficiently informed about forest issues to make well-informed decisions. And members of the general public may be concerned, or simply confused, about the value of such restoration techniques as thinning and prescribed burning, both of which do carry negative side effects.

It is for these reasons that the ERI at Northern Arizona University (NAU) has implemented a broad outreach program.

Different Audiences, Different Learning Styles

A great variety of groups are engaged in forest restoration in the Southwest. In many places, restoration projects have been conducted as exercises in broad-based collaboration that involve not only traditional land managers but such stakeholder groups as environmentalists, industry groups, community groups, fire departments, and others (Friederici 2003, Kusel and Adler 2003, Moote 2003). In addition, restoration can be a wide-ranging, holistic, and interdisciplinary endeavor that engages the skills and imaginations of many people and organizations (Light 2000). Restoration advocates who seek to influence the debate about such projects must recognize that members of these disparate groups are accustomed to learning in different ways because of their background, educational training, and professional culture (app. 1). It is to match those different learning styles that the ERI has generated a variety of publications and educational outreach events.

Academic Community

Members of the academic community are more likely than members of other groups to educate themselves through reading—in particular, they constitute the only audience likely to spend much time reading primary research results presented in professional journals. The ERI has maintained a robust research program that has resulted in numerous publications in the pages of professional journals, conference proceedings, and books. It has also organized professional conferences for the dissemination of new research results. In addition, ERI faculty educate the next generation of forest researchers by teaching undergraduate and graduate classes in restoration through the NAU School of Forestry.

Land Managers

Typically strapped for time, land managers are unlikely to closely read professional journals, but they do have an interest in research results. The ERI synthesizes those results into short, easy-to-read publications called working papers (app. 2). Each one summarizes lessons learned by researchers and practitioners working on restoration projects. Each includes readily usable tips for improving project planning and implementation. In addition, the ERI conducts workshops and classes, both in the classroom and in the field, that give practitioners a firsthand look at forest restoration concepts, strategies, and techniques.

Policymakers

Policymakers have even less time to devote to researching issues than land managers do. They require very short summaries of issues requiring their attention. The ERI has prepared a series of fact sheets, generally one page long, on such issues as fire behavior and variable ecological responses to different thinning treatments. The impact of such materials has been greatly enhanced through personal contacts with decisionmakers. Such venues as field trips offer an excellent opportunity to convert forest restoration from an abstract issue discussed in black and white text to a visible management strategy that affects how real forest stands look and interact with their surroundings.

Community Groups

Throughout the West, many community groups and other stakeholders who are not professional land managers are engaged in restoration efforts. Their involvement may range from providing input into desired future conditions to active participation in the work of thinning, prescribed burning, seeding, or monitoring. Their level of education in forest ecology may be high or low. The ERI reaches such audiences through such publications as its working papers and a detailed series of handbooks about monitoring strategies and methodologies. In addition, it maintains a large Web site that provides a wide range of information, at varied levels of detail, about restoration ideas and methods. The ERI staff members also actively participate in the meetings of a number of collaborative community-based restoration efforts in Arizona and New Mexico.

General Public

Most restoration efforts take place on public land, and many are set in or near wildland-urban interface areas where many people live. Public involvement is crucial to the success of most restoration efforts, yet public understanding of the rationales for and effects of restoration work is often lacking. The ERI attempts to reach the public through the publication of brochures aimed at such groups as homeowners who live in forest settings. In addition, it has participated in numerous festivals, Earth Day and Firewise events, school science presentations, and other special events. Outreach to newspapers, radio, TV, and other local, regional, and national media is also important in reaching both the general public and decisionmakers.

Note that tailoring a message is a matter of adjusting **form** rather than **content**. Successful targeting of different audiences is not a matter of telling different stories, but rather of telling the same story in different ways. Summarizing what is known about historical fire regime patterns, for example, requires an entirely different vocabulary in an academic journal article and in a newspaper article. Awareness of those differences before setting out to write can save a great deal of time in rewriting—or trying to rectify miscommunications—later.

An Example of Restoration Outreach

Since the mid-1990s, the USDI Bureau of Land Management (BLM) has been conducting large-scale experimental restoration treatments near Mount Trumbull in far northern Arizona. Scientists from the ERI, Arizona Game and Fish Department, and other institutions have monitored the effects of those treatments on understory plant species, wildlife, fire behavior, and other variables. Those studies have provided great insight into the theory and practice of forest restoration and can inform future work if they are sufficiently publicized. How can this best be done?

The ERI has produced a variety of outreach materials intended to bring these results to the audiences listed above. We have done so by producing a hierarchy of publications that reflect the expectations of different readers. The first level of publications, arguably the most important, consists of peer-reviewed articles that present primary field research to a scientific audience (summarized in Waltz et al. 2003). These articles appear in journals such as *Restoration Ecology, Forest Ecology and Management*, and others. Such articles have wide currency in the academic community, yet those periodicals are generally not accessible to the general public and policymakers, and often not to land managers.

To reach land managers and members of other groups particularly interested in forest management—such as environmental organizations and regional community groups focused on ecology and economics—the ERI has produced several working papers that summarize lessons learned during the course of restoration research at Mount Trumbull. In some cases, those lessons have been based on experimental studies; in others, they have been based on anecdotal observations made about operational successes and failures. For example, measurement of the effects of a prescribed fire that killed an unexpected number of old trees resulted in recommendations to be careful about burning on volcanic cinders, which were published both in a journal read by fire professionals and in a working paper distributed to practitioners in the region in both print and electronic formats (Fulé et al. 2002, Minard 2002). Full citations of the primary literature are provided in the working papers so that readers can look up the original, peer-reviewed research.

Other publications address readers who would not read even a working paper. The ERI has prepared a number of one- or two-page fact sheets that summarize research results for time-strapped policymakers. These, too, include citations that enable readers to understand where the data mentioned come from.

In addition, the ERI has published a brochure for the general public that the BLM has distributed at its field office and at the restoration site. It provides a general overview of the work being done and explains what viewers may see as they tour the site.

All these publications represent efforts to bring relevant research to audiences in appropriate forms. It is important to note, too, that this hierarchy of publications is not confined to print only. Much of the same material is available on our Web site, from downloadable copies of original journal articles to short, illustrated descriptions of research sites and projects that might appeal to the general public. The same hierarchy of outreach styles applies in presentations as well: a presentation of research results to an academic audience at a professional conference will differ in style from a presentation to a community group or a group of regional decisionmakers such as state legislators or county supervisors–even if much of the content is the same.

The Challenges of Using Science in Policy

Moving between one audience and another, though, presents significant challenges. Some of the thorniest challenges in educating varied audiences about a complex land management practice such as restoration stem from the different expectations to be found among those audiences. Ecologists, for example, are notoriously cognizant of the complexities of the systems they study (Noss et al. 1997). They are acutely aware that it can take years of study to construct even simplified models of ecological processes; that forest dynamics may be very different at different sites; that the effects of interannual variability in climate (which can be severe in the Southwestern States) can easily mask the effects of restoration treatments or any other forest management practices; that whatever variables are under study are inevitably affected by another set that is not being monitored. They may be reluctant to draw inferences about other sites from their study of one locale; they may point out that the complexities of ecological interactions make it difficult or impossible to draw precise cause-and-effect conclusions from even years of study.

Yet those conclusions are exactly what land managers, policymakers, and the general public are after. All these groups are under pressure of various sorts to show results on the ground, especially when the issue at play is as attention-getting and volatile as fire behavior in public forests. Under pressure from their own constituents, both land managers and policymakers are apt to ask scientists for precise and prescriptive advice about what to do in the forests. Such advice is precisely what most ecologists are most reluctant to give.

Presenting research results in a timely fashion, and in a format easily accessible to land managers and policymakers, is also often made difficult by the proprietary interest researchers have in their results, which are, after all, the result of a good deal of hard work. Academic researchers, in particular, are under consistent pressure to publish their results in respected, peer-reviewed professional journals. Publication of results in such formats as working papers or general-interest publications is often either frowned upon or entirely neglected when it comes time to review academic records for the approval of tenure or changes in job status. Most academic institutions are simply not structured to provide quick summaries of current research results to the land managers and other practitioners who have the greatest immediate need for them. Yet publication in peer-reviewed journals can take a long time, and even after publication, results may filter only slowly—or not at all—into formats accessible to those outside the academic community.

It is in large part because ecology is a complex science and drawing precise conclusions from it about management practices is so fraught with difficulty that debates about an endless array of management issues have come to be dominated by competing scientific claims (Cortner 2003). The scientific basis for practicing restoration in Southwestern ponderosa pine forests is excellent, but advocates can often buttress widely competing ideas with findings that seem to support one particular management practice or another. For example, it has been well established that Southwestern ponderosa pine forests burned often before the onset of livestock grazing and widespread fire exclusion (Allen et al. 2002, Covington and Moore 1994, Swetnam and Baisan 1996), yet reputable researchers have questioned the generally accepted methodologies that have helped lead to those conclusions (Baker and Ehle 2001).

Ecologists, like many other scientists, are also often reluctant to enter debates about land management because they are understandably worried about being misquoted or having their work taken out of context. Scientific results are almost invariably skewed or oversimplified when they enter public discourse. Newspaper and television accounts are rife with hyperbolic rhetoric; it is common to hear about enormous acreages “destroyed” by fire when in fact almost all fires burn in a mosaic of different severity levels, and when high-intensity fires are in fact crucial to the health of certain forest types (Smith 1992). Politicians and advocates of all positions are apt to oversimplify debates about any land management issue.

In light of this, it is incumbent on those charged with educating any audience about such questions to be both accurate and precise. When discussing forest fire, for example, it is critical to point out that different forest types have very different fire regimes. When discussing historical reference conditions, it is vital to delimit the discussion to the appropriate geographic area or ecosystem type. When deciding what sort of terminology is appropriate, it is important to be very judicious in the use of such politically loaded phrases as “old-growth tree” or “catastrophic fire.” In general, it is vital to carefully “translate” precise scientific terminology into language that other audiences can readily understand. Some simplification is generally necessary in order to discuss ecology in a way that is meaningful to land managers or the general public, but too much simplification is a disservice. Finding the right degree of simplification requires finesse and good judgment.

Conclusion

It is certainly possible to provide good information in a way that makes a difference. Our goal, as interpreters of science, should be to disseminate information so that those who make decisions—which in a democracy should include everyone from high officials in Washington, D.C., to professional land managers to lay members of the public—have the best possible background for making their own decisions. The results of those decisions may not always be what we ourselves would have chosen, but if they are based at least in part on good science, they will likely be far better than if they are based on no science at all.

If ecological restoration is a matter of returning an ecosystem to a healthier trajectory, then we might think of science education as the practice of slowly placing public decisionmaking on a trajectory that over time gives more weight to good science. It’s an evolving practice, never completed, but one that is crucial to the future health of our lands.

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Appendix 1—Principal target audiences for restoration outreach materials, and how they learn

Audience	How learning happens
Scientists	Peer-reviewed journals
	Professional conferences
	Personal contacts with other researchers
Policymakers	Lobbying
	Media
	Constituent input
	Fact sheets
Land managers	Some publications
	Personal experience
	Professional training at national, regional, and local levels
	Constituent input
General public	Media: TV, radio, newspapers, Web sites,
	Magazines
	Events
	Brochures and other publications
	Word of mouth

Appendix 2—Working Papers published by the Ecological Restoration Institute

- Restoring the Uinkaret Mountains: Operational Lessons and Adaptive Management Practices
- Understory Plant Community Restoration in the Uinkaret Mountains, Arizona
- Protecting Old Trees from Prescribed Fire
- Fuels Treatments and Forest Restoration: An Analysis of Benefits
- Limiting Damage to Forest Soils During Restoration
- Butterflies as Indicators of Restoration Progress
- Establishing Reference Conditions for Southwestern Ponderosa Pine Forests
- Controlling Invasive Species as Part of Restoration Treatments
- Restoration of Ponderosa Pine Forests to Presettlement Conditions
- The Stand Treatment Impacts on Forest Health (STIFH) Restoration Model
- Collaboration as a Tool in Forest Restoration
- Restoring Forest Roads
- Treating Slash After Restoration Thinning
- Integrating Forest Restoration Treatments with Mexican Spotted Owl Habitat Needs
- Effects of Forest Thinning Treatments on Fire Behavior

Why Good Ideas and Good Science Do Not Always Make It Into the Marketplace

Charles R. Frihart[1]

Abstract

Good ideas and good science are not sufficient in and of themselves for successful commercialization of new technology. Understanding the barriers to commercialization so that ways around, under, over, or through them can be found is also crucial to success. Barriers can include market needs, technology push versus market pull, availability of a window of opportunity, economics, and risk aversion. A good starting point is to understand how the technology will fit in with a potential customer's operation. Pushing technology usually is not successful because of customer concerns about new products and processes; however, semitechnical education of the end user is an effective way to build market pull. Evaluating the economics of new technology is important not only to comprehend the potential of the new technology, but also to understand the most effective use of resources in the technology development. Risk aversion on the part of the customer often overrules the potential economic benefits of a new technology in the decisionmaking process. To address these issues, many corporations have established stage-gate and portfolio-management processes. These concepts can be used effectively even without the establishment of a formal process. Both successful and unsuccessful new products and new processes are provided to illustrate these issues and the ways to solve them.

Keywords: Barriers, economics, risk aversion, technology push, market pull, stage-gate.

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Introduction

As technologists, our main goal is to develop a specific technology and then to work on turning it into a commercial success. The problem with this strategy is that it often leads to technical success but no real implementation, causing great frustration for the scientist. It is unnecessary to list examples of failed technologies here, as many of us are familiar with these from our own experience. Rather, it is more important to consider the potential hurdles from invention to commercial success, evaluate which ones are likely to limit or be fatal to technology implementation, and then address them as early in the development process as possible.

Although many articles have been published on the subject of technology development and implementation (Google® identified 73,300,000 citations, including 94,000 books), the information seldom seems to fit a person's particular program. For example, a roadmap developed for crossing the Great Plains is unlikely to be useful for the Rocky Mountains. Each technology has its own unique hurdles, whether it be rivers, lakes, swamps, or mountains; thus, each technology needs it own roadmap. By thinking through the entire process beforehand, a good roadmap can be developed and used to avoid ending up frustrated in a dead-end canyon or standing precariously at the edge of a mesa.

Large organizations are able to use strategies, such as stage-gate processes and portfolio management, to make research more profitable by concentrating on the technologies that offer greater payouts, higher chances of success, and lower risk to the organization. For most organizations, such formal processes are too cumbersome. However, the technologist can apply some of the thought processes that have gone into developing these formalized methodologies in a less formal manner.

This paper does not intend to design an exact pathway but rather to list factors that should be considered and addressed throughout technology development and implementation. Although this author's area of expertise is organic chemistry, the rules are based on more general principles and will transfer across most market segments. Note that these comments apply more to typical manufacturing industries than to those that depend on new products for survival.

Understanding Needs

It seems obvious that in developing a product it is important to meet the needs of the marketplace. However, information on exactly what is needed can often be difficult to obtain for several reasons. First, technical people are usually not directly in touch with potential end users of the technology. Second, customers may not realize what new technology they need. Third, although the new technology may seem to have a market fit, it may not actually be the best available.

The separation of technical people from end users leads to an unclear idea of what is needed for a technology to succeed. Some routes for information transfer are illustrated in figure 1. Every step in the transfer of information—from the end user of the technology to the person developing the new technology—serves as a place where information may get filtered and distorted. Although technical service, sales, and marketing people are very good at what they do, they tend to think of products from the viewpoint of current technology. In concentrating on their job, they simply fail to record information that is important for the development of a successful new technology. In many cases, they may not understand the information provided as it relates to more sophisticated or longer term applications, and they seldom have the background to brainstorm with customers on developing new technology. Finally, they are rewarded for current sales and have no incentive for time spent on sales that would not take place for 5 to 10 years.

Even if technical people can have direct contact with users of the technology, customers may not always know what they actually need. As packaging for pet food and fertilizer changed from plain to printed bags, the packaging companies encountered problems with the adhesives for sealing the bags. They requested better adhesives to bond the printed surfaces. In many cases, however, the adhesives stuck very well to the ink film, but the ink film did not adhere well to the bag. Thus, what was needed was a better ink, not a better adhesive.

Even if we can develop seemingly suitable technology, it may still not be the right technology. Many companies developed waterborne adhesives and inks to replace solventborne products, figuring that companies would switch for environmental reasons. In some cases, the waterborne systems were accepted in the marketplace, but in other cases the waterborne technology was not a commercial success for a number of reasons. First, few and less stringent regulations have been put into place than once feared; thus, many operations still use solventborne systems. Second, there has been a general realization of the paucity of a market for environmentally friendly products that cost more or have lower performance. Customers will not buy an inferior product for the same price. Paper companies learned this lesson in the recycled paper market by having to spend considerable amounts of money on additional technology and equipment so that the recycled fiber would meet standard paper specifications for brightness. Third, companies found other ways to solve environmental issues. Many printing operations continue to use solventborne inks with collection and recycling of the volatilized solvent, rather than trying to solve the print quality and slow drying problems associated with waterborne inks.

Regulations have a major impact on technology implementation. An important benefit of dealing with potential customers early in the development of a product or process is to learn all the regulations that must be

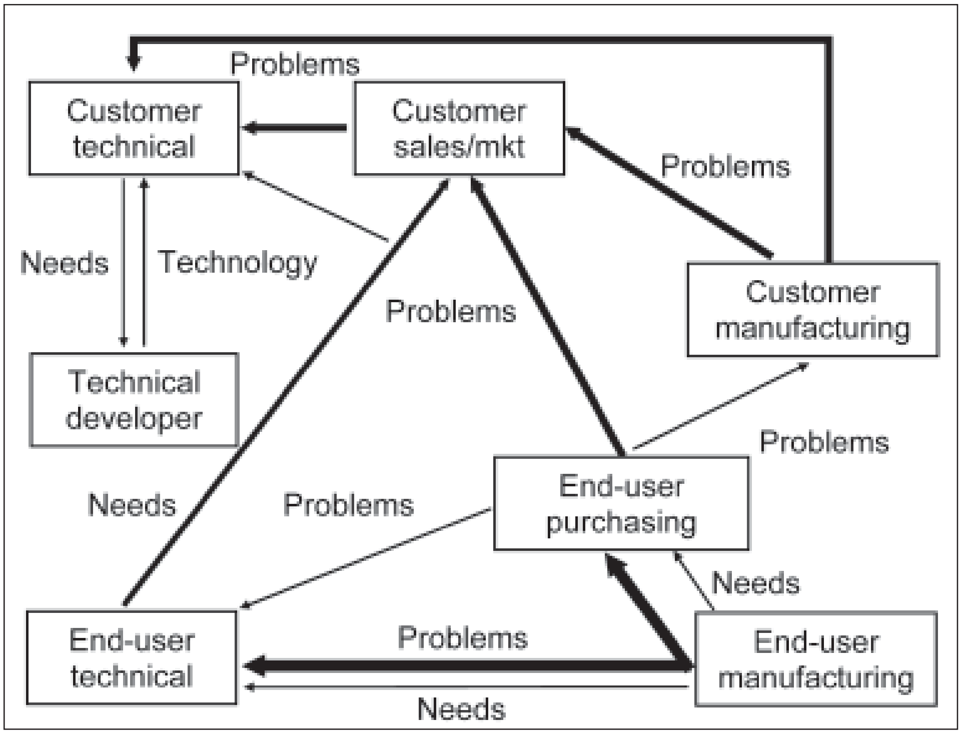

Figure 1—Information transfer between technical developer, customer, and end user is complicated. Problems flow back through the system quickly and with great emphasis. Needs are less likely to flow back through the system because of filters.

balanced to run the business. Does the new technology positively or negatively affect the company's ability to meet these regulations? This includes not only product performance, but also air and water emissions and disposal of byproducts.

How do we address these issues? Nothing replaces direct contact between the person developing the technology and the potential users of the technology. If at all possible, visit the customer's technical staff, the plant's production and technical personnel, and key marketing and business personnel. If the immediate customer's product is sold to another manufacturing operation, it is equally important to visit these people in that operation as well.

In addition, many users of new technology may be outside the company's current customer base. How can relationships be built with these potential customers? Attending meetings and conferences is crucial for cultivating relationships with technical people in other companies. However, it is also important to attend meetings that are attended by users of the technology. If you are trying to promote a wood adhesive, note that more adhesive users are likely to be present at a wood products meeting than at an adhesives meeting; in addition, these meetings are important for finding out the limitations of current products and discovering new products.

Leveraging can take place by looking outside your immediate field. Union Camp developed a gel candle business because technical personnel in the Bush Boake Allen Division that made fragrances worked together with technical personnel in the Chemical Products Division that made gellants from fatty acids. Together they made a unique product that was presented as a concept to the specialty products industry and was commercially implemented.

Aspects to Implementing New Technology

Market Pull Versus Technology Push

An important aspect of marketing new products is understanding the difference between technology push and market pull. Assume that we have developed a wonderful new adhesive technology for stronger engineered lumber. The standard model is to promote the technology to an adhesive company. If this company decides the technology is interesting, then it will need to convince an engineered wood producer to develop a product using the new adhesive. If the engineered wood producer decides to market the new bonded lumber, then its sales team will have to convince a builder to use it. Each step of the technology push involves convincing technical, sales/marketing, and business people in each company, and the developer of the adhesive technology generally has control over only the first step of the chain.

On the other hand, if you work with a major builder to show the economic advantage of a new engineered lumber, you are using market pull. When the builder asks the supplier for the improved engineered lumber, you can bet that this project will get priority with the engineered lumber producer, as well as with the adhesive supplier.

Because we are technical people, our emphasis is almost always on technology push, rather than market pull. The problem is that this route is often like pushing a rock up a steep hill; we are likely to be run over if we are not always pushing hard. With enough hard work we may convince the technical personnel at another company of the advantage of this technology, but generally these people have the least influence on product direction. The sales and marketing personnel are the most influential, and production personnel are second. Technical push can work if you are providing a product or process that falls within a company's current business strategy for new products. If the company has decided to make a composite that has no formaldehyde emissions, then the technology for a formaldehyde-free adhesive is more likely to be readily accepted.

On the other hand, market pull uses other people, in particular the customers of your target company, to help get the rock up the hill. Thus, you first convince the users of composite panels that the new adhesive will provide them an advantage. They will then pressure the composite manufacturer to use the adhesive technology, and the composite manufacturer will in turn put pressure on the adhesive manufacturer to implement the technology. As mentioned before, it is important not only to understand your customer's operations but to also understand your customer's customer's operations. Plus, the contacts that you develop in assessing market needs can be used later in developing market pull.

Technology push can work, but it is better if it can be combined with market pull. The benefit of working both routes can be illustrated in Ikea's interest in environmentally friendly wood products. Knowing Ikea's interest, a panel producer could approach their adhesive supplier and ask for a low- or non-formaldehyde-emitting panel product. The adhesive supplier may indicate that it can supply a low-formaldehyde product that meets the German E1 emission class or the more recent Japanese standard, but it may also indicate that there are no suitable adhesives for panel products that have no formaldehyde emissions. Thus, if an adhesive can be developed with no formaldehyde, then promoting this technology with both the adhesive manufacturer and the panel producer would greatly increase the likelihood that the technology would be accepted.

Window of Opportunity

Window of opportunity is the time in which the market is open for new technology. The window opens as a result of changes in regulations, economic forces, or consumer interests. The window generally closes when technology is implemented to meet the new market demand, the altered economic forces are no longer present, or consumer interest changes to something else. Concerns about formaldehyde emissions led to regulations that limited emissions. Changes in adhesive formulation then led to fulfillment of the regulations and closed the opportunity for other adhesives. Surging gas prices led to increased sales of more efficient automobiles and trucks, but the demand for these vehicles decreased as gas prices declined. The success of environmentally friendly products often depends on consumer interest at the time.

The appropriate technology generally needs to be created prior to the need because technology development takes too long to fit into a window of opportunity. Therefore, it is important that new technology development is accompanied by foresight. After agreeing to limit the use of wood treated with chromated copper arsenate (CCA), companies needed fully developed technology that wood treaters could use immediately. Prior to this agreement, however, it was difficult to convince managers, marketers, and sales staff of the need to develop alternative treatments. As soon as the window opens, the technical person must have the alternative ready to go. Market anticipation is a valuable skill for any organization.

On the other hand, technology developed before a window of opportunity opens often has to sit until the window opens. No matter how hard you push, alternatives that are costly or do not improve performance are not likely to be used as long as the current product is acceptable in the marketplace. Thus, in the case of treated wood, companies had known about alternative products such as copper azole or alkaline copper quat (ACQ) for a long time, but these products could not compete against CCA-treated wood on the basis of price or performance. The reduced use of CCA-treated wood opened the window for other treatments to enter the marketplace.

Of all the factors affecting new product success, the window of opportunity is the hardest to plan for because it involves some event or series of events over which the developer of the technology generally has little control. The technical person has to realize beforehand that a window may open and have the product ready for implementation in a short time. Again, market anticipation is important for success. On the other hand, educating the customer about the benefits of a new technology can sometimes open a new window of opportunity or accelerate the opening of a window.

Not every technology is highly controlled by a window of opportunity. After all, we continue to await a better mousetrap because mice and rats continue to invade our living quarters. The current traps work, but if a better trap comes along it will no doubt succeed, as long as it offers some distinct advantage to the customer.

Economics

It seems obvious that economics is an important issue for implementing new technology. However, economics often gets deferred until late in the development process because technical people are often not trained in economic calculations and generally have insufficient information to calculate the detailed economics of a new process. Nonetheless, it is important to do the best possible economic evaluation from the beginning of technology development and to refine the evaluation as process development continues and more information is gathered. The primary reason for this evaluation is that it makes little sense to develop a process or product for which the economics are highly unfavorable. Secondary reasons are that economics can indicate which areas of research are most important and can be useful in promoting the technology. Without a good idea of the economics, it is difficult to promote any technology and impossible to prioritize research and development projects.

How do you conduct an economic assessment? The four main factors to consider are the net worth of the material, production labor costs, indirect costs, and capital costs.

Net worth of material—
The net worth of a material is the easiest of these factors to estimate and can initially be used to select programs

with a chance of success compared to those that are clearly uneconomical. The simplest calculation involves the price per one unit of the product minus the cost of the raw materials required to produce that unit of product. This figure is then adjusted by the value of the byproducts (either credit or debit). For uncertain values, use your best estimate and see what happens to profitability when this estimate is varied by a 10 percent, 20 percent, and 30 percent increase or decrease. If the cost of the product is more than the expected sales price or profitable only by taking the most optimistic case, your efforts are probably better spent elsewhere. These calculations can also help focus the development process on the issues that will provide the greatest reward. How critical is it to improve product yield, or to find value for the byproducts, or to find a lower cost raw material? Many processes suffer from the low or negative (pay for disposal) value of the byproducts. The fermentation of corn to produce ethanol can leave a byproduct of lesser value than that of the raw material, which drags down the overall economics of the process. The net worth value of the material needs to be very positive because the production, indirect, and capital costs need to be subtracted, as illustrated in figure 2.

Production labor costs—
Production labor costs can be the most significant part of total production costs because for most companies, labor costs are the largest expense and represent the greatest cost difference between production in developed and underdeveloped countries. Most companies are willing to spend capital money to reduce labor costs, as evidenced by the purchase of equipment ranging from mechanical tree harvesters to automated production lines. Other production costs such as utilities are often less critical, but they can be a significant factor if, for example, a large amount of water is evaporated as in the drying of wood or manufacture of paper.

Indirect costs—
Indirect costs are usually dominated by management, sales and marketing costs, and, in some cases, by research. If the new technology fits within the customer's current operation and markets, it has little or no effect on these costs. On the other hand, new product lines in new markets require additional staff and result in higher indirect costs to the organization.

Capitol costs—
Capital costs can be a significant factor. The way to keep these costs at a minimum is to develop technology that fits within the organization's current processes, both for the equipment used and for maintenance of the current production rate. Any new equipment will need to pay for itself in a short timeframe and will have to compete against other capital expenditures within the company. Any decrease in production rate is doubly detrimental because less total product is created and consequently less total output per worker. On the other hand, an increase in production rate is of interest to both management and production. A brand new process for pulping wood can have many advantages but it often requires new equipment, which means scrapping much of the invested capital currently in use.

Gathering of economic information—
How is economic information gathered? Information can be obtained from many sources, depending on the specific new product or process. The best source is to work closely with a potential customer and its customer(s), who often provide general price information once you have developed rapport. Many government agencies, including extension services, and local business development groups have information on economics or can provide contacts. In some cases, multiclient studies are available.

Companies are in the business to make money. Why would they want to waste their time and money on processes or products that will not improve their profits? The less you understand about the economics of the

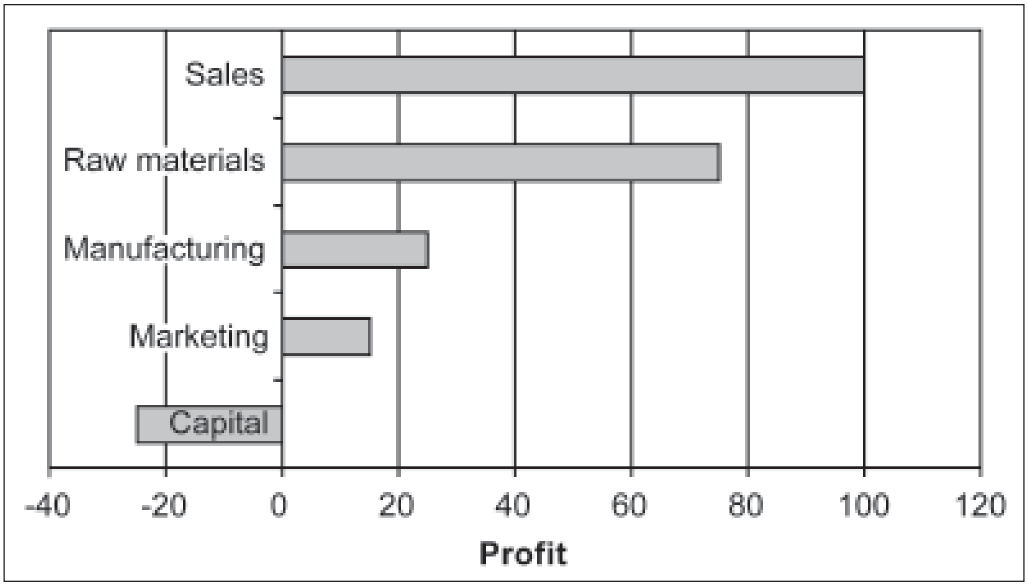

Figure 2—The economics of introducing new products: profit diminishes with each additional factor. To be viable, it is best to minimize the cost of each step. If capital expenses are significant, it could be worth spending efforts on reducing capital costs at a higher production cost for a new product until the technology is proven.

technology that you are promoting, the lower your creditability with the potential user of the technology. The additional benefit of starting an economic evaluation as early in the process as possible is that it can help direct the research to improve the economics of the technology.

Risk aversion

Risk aversion is the least appreciated aspect in implementing new technology and is often the overriding reason that new technologies are not implemented. After investing a lot of time and money, what happens if the technology does not meet the target expectations? Will major customers be lost because the new product does not meet expectations or because the customer does not foresee higher value from the new product? Has plant output been slowed because of scale-up issues or equipment problems related to the new product? Will the variability of the feed or production equipment lead to low-quality products or low product yields? And so forth.

Companies are always concerned about losing a major customer if the new technology does not live up to expectations. Consequently, sales and marketing staff tend to stick to the status quo. They often do not understand the technical benefits for the company and for their customers. Education is crucial—even to the point of dragging company reps into the lab or plant so that they can appreciate the new technology. A fair amount of time and effort is sometimes required to develop a way of communicating the technology to nontechnical people, but it is better to have these people working with you rather than against you. We had developed a way to reduce the perception of odor in one of our products, but the technology was stalled within our company owing to management objections. This was solved by getting the marketing manager involved with the project from the scientific perspective. A blind odor evaluation by the marketing manager convinced him of the value of the technology and led to its presentation to our customers, ultimately leading to commercial implementation.

Like sales and marketing personnel, production people generally like the status quo. They know how to deal with the current process, even if it has problems. They are concerned about new technology because they will need to learn how to make adjustments when things go wrong, as they often do. By understanding how things are done in a plant, you can try to direct new technology so that it requires the least change from existing operations. It is also important to develop processes that are the most robust, that is, the least influenced by changes in materials and conditions.

Risk aversion is an extremely important issue in the implementation of new technology. The best way to deal with it is to understand why people are afraid of change and then to make sure that you minimize the effect by educating all the right people and making your process as robust as possible.

Ways to Implement New Technology

Stage-Gate Methodology

The discussion thus far has been on specific areas of concern that need to be considered in developing and implementing new technology. Many large corporations have put into place formal systems to evaluate where to spend research dollars. These systems have been called by various names, but stage-gate seems most appropriate. This system places evaluation gates at set places between the initial idea and final implementation, as shown in figure 3.[2] At each gate, the technology receives greater scrutiny to correspond to the greater commitment of corporate dollars and staff power to the technology. These processes are highly formalized and require too much time to be useful for many organizations. On the other hand, not using this methodology leads to research and development time spent on projects that have little chance of success. Even if a formalized process is not used, the more knowledge that people have about technology assessment, the better they are at planning and developing new technology.

The benefits of looking ahead at future stages are to determine the hurdles before they become a major problem and to learn, before investing a lot of resources, if a hurdle is likely to kill a project. An example of a project killer is trying to use a natural material that is available only in low volumes for a large-volume market. A similar problem is using a natural material that has high variability in its composition, which could lead to major difficulties in converting the material into a consistent end product.

Another advantage of looking at all steps of new technology implementation is that it becomes evident what resources and additional expertise are needed. Using the expertise of others is important to efficient technology development. If at some point technology development requires a process engineer or a marketing person, then why not involve such staff early on so that they can provide insight into critical parameters? It is generally better to address these issues in the beginning stages rather than modify the process because a critical hurdle cannot be solved by the current technology.

Portfolio Management

Large companies go beyond stage-gate methodology to portfolio development to allocate resources between short- and long-term programs and to decide upon individual projects within these programs. It is beneficial for some of the same concepts to be used within smaller organizations. One of the greatest challenges in research is to determine when an individual program should be terminated as a result of some hurdle—technical or business—that cannot be overcome or would require too many resources to overcome. Evaluating a variety of research programs allows you to determine if there are better places for developmental efforts.

[2] Cooper, R.G. 1993. Winning at new products. Accelerating the process from idea to launch. Reading, MA: Addison–Wesley Publishing Company.

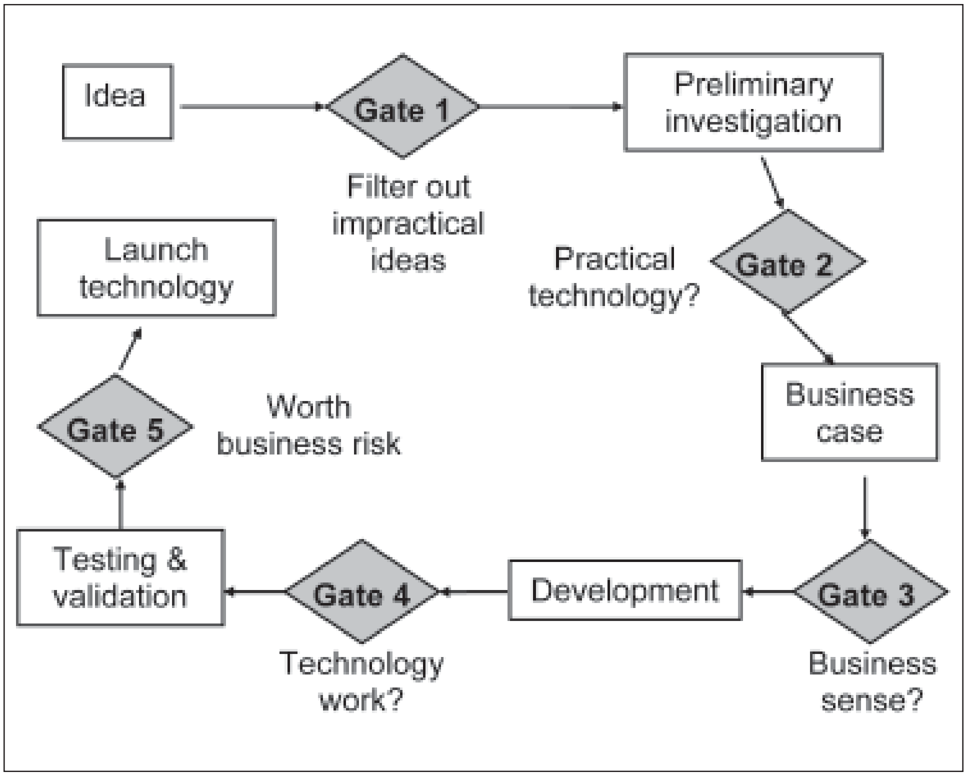

Figure 3—Stage-gate evaluation: each gate serves as place to filter out projects with less chance of success.

Concluding Remarks

The successful implementation of technology depends on many factors other than the quality of the technology itself. It is important to understand these other factors early in the development process to give the new technology the best chance of success. First, it is necessary to obtain a clear understanding of the customer's real needs, not just perceived needs, by close interaction with both the direct customer and that customer's customer. Second, by working with the end user as well as the direct customer, you can exert an influence on both technology push and market pull.

Even if you maintain close interaction with customers, many hurdles can stall technical implementation. For many technologies, there is a window of opportunity when new technology is most likely to be implemented as a result of changes in regulations, outside economic forces, or market demand. Evaluating the economics of the technology is too important to postpone until the technology is developed. Early economic evaluation with refinement as more information is developed can be a strong asset in determining the most critical issues in technology development and in presenting the technology to potential customers. However, even technologies with good market needs and economic potential can have their implementation stalled by risk aversion.

Stage-gate evaluation and portfolio management are formal processes for evaluating where to put research resources. Although these methods may be too formal for most uses, the thought processes used in developing them can help to ensure that key hurdles are considered early in the process and that ways to overcome the hurdles are incorporated into development.

Technology transfer is not something that should be considered after a technology has been developed. It should be integrated in the development process itself. You are unlikely to be successful at chess if you think of the opening moves and the checkmate as disparate entities rather than integral parts of a complete plan. Why should technology development and transfer be any different?

Acknowledgments

Too many people were instrumental in my years at Union Camp for me to thank each individually. I do want to single out Bill Trice, Robert Lazar, Tony Montgomery, and Mark Pavlin for their large contribution to my understanding of taking technology from the laboratory bench to commercialization.

Photomonitoring

Frederick Hall[1]

Abstract

Photographic documentation (photomonitoring) of research studies can be used to illustrate measured changes and to introduce results to people unfamiliar with the topic. Photomonitoring means repeat photography at selected photopoints under strict methodological constraints in order to document and quantify change. Photomonitoring grid analysis provides a numeric index of change over time. Accurate photo replication requires the use of a meter board at the photopoint to identify the topic, orient repeat photographs, and provide a measured reference for grid analysis of change. Most importantly, the distance from camera to meter board at the photopoint must remain the same for all repeat photographs, so both camera location and meter board must be permanently marked at each photopoint. Effects of different distances and camera lens focal lengths are illustrated, and use of a grid for measuring change is shown.

Keywords: Monitoring, photography, change.

Introduction

Photomonitoring is a method of repeat photography that provides a numeric index of vegetation at a specific site. The index is not an estimate of vegetation profile area, but, rather a method of numerically documenting change. Repeat photography uses a system of photopoints to illustrate what a measurement sampling system is characterizing, or to document change in soil or vegetation over time. A photopoint is a permanent location where the camera site and meter board are permanently marked. It has particular value in showing how a treatment has modified vegetation or soil conditions (Hall 2001, 2002).

Components of Photomonitoring

Photomonitoring depends on the precise replication of repeat photography at selected photopoints. Precise replication requires (1) a map to find the sampling location; (2) a map of the photomonitoring layout; and (3) documentation of the monitoring system to include purpose, camera type, season, repeat schedule, sampling system, and equipment.

Replication requires use of a meter board to mark the topic of interest. The meter board is a board 1 m tall marked in decimeter increments. It is used to orient the camera by placing the "1M" on the top of the board in the center of the original and all repeat images. It is also used to focus the camera for maximum depth of field, and it can provide a measured reference for grid analysis of change. Figure 1 contains samples of meter boards.

The Distance Factor

An essential characteristic of replicable photomonitoring is unchanging distance from camera to meter board between repeat photographs at a given photopoint (Hall 2001). Figures 1 and 2 illustrate this requirement. In figure 1, both camera lens focal length and distance to the meter board are adjusted to make the meter board the same size in each photograph: 50 mm at 10 m distance and 35 mm at 7 m distance. Each of the items is outlined on clear plastic overlays as follows: "50-mm @ 10m" outlined in a solid line and "35-mm @ 7m" outlined in a dotted line. Note differences in backgrounds even though the meter boards are the same size.

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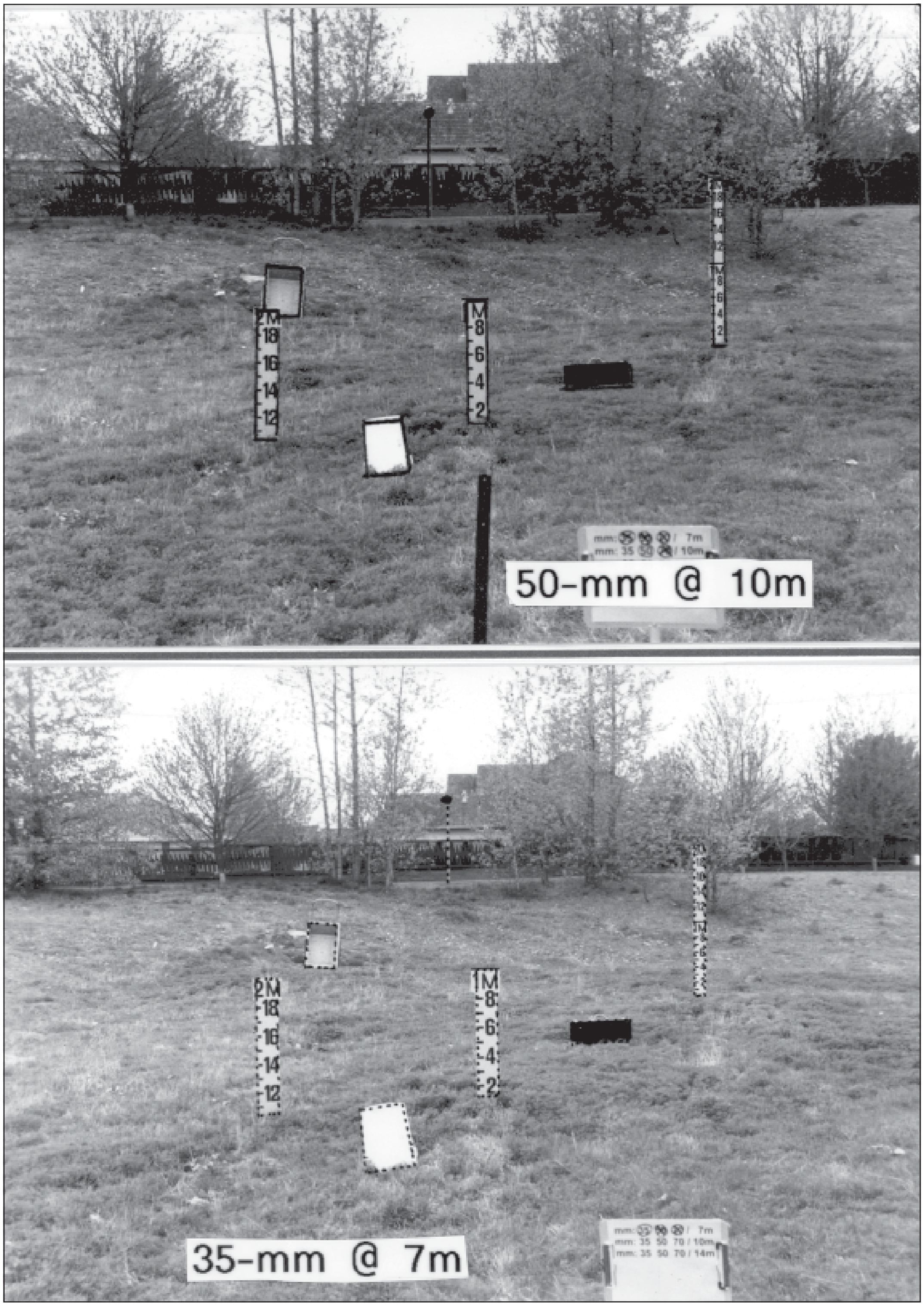

Figure 1—Different camera-to-meter-board distances and different camera focal lengths.

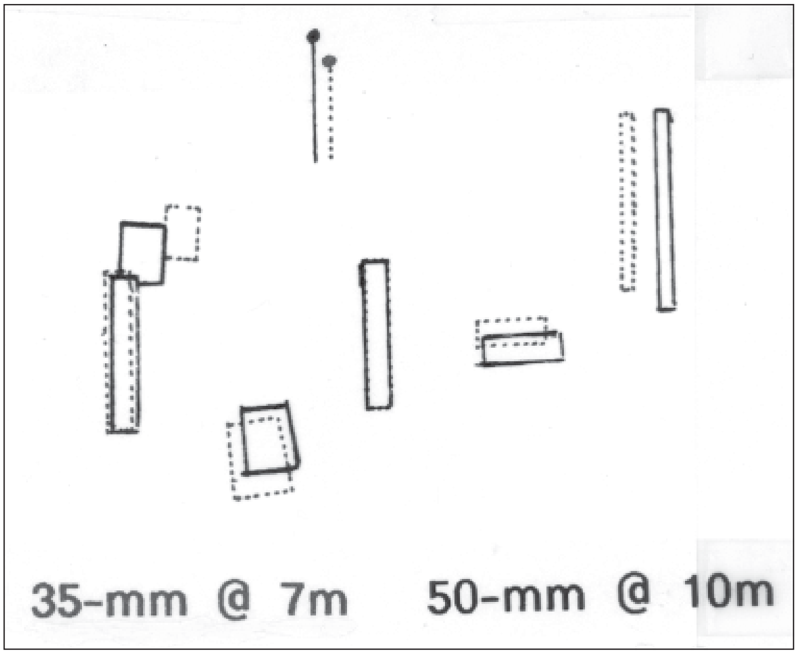

Figure 2—Object comparison, different camera-to-meter-board distances.

Figure 2 compares the object outlines. The outlines from both photographs in figure 1 are overlaid to evaluate the effects of camera focal length and distance from camera to meter board on size and location of objects. The overlays for “35-mm @ 7m” and “50-mm @ 10m” show different sizes and locations of the same objects in front of, and behind, the meter boards even though the meter boards are the same size. If the distance from camera to meter board changes from one photograph to another, the size and location of objects changes from one image to the next. This is because geometric angles from camera to objects change as distance changes. If objects in photographs are to be measured for change, distance from camera to meter board must remain the same.

To keep the same distance, both the camera location and the meter board must be permanently marked with steel stakes or fence posts for each photopoint. Steel is preferred because it is easily detected by any inexpensive metal detector.

Figures 3 and 4 demonstrate that although distance from camera to meter board must remain constant, camera focal length is a correctable factor. Fortunately, the same camera lens focal length is not required for subsequent photographs. This is a highly desirable feature because many inexpensive digital cameras have zoom lenses that cannot be set to a specific focal length (Hall 2001, 2002). Images in figure 3 appear different because focal lengths differed (35 mm and 50 mm).

Figure 3 demonstrates the differences between camera lens focal length of 50 mm and 35 mm at 10 m distance from camera to the meter board. Objects in each photograph are, again, outlined on clear plastic overlays and adjusted in size to the 50 mm lens at 10 m as follows: (1) the meter board in the “50-mm @ 10m” photograph is measured at 20 mm and the meter board in the “35-mm @ 10m” photograph is measured at 14 mm; (2) the percentage of enlargement for 35 mm is calculated as: 20 ÷ 14 = 143 percent. The 35 mm at 10 m distance outline is enlarged 143 percent and compared to the 50 mm at 10 m outline in figure 4.

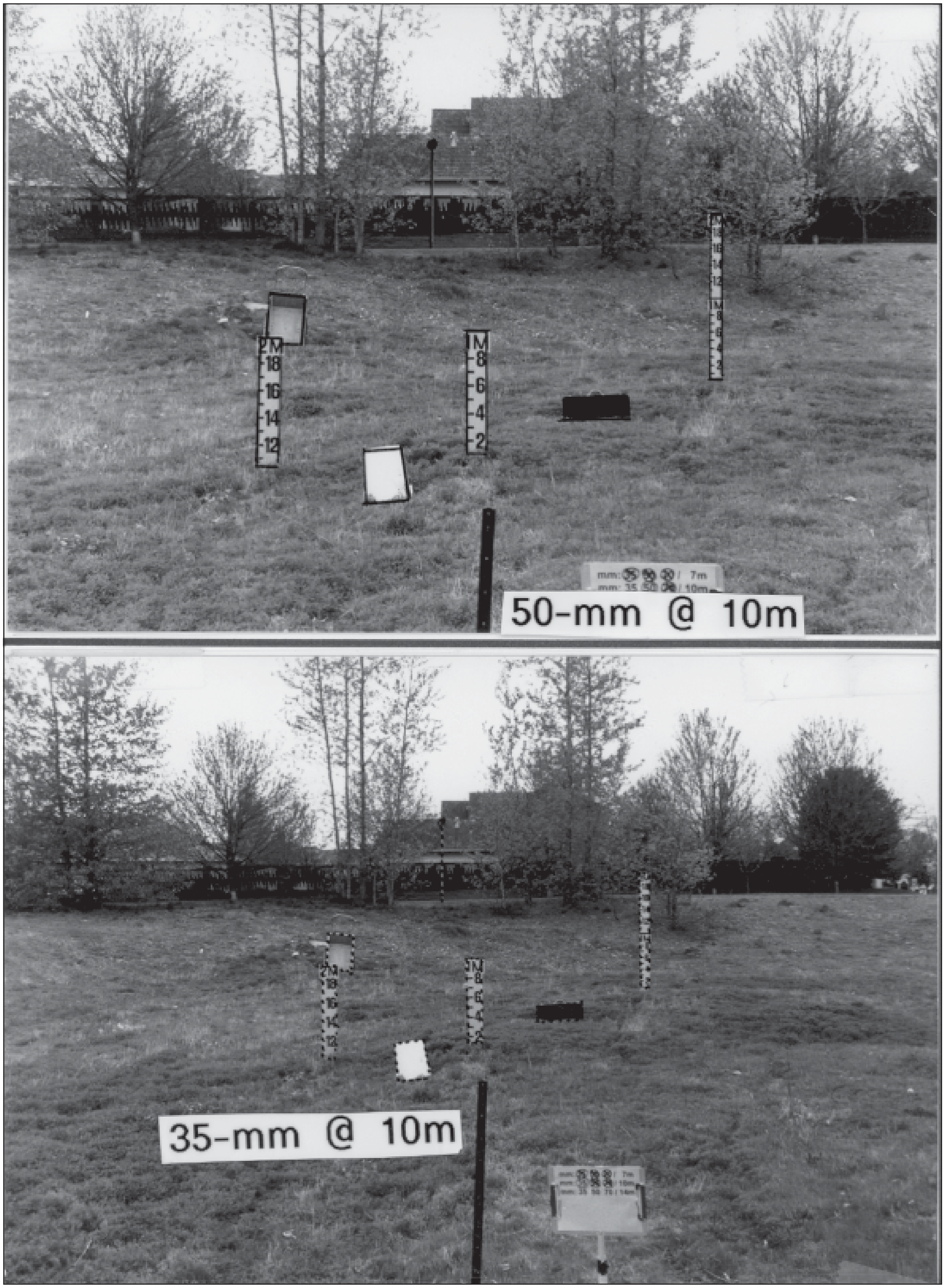

Figure 3—Same camera-to-meter-board distance, different camera focal lengths.

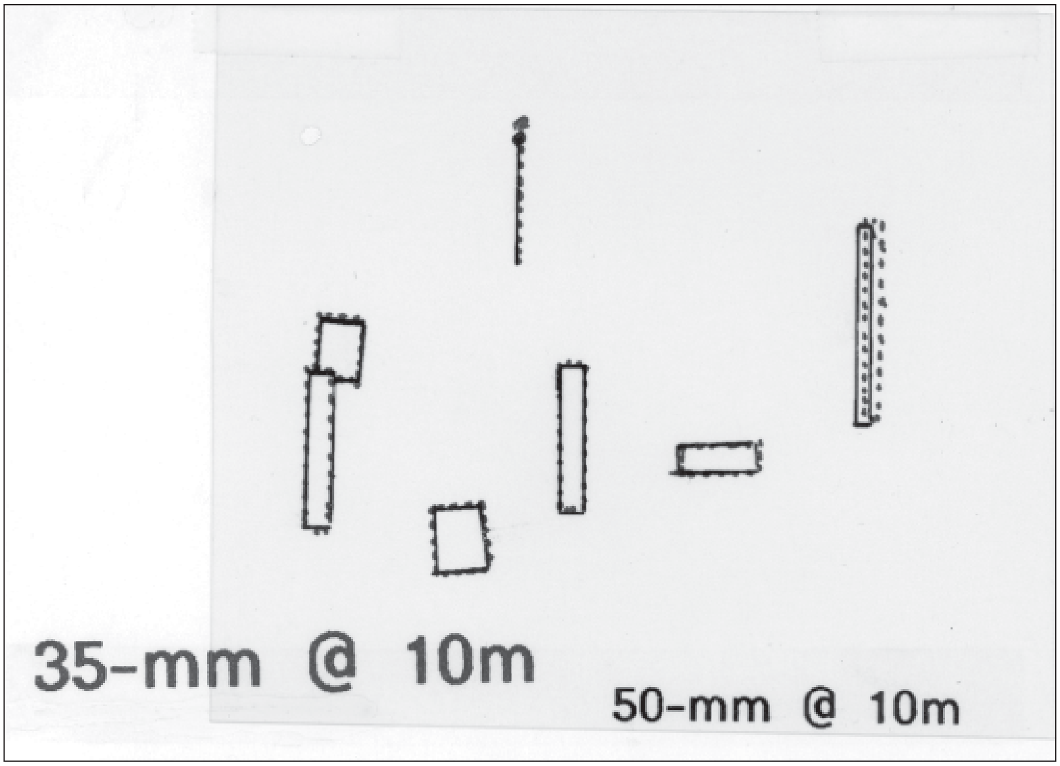

Figure 4—Object comparison, same camera-to-meter-board distance.

In figure 4, the 35-mm image is enlarged to match the height of the meter board in the 50-mm image (143 percent). Overlaying the enlarged 35-mm outline on the 50-mm outline shows little difference in object size or location. Note the difference in size between "35-mm @ 10m" and "50-mm @ 10m" outlines. The items in each photograph are about the same size and occupy the same location, demonstrating the importance of distance and the ability to correct for focal length. Camera focal length may differ without affecting analysis of photographic items when images are adjusted to a common size meter board.

A set distance from camera to meter board across all photopoints is not required. Distance may range from 5 m to 10 m depending upon the purpose of the monitoring. However, the meter board should be at least 25 percent of the image height to provide adequate precision of measurement when using grid analysis. For example, a meter board set 10 m distant is about 25 percent of image height when using a camera with a 50mm lens. For digital cameras with zoom lenses, zoom the lens so the meter board is at least 25 percent of the image height.

Measurement of Change

Change can be shown by using repeat photographs and by using a grid analysis. Figures 5 through 7 illustrate use of a meter board for measuring change in shrub profile area. Figure 5 documents shrub profiles in 1981 prior to beavers (*Castor canadensis*) moving into the area and again 15 years later in 1996 after they departed. Beaver harvested willow stems for dam construction and forage from 1983 to 1993.

In figure 5, clear plastic is laid over the photographs and shrub profiles are outlined. Each overlay is a data sheet and must have all information entered to identify the outlines. (Note that the date on the data sheet is the

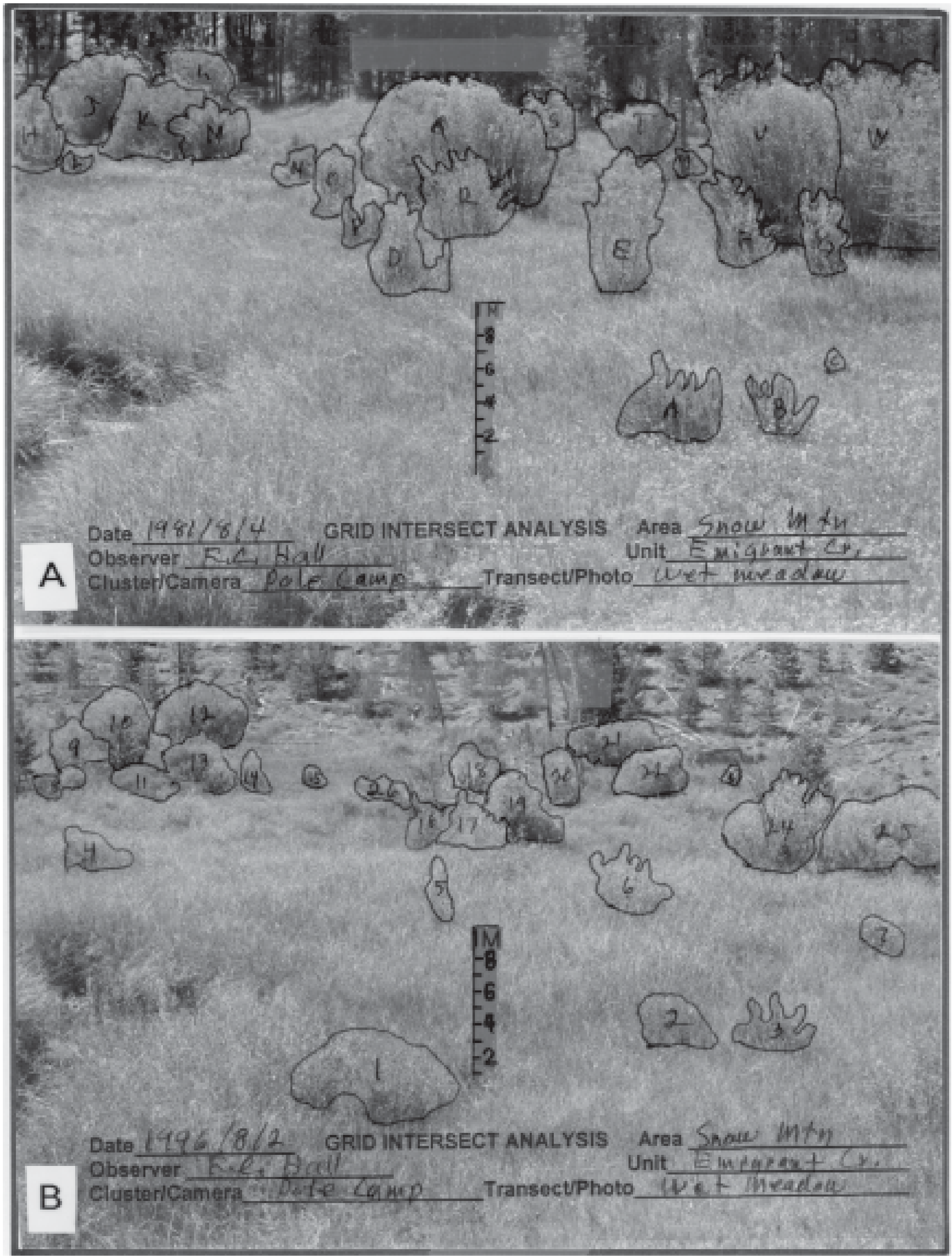

Figure 5—Pole camp shrub profile photographs.

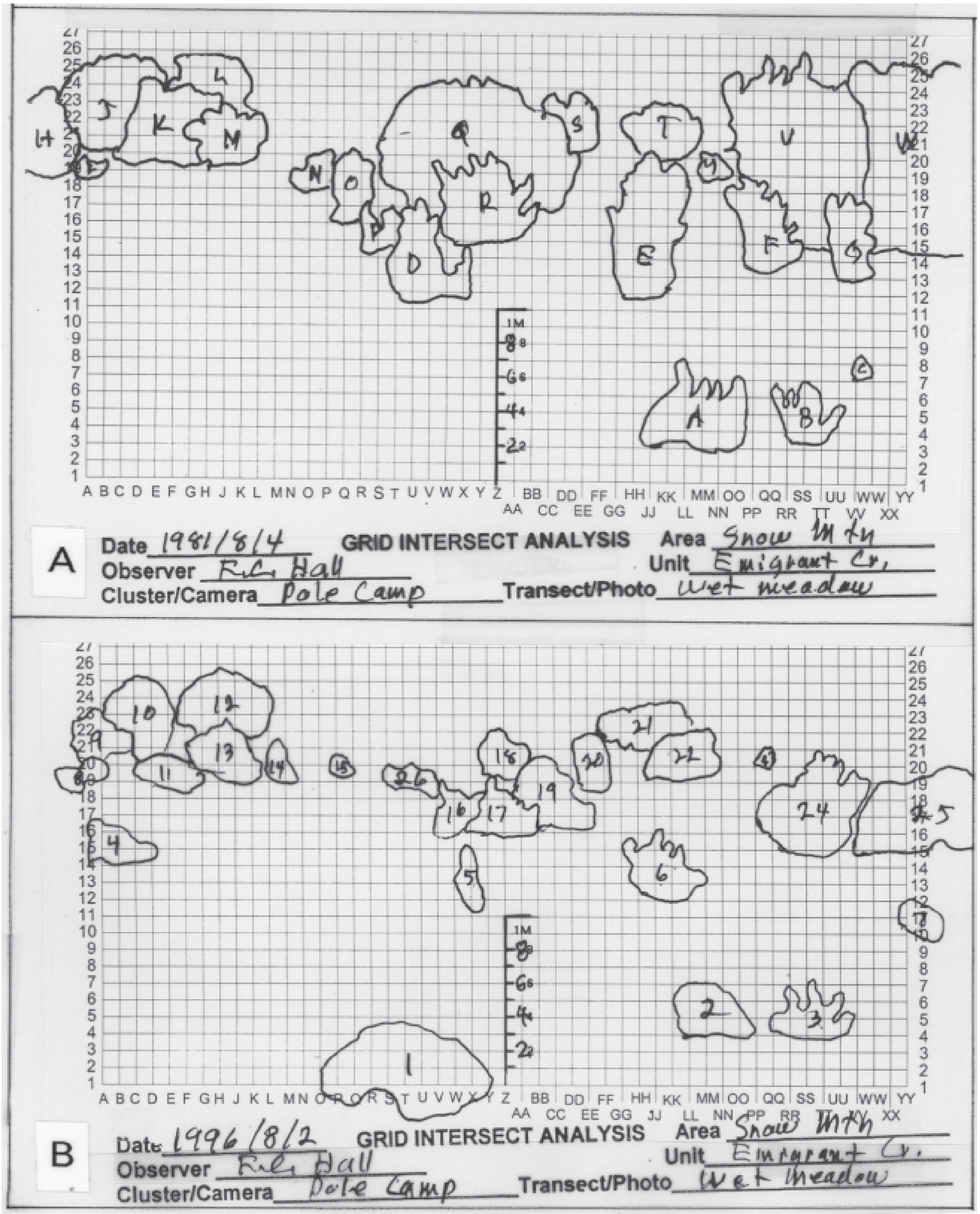

Figure 6—Pole camp shrub profile analysis grids.

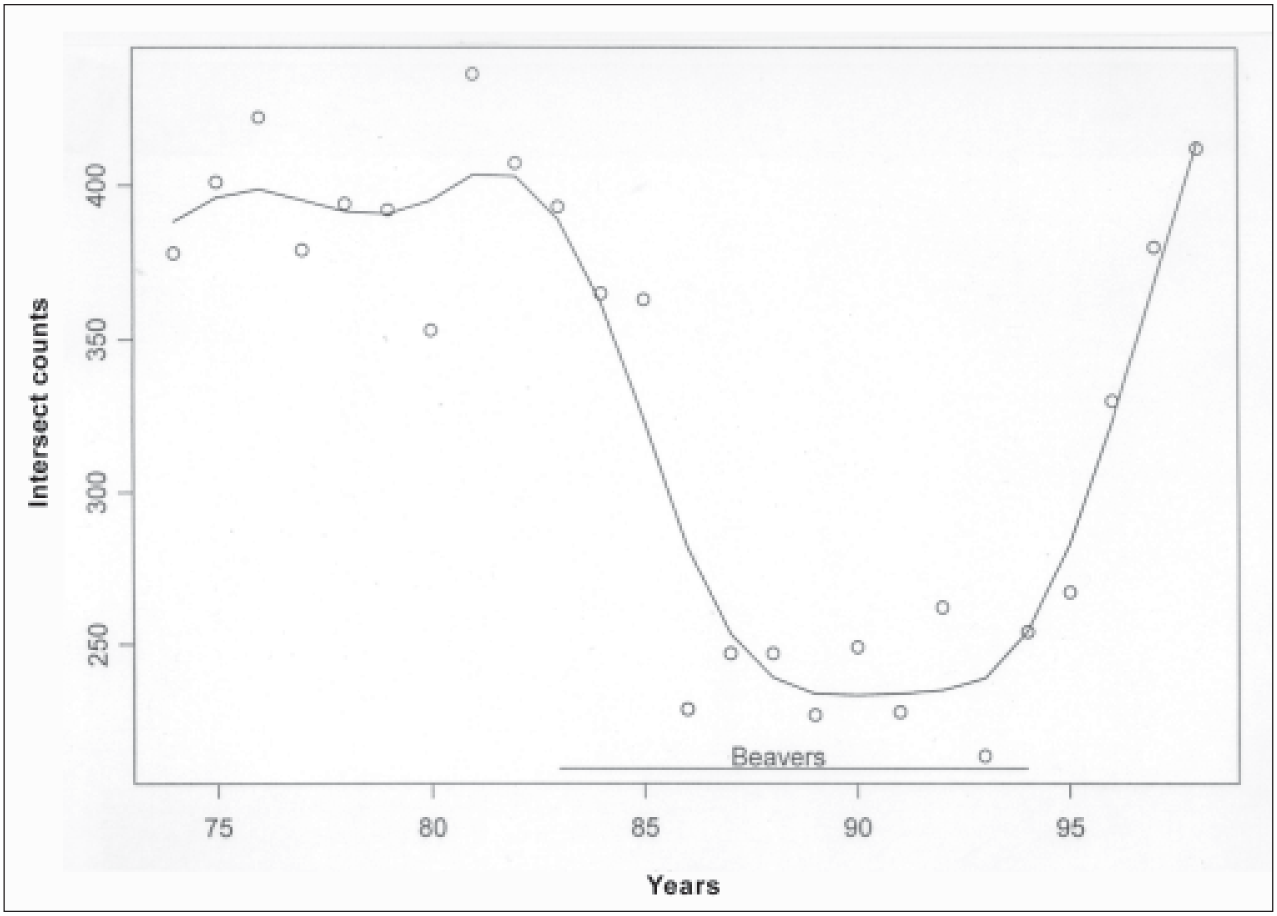

Figure 7—Pole camp shrub index 1974 through 1998.

photograph date, not when the outline was drawn.) The meter board is outlined on its left side and top, then each visible decimeter line is marked and the decimeter number written on the overlay. Finally, each shrub is carefully outlined and given either a letter or number identification.

The next step is size adjustment of a clear plastic analysis grid. The grid has its own meter board imprinted on it. Adjust the grid meter board to exactly match the outline meter board. Figure 6 shows the grid overlaid on the outlined meter boards. Note the overlaid numbers marking decimeters on the meter board. Outline overlays are placed under analysis grids for counting shrub profile intersects on and within each outline.

When an outline crosses a grid intersect, such as in the lower photo between shrubs 17 and 19 (intersect AA-18), count the intersect for the shrub in front (number 17). Also in the lower photo, count intersects along the grid edge, such as the five intersects in shrub 25 on line YY. Tally the number of intersects for each shrub and total the number of intersects for the photograph. Please note that this is an **index** and not an estimate of shrub profile area even though, in this example, each grid is 1 dm^2 at the meter board. A grid box at the meter board 10 m distant is 1 dm^2, whereas at 20 m it covers 4 dm^2.

Figure 7 plots the results of 24 years of shrub intersects (Hall 2001). The procedure used in figures 5 and 6 was followed for each year from 1974 through 1998 and plotted by using a smoothing spine regression as shown in figure 7. One observer made all 24 measurements. Intersect values range from a low of 230 to a high of 445. No intrinsic value can be placed on the intersect values. They simply document change. Beaver presence is shown above the dates

This kind of measurement is not possible without strict adherence to unchanging distance between camera and meter board for repeat photographs. Comparing figures 2 and 4 confirms the requirement.

English Equivalents

1 millimeter (mm) = 0.039 inch
1 decimeter (dm) = 3.9 inch
1 meter (m) = 3.28 feet
1 square decimeter (dm^2) = 0.12 square yard

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Diffusion of Innovation Concepts for Evaluating Adoption of Practice

William G. Hubbard[1]

Abstract

Educators and technology transfer specialists have an innate interest in understanding the result of their efforts. What is the change in behavior of program participants from a particular educational intervention? What is the change in knowledge? What is the change in skill level? And, ultimately, was there an adoption of practice? Although every educator aims for 100 percent adoption of practice from program participants, in reality, several factors keep this from happening. Some factors influence adoption from a positive perspective, and some influence adoption negatively. These factors can be grouped into those that relate to the educator or educational program and those that do not. The purpose of this paper is to summarize these factors and to explain how they influence adoption of practice and why educators should be knowledgeable about them. In addition, this paper will outline how diffusion of innovation concepts can be used to more adequately address program evaluation concerns. Educators and technologists can develop more sound programs and ultimately affect more program participants if they are cognizant of these factors and their influences.

Keywords: Adoption of practice, diffusion of innovation, technology transfer, evaluation.

Introduction and Background

For most people involved in natural resource education and technology transfer, success is measured by a change in behavior, an improvement in a skill, an increase in knowledge, or an adoption of practice. Surveys, tests, observations, and experiments are often conducted to quantify this change or adoption. Numbers obtained from these quantifiable measures are then aggregated across all participants in the event to get the percentage of participants who adopted a practice, changed behavior, etc. Results such as 60 percent of program participants adopted practice X or 80 percent increased their knowledge on a subject matter are common in evaluation literature today. Although some impacts such as those related to change in knowledge, skill, or behavior may be measured adequately by these methods, the adoption of a particular practice owing to an educational intervention can be more difficult to measure. The purpose of this paper is to point out the highlights of over 50 years of research on diffusion of innovations and adoption of practice and to illustrate the potential for use in program evaluation.

Getting information and science to individuals in a manner that can be interpreted and internalized for use is only one part of the process. If the adoption of a desired practice (or the cessation of an undesirable practice) is the preferred result that will be measured, then several factors must be taken into account. These are primarily related to the delay in time between the educational event and the implementation of the practice, factors that relate to the individual's abilities and capacities to implement the practice, and factors beyond the control of the individual that can affect their adoption of the practice. Extensionists and others who comprehend this and incorporate it into their programming will find this useful. Professionals with responsibilities in this field need to have a keen understanding of these other factors and how they might influence the actual adoption of practice to understand their effectiveness.

Two examples may help to illustrate this concept. First, from a general educational perspective, consider a

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vocational teacher who provides training in a specialized area to a group of students. She surveys the group 2 years later and finds out that only 50 percent of the students found jobs in the field of training. Upon further investigation she finds out that there are a number of factors, in addition to the training she provided, that affected the "success" rate of her pupils. She found some trainees had motivational issues, some had resource limitations (no car to get to work, no money to buy nice clothes for interviews, etc.), some interviewed poorly, and some had no interviews owing to lack of potential job availability. She used the results of her informal study to revamp her efforts. The next time she taught the course, she provided limited counseling (and actually conducted a voluntary motivational test), held a job fair, and even coached her students on how to interview. In addition, she offered to provide transportation vouchers to anyone who had a legitimate job interview. Granted, this went way beyond the call of duty, but it illustrates two important points: that there are factors in addition to education that influence the outcomes, and that we, as educators can do something about them.

Another example in the natural resources field further illustrates this point. A shortcourse on forest management was conducted via satellite program in the Southern United States. Information on a variety of topics was presented to several thousand landowners. A followup survey was conducted to see which practices that had been promoted in the program might have been adopted (e.g., tree planting, estate planning, food-plot planting, etc). In addition, questions were posed to the participants that focused on the reasons for adopting or not adopting the practice. From these surveys, the program developers not only obtained an idea of the level of adoption but obtained an idea as to the factors that affected adoption. Some of the reasons included the fact that the shortcourse speakers were too difficult to understand, the practice would have required resources that the owner did not have at the time, and the owner hadn't had the time to implement the practice. From this information, the program producers were able to design future programs that were more effective at meeting the needs of participants.

Reinventing Rogers—The Adoption of Diffusion Theories and Opportunities for Use in Program Evaluation

What are the factors that can influence the adoption of a practice, and, more importantly how can educators and technology transfer specialists work within this framework to be more effective? To answer the first question, we start with a set of theories that was developed over 50 years ago by social scientists in the agricultural fields (Beal and Bohlen 1957, Beal et al. 1962). These scientists were specifically interested in factors that affected the motivation of farmers to adopt agricultural practices. Soon after, one social scientist in particular, Dr. Everett Rogers, compiled these observations and began making many of his own (Rogers 1963). He searched the literature, conducted surveys and experiments, and came up with a series of posits designed to explain the concepts related to the diffusion of innovations and adoption of practice. In addition to several other concepts related to diffusion of innovation, he found that the adoption of practice was affected by three major categories of factors: those relating to the individual, those relating to the social system, and those relating to the practice itself. In addition to these attributes, there are external factors and factors relating to the educational experience that can influence the adoption of practice. Each of these categories is discussed in more detail below.

Individual Attributes That Influence Adoption of Practice

One of the more common concepts that Rogers posited was the idea that people are different and that they will use the information provided to them in different ways. He grouped society into five categories, which include innovators, early adopters, early majority, late majority, and laggards (Rogers 2003). Many students of communication, education, and marketing are fairly familiar with the bell-shaped curve (fig. 1) depicting the relative percentage of each category in the population. Understanding that we have innovators and early adopters and who they are is important for educators. Although innovators aren't necessarily the greatest communicators and leaders, they are an important part of the diffusion process because they are more willing to take a risk on a new practice or idea. Once the early adopters are keyed into any successes and failures then their adoption or rejection of a practice begins to spread throughout the system more rapidly. This is depicted in the S-shaped curve showing the typical rate of adoption of a new practice (see fig. 2).

There are other characteristics that relate to the nature of the individual; some are innovative and others aren't. Characteristics such as age, education, and availability of disposable income also affect a person's willingness and ability to adopt a new practice that they've been exposed to. An educator that understands these factors can also develop programs or modify delivery systems to better meet the needs of their participants.

Attributes of the Practice That Affect Adoption of Practice

The concept of perceived attributes is based on assumptions that relate to the practice's perceived complexity, compatibility, trialability, relative advantage, and observability (Rogers 2003). These five characteristics of a practice often influence the degree to which a practice is adopted. Each of these is discussed

Complexity—
Forests and natural resources are complex systems. Understanding these systems and applying practices to them can be difficult and challenging. The degree to which the concept can be fully explained and understood affects what practices are adopted by participants. Some of the weight rests on the ability of the instructor and some on the inherent complexity of the proposed practice. The

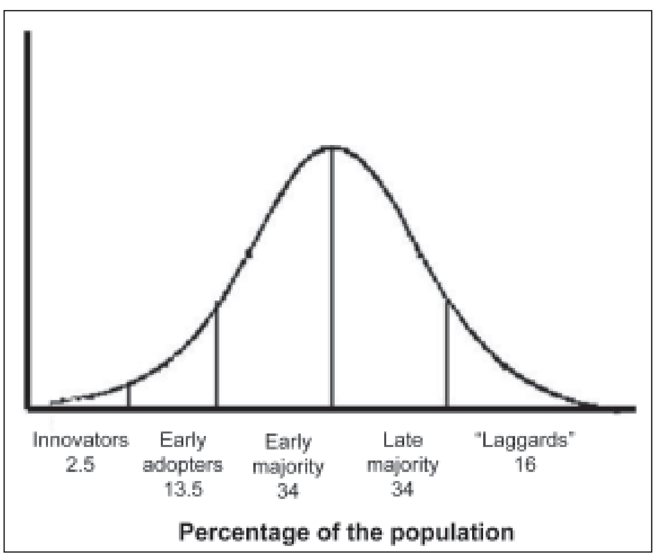

Figure 1—Bell-shaped graph depicting levels of adopters (from Rogers 2003).

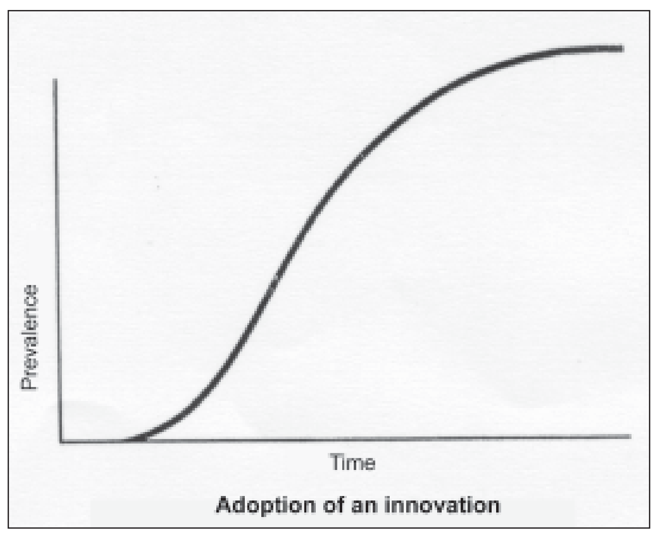

Figure 2—S-Shaped curve depicting the adoption of technology over time (from Rogers 2003).

former concept will be discussed in more detail shortly. Conversely, if the practice is relatively easy to understand, then the chance that the practice is adopted is higher. Programs that incorporate a step-by-step or how-to approach are more successful at getting people to adopt practices than those that are more theory or concept based.

Compatibility—

How compatible is the proposed practice with the current philosophies and practices of the individual? A simple example of this might be teaching reforestation practices to a forest owner who already has a young stand of trees growing. This owner has no immediate need for this information so will most likely retain little to nothing. Another example might be promoting the use of chemicals to a forest owner who prefers not to use them. Compatibility issues arise for a variety of reasons and can also be the result of poor communication if the instructor does not adequately explain how a practice may fit into the owner's management strategy. In any case, the degree to which a proposed practice is compatible is important for educators to understand. Programs that are developed with these concepts in mind will show more successful results in the long run.

Trialability—

If a proposed practice can be experimented with or adapted to a program participant's individual needs, then the chance that the practice will be adopted is increased. This is because risk can be managed through testing the practice first before wholesale adoption. Although the overall investment might be greater, the fact that the program participant does not have to "put all of his or her eggs in one basket" leads to the chance that the practice will be adopted more easily.

Relative advantage—

Most participants attend programs, learn new things, and adopt new practices because they are interested in improving something. Perhaps it is the stewardship and sustainability of their resource. Perhaps it is the potential for an increase in income or a decrease in expenses related to their property. In any case, the degree to which the practice has the potential to improve some aspect of the program participant's life or livelihood influences the degree to which the practice is adopted.

Observability—

Finally, how observable are the results? Can one readily see the results of the application? If results are visible and apparent and can be attributed to the practice, then its chance of being adopted is greater than if it isn't visible. This is one reason why a practice such as the creation of an estate plan is difficult to get adopted by so many people. The results just aren't visible enough for program participants to readily adopt. Demonstration forests and field days are valuable because they demonstrate what the practice looks like for the potential adopter.

Social System Factors

Most of us, forest owners included, live and operate in a web of life. One of the fundamental difficulties of technology transfer is the fact that our program participants are inherently different (Rogers 2002). The networks we establish, the communication we have with individuals and the media, our personal friendships, our mentors, experts, etc. all have a bearing on our motivation to adopt a practice. If we are inclined to join an association where a certain practice is considered taboo, then our chances of adopting that practice are more than likely reduced. If, on the other hand, the association not only supports it but can provide technical or even financial assistance, then the chances are increased. The availability of social system support mechanisms has been found to be a determining force in whether adoption of practice is undertaken (Baldwin and Haymond 1994).

Other Factors

In addition to these factors, there are other, external factors that affect the adoption of practice. These may include for example, the current market or political situation. For example, forest owners will probably elect to wait on a timber harvest if prices are expected to stay low for an extended period. However, if a sudden need for resources arises, and mature timber can be harvested, then an owner may have no choice but to undertake the practice. An example of a policy that affects a forest owner's decision to implement a practice might be federal tax law.

Factors Relating to the Educational Program

In recent years, educators have become more interested in the influence that they may have on the adoption of practice. Factors that have been examined include program participant's perception of the instructor's knowledge of a subject; participant's level of trust in the instructor(s); and participant's perception of whether program objectives were defined early enough and were adequately met. In addition, educators and others are interested in the relative impacts of traditional and emerging teaching technologies such as distance education, coached planning, and others.

These factors of the educator and the educational program are of particular interest to those in the technology transfer field because they are the factors that we can most directly control. For example, how do we as educators come across to our audience? Do we seem knowledgeable? Arrogant? Disinterested? Do these factors have an affect on the success of our program? In our promotional materials, did we adequately state the purpose of the program? Did our agenda stray from meeting stated program objectives? Were there things left out of the program that should have been included to better encourage the adoption of practice? These questions and others need to be asked if we are to develop programs that result in change.

Implications for Natural Resource Technology Transfer and Extension

Evaluation studies of technology transfer programs typically involve surveys to measure the change in behavior or adoption of practice. These surveys are usually fairly basic and simply query whether a behavior is changed or a practice is adopted. If educators are truly interested in what happens following an educational program, then knowledge concerning the factors that affect these changes in behavior or adoption of practice should be acquired as well. By understanding why behavior is changed or a practice is adopted, or, perhaps more importantly, why behavior or practices are not changed, the educator can be in a better position to affect change.

There exists an opportunity to develop theoretical adoption models and test them empirically. In these models, the dependent variable is adoption of practice and the independent variables might be a host of critical factors that are believed to affect adoption. Some of these critical factors have been described in the sections above; others might be drawn up on a case-by-case basis.

In the health field for example, Cervero and Rottet (1984) created an instrument designed to empirically test an adoption of practice model. Specifically the study's objective was to analyze the impact of a training program on employee performance. A 51-item survey instrument was designed, tested for validity, and implemented. Data collection included the review of charts, interviews with participants and supervisors, and observation. Results indicate that the framework's predictive power ranges from modest to highly explanatory; between 39 and 81 percent of the variance of the dependent variables could be explained. This suggests that this design and framework could be useful in other fields including natural resources.

Although every technology transfer effort cannot be designed and tested in the manner described above, insight from a few studies in our field should provide valuable insight. Studies that look at the factors that influence behavior change and practice adoption can shed light into the overall effectiveness of our efforts and the efforts of others who similarly desire to affect changes to our natural resources through technology transfer.

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North American Perspective on Successful Strategies in Extension and Technology Transfer

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Abstract

Improved natural resource management to achieve sustainability is a key objective of both domestic and international extension programs. As such, there are common strategies that have been tried and tested throughout the world, some of them quite successfully. During 2003, the International Union of Forest Research Organizations (IUFRO) Extension Working Party hosted a conference, in Troutdale, Oregon, entitled "Building Capacity Through Collaboration." The conference featured 35 published papers from 11 countries. A review of the 35 papers revealed 119 "successful strategies" that were further condensed into 45 strategies in three key areas: strategies associated with learners (16), strategies associated with extensionists (7), and strategies associated with educational approaches (22). During fall 2004, the IUFRO Extension Working Party was surveyed, by using a printed and mailed survey, to determine the degree of use of these strategies and barriers to further use. Responses from Canada (18 percent) and the United States (44 percent) are summarized here. Canadian responses were mainly from nongovernmental organizations (57 percent), whereas U.S. responses were mainly from cooperative extension services (86 percent). The learner-centered strategy most commonly used was **Allow opportunities for feedback from learners to extensionists** (Canada 100 percent, United States 94 percent). The learner-centered strategy most often not used was **Use of farmer-to-farmer (forest owner-to-forest owner) approaches in which the trainers are paid a fee to provide educational services to their peers** (Canada 86 percent, United States 75 percent). The extensionist-centered strategy most often used was **Extensionists build trust with learners** (Canada 90 percent, United States 88 percent). Whereas that most often not used was **Extensionists receive training and licensing** (Canada 71 percent, United States 17 percent). One strategy associated with the educational approach received 100 percent responses from both Canada and the United States: **Deliver practical and up-to-date information**. Whereas the strategy most often not used was **Identify and engage under-served audiences in extension programs**, (Canada 57 percent, United States 33 percent). Key barriers to the adoption of additional successful strategies include lack of funds and staff, time to test and implement the strategies, and lack of training opportunities (mainly in Canada).

Keywords: Extension forestry, technology transfer, forest owners, best practices in extension.

Introduction

The forests of North America are under increasing pressure to provide a wide array of goods and services to the growing population. In the United States, the forests in private ownership are increasingly providing these goods and services, whereas in Canada the government-owned forests are paramount in this regard. Examples of these goods and services include products such as timber for

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pulp, saw logs, composite wood products, and fuel; nonwood products such as mushrooms, berries, medicinals, and floral materials; and ecological services such as wildlife habitat, clean water, viewscapes, wetlands, and endangered species protection. Furthermore, these goods and services are expected to be produced in a sustainable manner, to ensure a strong future supply. Informal education and technical assistance services to landowners are needed to assist with the management of private forests and improve the level of management planning and on-the-ground practices. Commonly referred to as extension, these educational services are offered through formal Cooperative Extension Services and state agencies in the United States, and through nongovernmental organizations and government-funded partnerships in Canada.

Growing out of traditional agricultural extension (van Den Ban and Hawkins 1996), forestry extension has emerged as a critical service to improve the management of forests and the livelihoods of forest owners and forest-dependent communities (FAO 1986, Sim and Hilmi 1987). As part of this development, the International Union of Forest Research Organizations (IUFRO) authorized the development of an Extension Working Party in 1991, which began work in 1994 (Johnson 2003). The objectives of the working party follows:

- Serve as a forum for information exchange among extension forestry workers worldwide.
- Promote the concept of extension through the transfer of knowledge and technology to improve the lives of people.
- Improve the quality, quantity, and effectiveness of extension programs worldwide.
- Advance the quality and impact of research on extension methodologies.

In keeping with these objectives, the Extension Working Party hosted an international symposium in Troutdale, Oregon, in 2003, entitled "Building Capacity Through Collaboration." As part of this symposium, 35 papers were presented from 11 countries, each focused on a specific project or collection of methodologies that has led to program success. The objective of this paper is to discuss the use of a collection of **successful strategies**, as determined from these papers, by extension professionals in the United States and Canada.

Methods

Initially, the intent was to develop a set of "best practices for forestry extension"; however, the concept of best practices implies that the practices have been tested and replicated over time and with different audiences. Instead, the 35 papers presented at the 2003 symposium were reviewed, and a set of 119 "successful strategies" compiled. Through a process of combining like items, the original set was reduced to 45 strategies in three categories: strategies associated with learners (16), strategies associated with extensionists (7), and strategies associated with the educational approach (22). The emphasis on successful strategies indicates that the strategy was featured in the paper, and in some way led to success of the program.

Following the symposium, in August of 2004, an advisory group of representatives from the following agencies convened in Washington, D.C., to provide additional advice and guidance to the project: Inter-American Development Bank; U.S. Agency for International Development; Peace Corps; USDA Cooperative State Research, Education, and Extension Service; USDA Forest Service—International Programs; Virginia Tech (1862 Land Grant University); and Tennessee State University (1890 Land Grant University). This group reviewed the process used to develop the categories and developed the concept of "successful strategies" as opposed to "best practices."

From November 2004 through March 2005, a written survey was administered by mail to the 500 members of the IUFRO Extension Working Party, representing 70 countries. A followup mail survey was also sent to

Table 1—Demographic responses by Canadian and American extensionists

	Canada (n = 7)	United States (n = 53)
Gender		
Male (percent)	71	95
Female (percent)	29	5
Mean age (years)	41	50
Mean years experience	10	18

Table 2—Employment profile of responding Canadian and American extensionists

Employed by	Canada	United States
	Percent	
Government agency	28	6
Research Institute	1	4
School/college/university	14	86
Nongovernmental org.	57	0
Consultant	0	2

nonrespondents, and the response time extended in an attempt to increase the response rate. In addition to demographic data, the survey used a five-point Likert scale to ascertain the degree of use of the 45 successful strategies previously identified. In this paper only the responses from the United States and Canada will be considered. Responses from other countries will be analyzed and published in the future. Respondents were provided with the list of 45 strategies and then asked to rank whether they use the strategy often or sometimes, do not use the strategy but would like to, do not use the strategy because it does not apply, or have no opinion on the use of the strategy.

Results and Discussion

Responses from the United States totaled 53 out of a sample population of 121 (44 percent usable responses), and from Canada 7 usable responses were received from a sample population of 38 (18 percent usable response rate). Admittedly, this response rate from Canada is low, and any interpretations made should be considered as preliminary. Demographic data are presented in tables 1 and 2. The survey respondents were predominantly male (95 percent in the United States and 71 percent in Canada). Mean age of respondents was 41 for the Canadians and 50 for the Americans. The Canadians had, on average, 10 years of extension experience, whereas the Americans had 18 years. Most of the U.S. respondents worked for universities (86 percent, most likely within the Cooperative Extension system of the Land Grant Universities), whereas the Canadians worked mostly for nongovernmental organizations (57 percent).

Strategies Associated With Learners

Of the 16 strategies associated with learners, the top four that are most commonly used and the four that are least used are presented in table 3. Allowing for learner feedback, surveying the target audience for needs, focusing initial efforts on innovators and early adopters, and using peer-to-peer learning all scored highly with both the Canadian and American respondents. All are basic tenets of the concept of adult education, and recognize that the learners have much experience and knowledge to bring to the educational experience (Seevers et al. 1997). Focusing early efforts on the innovators and early adopters, about 16 percent of the population, has long been touted as an excellent extension strategy (Rogers 1983). The majority of the population learn from these often successful opinion leaders, and if the practice appears beneficial, follow along soon after.

Learner-centered strategies that are not widely used are also presented in table 3. Approaches in which the learners become instructors and are paid for their services was not used much either in Canada or the United States (86 percent did not use in Canada and 75 percent did not use in the United States). Furthermore, only 14 percent of Canadian and 28 percent of American respondents indicated they would be interested in trying this approach. This strategy was cited as being successful by

Table 3A—Learner-centered strategies used often or sometimes by Canadian and American extensionists

Strategy	Canada	United States
	Percent	
Allow opportunities for feedback from learners to extensionists	100	94
Survey target audience to determine needs, wants, desires, and barriers to adoption.	100	90
Focus initial extension efforts on innovators and early adopters.	100	84
Facilitate peer-to-peer learning opportunities within the target audience.	85	83

Table 3B—Learner-centered strategies not often used by Canadian and American extensionists

Strategy	Canada	United States
	Percent	
Use farmer-to-farmer (forest owner-to-forest owner) approaches in which the trainers are paid to provide educational services to their peers.	86	75
Emphasize human welfare in educational programs.	86	28
Hire learners to work on projects to build trust and spend project funds locally.	71	64
Formalize the roles and responsibilities of partners through memorandums of understanding.	43	45

Kaudia et al. (2003) for a Demand-Driven Forestry Extension Project in Kenya, in which the participants are involved in determining the educational content. In addition to providing income to farmers who share their knowledge, this project sought to build human capacity. North American extensionists cited a series of barriers to adopting this approach, including availability of funds to support the approach, lack of manpower, and uncertainty of how to implement the program. A contrast between Canadian and American responses occurred with the strategy "emphasize human welfare in educational programs." Whereas 86 percent of Canadian respondents indicated that they do not employ this strategy, the corresponding value for the Americans was 28 percent. Possibly this difference is reflected in the long-standing American tradition of building the family and community unit through adult education, rather than on merely transferring technology. Additionally, Canadians have a strong government-based social support system, and possibly Canadians interpreted this strategy as one not related to extension programs.

Strategies Associated With Extensionists

The strategies associated with extensionists used most often or not used are presented in table 4. Extensionists building trust with the learners, involving learners in project planning, and establishing rapport with the learners were all used widely by both Canadian and American extensionists. Again, these are all key elements associated with successful adult education programs

Table 4A—Responses of Canadian and American extensionists to strategies associated with extensionists used often or sometimes

Strategy	Canada	United States
	Percent	
Extensionists build trust with learners.	90	88
Extensionists involve learners in project planning.	85	84
Extensionists establish rapport with landowners, particularly if extensionists are strangers.	87	71
Extensionists are members of a professional society or association.	57	90

Table 4B—Responses of Canadian and American extensionists to strategies associated with extensionists that are not used

Strategy	Canada	United States
	Percent	
Extensionists receive training and licensing.	71	17
Extensionists receive in-service training and leadership development.	71	11

(Seevers et al. 1997). Interestingly, 90 percent of the responding American extensionists indicated that they were members of a professional society, whereas the comparable figure for Canadians was 57 percent. In the 2003 symposium, Adams (2003) highlighted the diverse benefits of extensionists working within the structure of a professional society or association. In the United States, there now exists an organization known as the Association of Natural Resource Extension Professionals (ANREP), which serves as a professional development association for extensionists. A similar organization does not exist in Canada.

Another difference exists between the Canadian and American responses in regard to strategies not commonly used (table 4). Whereas 71 percent of the Canadian respondents indicated that they do not receive training, licensing, or leadership development, only 11 to 17 percent of American extensionists indicated that they do not receive these professional development opportunities. These strategies scored highest as "not used" by the American extensionists. Barriers cited by the Canadians include the following: lack of a critical mass of extensionists within various organizations, lack of funding to support such activities, and lack of training opportunities. This may also be related to the minimal involvement in professional societies, which often serve as vehicles for professional development. In the United States, in-service training for extensionists is widely recognized as essential for a modern educational workforce (USDA 1994). Canadians also recognize the importance of a trained and effective extension workforce. According to Bunnell (1988): "People—trained, knowledgeable, and empathetic—are the prime ingredient in developing and maintaining an effective extension program. Institutional and administrative support is needed for the people who are engaged in extension activities." Despite the lack of training and professional development opportunities available to the Canadian respondents, the use of successful strategies in program development is similar to use in the United States. Perhaps similarities in culture and educational methods between the two countries create more commonalities than differences.

Strategies Associated With Educational Approach

The strategies associated with the educational approach most commonly used and not used by Canadian and American extensionists are listed in table 5. The strategies most commonly used would be considered key elements of most adult education programs, and there were no observable differences between responses from Canada and the United States. For example, delivering practical and current information, ensuring the information meets the audience's needs, utilizing available information technology, adapting programs to local conditions, etc. are all well-known and accepted strategies (Seevers et al. 1997). Of more recent interest is the idea of maintaining close collaboration between research and extension. In the U.S. cooperative extension system, a network of extension specialists located at Land Grant universities ensures this close tie. Many of the specialists are also cofunded by extension and research, and perform dual functions (Hamilton and Biles 1998). Ninety-eight percent of American respondents maintain a research tie to their educational programs, while 85 percent of the Canadian respondents indicated the same for their programs.

Strategies that were not used as often include engaging underserved audiences, involving learners in the instruction, using principles of total quality management (TQM), using prototype extension models, and using on-farm or in-forest research or demonstration plots (table 5). Barriers to the use of these strategies were identified as lack of money and resources, lack of manpower, lack of training, and internal resistance to concepts such as

Table 5A—Responses of Canadian and American extensionists to strategies associated with educational approaches often or sometimes used

Strategy	Canada	United States
	Percent	
Deliver practical and up-to-date information.	100	100
Ensure educational programs meet the needs of the target audience.	100	96
Utilize information technology when appropriate– World Wide Web, satellite.	100	96
Adapt educational programs to local conditions.	100	96
Encourage learner participation through personal invitations.	100	89
Target educational programs to the needs of learners.	100	91
Maintain a close collaboration between research and extension.	85	98
Use a variety of teaching methods to accommodate different learning styles.	85	96

Table 5B—Responses of Canadian and American extensionists to strategies associated with educational approaches that are not often used

Strategy	Canada	United States
	Percent	
Identify and engage underserved audiences in extension programs.	57	33
Involve learners in the delivery of educational programs.	57	17
Employ principles of quality management for educational programs.	43	34
Develop and use a prototype extension model that can be modified based on initial feedback.	28	35
Use on-farm or in-forest applied research plots for demonstration purposes where appropriate.	56	24

TQM and to use of prototype programming models. Many respondents cited barriers to reaching underserved audiences, including lack of time, uncertainty with how to identify some audiences, difficulties with getting underserved audiences to participate in educational programs, cultural barriers, and a lack of minority extensionists to reach the underserved audiences. The greatest difference between Canadian and American responses occurred with the strategy of involving learners in the delivery of educational programs. In Canada, 57 percent of the respondents indicated that they did not use this strategy, whereas the comparable figure in the United States was 17 percent. However, all of the Canadian respondents indicated that they would like to use this strategy.

Conclusions

Forestry extension programs in the United States and Canada are active and evolving. In the United States, extension services are provided most commonly through the nationwide cooperative extension system, whereas in Canada, nongovernmental organizations and partnerships such as FORREX are most common (Morford 2003). In general, extensionists in North America base their educational programs on a needs analysis, allow for feedback, support peer-to-peer learning, deliver practical and current information, adapt methods to local conditions, and are at the forefront of information technology. Extensionists have difficulty identifying and targeting underserved audiences, and typically do not hire learners to work as instructors, although many found this strategy to be intriguing. Some other concepts, such as the use of TQM techniques applied to extension programming and the use of prototype programming models for testing purposes, were also not widely adopted either in Canada or the United States.

Numerous barriers to adopting some of these strategies were identified by both U.S. and Canadian respondents. The usual barriers, lack of time, money, and staffing were cited frequently by respondents from both countries. Other barriers were also identified, such as an internal resistance to some concepts, and a lack of minority extensionists capable of reaching underserved audiences.

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Science Writing—A Promising Way to Intensify Knowledge Transfer in Forest Sciences

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Abstract

Since 1787, when the first forestry school was founded in Germany and forest research started, a huge amount of scientific knowledge has been accumulated in Central Europe. Unfortunately, compared to the publication activity on forest-related topics worldwide, the number of articles written by German-speaking authors was rather small for a long time. Since 1990, however, the number of articles in both peer-reviewed journals and technical magazines has been significantly increasing. This is particularly true for the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL). When governmental funding decreased, it became more relevant to transfer its findings to target groups and the public.

To intensify the institute's ability in science writing, i.e., writing about scientific issues and topics for a general audience, one of its scientists took a training to become a science writer. As a result, he managed to publish articles on scientific topics in regional and national newspapers. To gain more experience in journalism, he took further training at the editorial department of a daily newspaper. This, again, helped him publish more articles and get in touch with journalists through the electronic media.

In cooperation with the public relations manager of the institute, the science writer helped enable the institute's scientists to publish more articles written in a popular way. For example, he started to pre-edit manuscripts his colleagues from science had written. This helped increase the number of manuscripts published in technical magazines. The science writer and a few other scientists gained further trainings in writing, Web editing and Web publishing to better transfer scientific information through the Internet. As a result, many new Web sites were developed attracting the attention of special target audiences as well as the public.

Between 1999 and 2004, the numbers of articles written by WSL scientists showed a strong rise in all the publication categories, and the citations in the press also have increased. This result exemplifies how a research institute today has to do duel duty to optimize the communication of its findings. It has to both communicate with practitioners and publish its findings on an international scale to receive reputation from abroad. Science writing does not just enlarge the number of articles in the media. It also supports the process of creating new publications such as newsletters, technical bulletins, fact-sheets, Web sites, and e-learning tools. All together, it is an effective way of transferring science findings to a wide audience and attracting attention.

Keywords: Science writing, knowledge transfer, forestry, journalism, further education.

Research Institutes—Treasury of Knowledge

Forest research has a long tradition in Central Europe because this region is the cradle of European sustainable forestry. In 1787, the first forestry school was founded at Dillenburg, Germany, and, in addition to teaching, re-search activities were soon started. Since the 1870s, when the first research institutions were founded, forest research has accumulated an enormous amount of forest-related knowledge in Germany, Austria, and

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Switzerland.[2] Long-term investigation in all major forest types has a long tradition, producing extensive data on tree and forest development. Although it is almost impossible to summarize and analyze all the research projects from these institutes, it can be assumed that most of them have gathered a huge amount of scientific results.

Based on an analysis of the publication statistics of 1992, 1997, and 2002 in *Web of science* (oral message from A. Kempf, Swiss Federal Institute for Forest, Snow and Landscape Research [WSL]), it can be assumed that of the total accumulation of knowledge related to forests and forestry, only the rudiments have been published. Compared to the publication activity on these topics worldwide, the number of papers published in peer-reviewed journals with at least one author from a German-speaking country involved is fairly small. Between 1992 and 2002, the number of papers dealing with forest-related topics increased from 0.95 to 1.17 million (+ 23 percent) worldwide. At the same time, the number of papers written by authors from the German-speaking countries rose from 160 to 283 papers (+ 77 percent). In the German-speaking countries, there was—and possibly still is—a huge backlog in publishing on the international scale. Compared to the large number of publications worldwide, the scientific potential for German-speaking scientists to publish in peer-reviewed journals must be assessed as still enormous. The publishing backlog is probably due to the fact that until about 1990, many of these institutes did not have a strong obligation to justify their scientific excellence or even their existence by their publication intensity.

Besides the very few peer-reviewed articles in scientific journals, most of the research findings—at least if they were relevant to forest managers—were published in the series issued by the research institutes themselves or in forestry magazines written in German. Although there are no reliable data available on the number of articles that have been published in German, it seems that this number has only slightly increased between 1992 and 2002. There might be two reasons for this: (1) In the 1980s science started investigating "forest die-back," which resulted in a high number of projects and, subsequently, in publications as well. After this bump, this topic became less attractive, and in the 1990s, the number of publications decreased. (2) At the same time, both the number of forest-related journals as well as their issues decreased slightly. Some of them have disappeared since, and some merged together. In contrast to this trend, technology transfer to practitioners became more attractive during the last years, which resulted in a rise in the number of popular papers.

In Switzerland, governmental funding decreased in the early 1990s. It became more and more relevant for research institutes like the WSL to present its scientific success, transfer its findings to its customers and stakeholders, and justify its activities as well. Besides other criteria, both the number of publications in peer-reviewed journals and the amount of citations are, today, the main indicators ranking scientific institutions among others in the world. Therefore, as at other research institutes in the German-speaking countries, more and more scientists at WSL published their results and conclusions in peer-reviewed journals as well (fig. 1).

In the mid 1990s, WSL learned how some research stations of the USDA Forest Service communicated their findings. Referring to the stations' experiences, it was obvious that WSL should be able to both publish more intensively as well as better focus on special target groups (i.e., foresters, conservationists, governmental decisionmakers, politicians). But as the only federal research institute in its field, WSL has to also consider its obligation to justify its activities nationwide because of its mandate given by the government or by parliament. The WSL, in general, has to meet two needs at the same time: it has to publish its research findings

[2] Forest research in the German-speaking countries is being done at three governmental research institutes, at nine state research institutes, which, as a rule, belong to the forest service in the federal states of Germany, and at six universities. The term "research institutes," being used in this article, summarizes them all together.

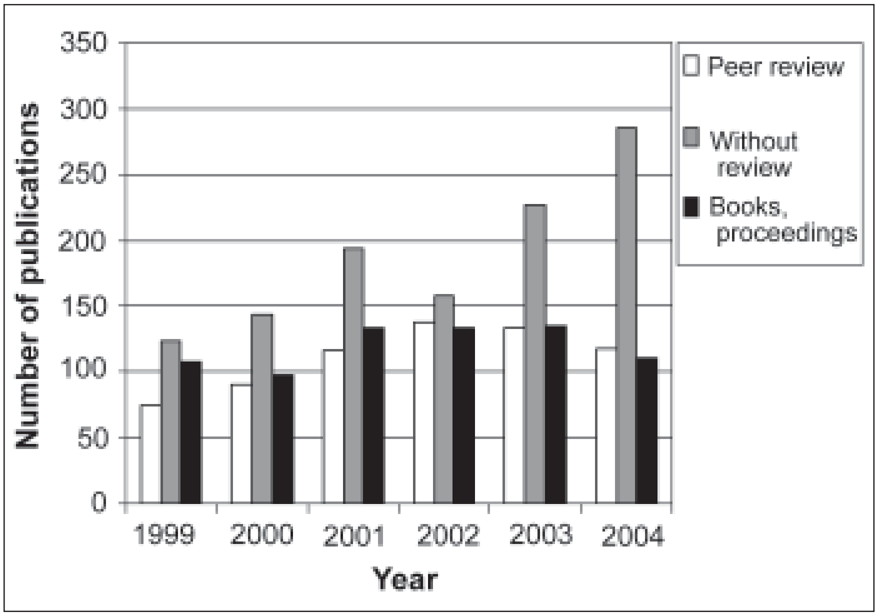

Figure 1—Annual number of publications by authors of the Swiss Federal Institute for Forest, Snow and Landscape Research, 1999-2004.

in peer-reviewed journals, and it has to transfer them on the national scale. Switzerland is a multilingual country, which implies that sometimes there is an obligation to publish in more than just one language. In times of shortage of federal funding, the research institute has to be more transparent and, therefore, it was a must to increase its knowledge transfer.

Popularizing Research Findings

There are several ways to increase the transfer of scientific findings to a wider audience. A research institute could organize, for example, open houses, workshops, excursions, exhibitions, fairs, or adventure trails. Another possibility is to make its Web site more customer-friendly, i.e., by putting more and easily understandable information on it. An example of the latter is the highly educational Web site http://whyfiles.org that successfully makes scientific knowledge and context as easy to understand as possible.

In terms of intensifying knowledge transfer, the question arose whether it is feasible for a research institution to popularize research findings itself? Referring to this, one big problem is that a great number of scientists are not educated in transferring their knowledge in a popularized way. Some of them were employed when scientific expertise was the one and only attribute to get a job and not popularizing or communicating the findings. But most of the transfer activities mentioned above require special skills in writing and communication. Therefore, scientists need either support from specialists, who were trained in science writing, i.e. writing about scientific issues and topics for a general audience, journalism, or public relations, or some of them must be trained in at least one of these fields.

Like the journalists at the newspapers, science writers, editors, and public relation specialists know how to “translate” research findings into a language that is easily understood. Usually they also know a method to transfer findings to special target groups in a popularized way. Therefore, science writers are able to improve at least some of the products a research station is going to publish and, additionally, to write and publish articles that directly appeal to the public. A science writer in-house provides the big advantage of their insight in up-to-date research topics and processes.

During the last 20 years, it has become quite popular in Switzerland to report on science issues. Most of the larger newspapers regularly produce science pages. Besides the staff at the publishing houses, there are many freelancers specialized in science reporting. Since the early 1990s, the number of science writers in both research and development as well as communication departments has also increased because of a great need to inform special target groups about industrial products, science, environment, or public administration in an appropriate way.

As part of this inquisitiveness on environmental issues, both the practitioners and the public wanted to know more about forest-related topics. Therefore, and because of the above-mentioned obligation to justify its activities, WSL, in 1998, intentionally intensified its knowledge transfer. Another aim was to be cited in daily and weekly published newspapers and magazines more often. An increased competence in science writing was one contribution to reach this aim.

Effective Capacity Building

Considering the above-mentioned goals, it was necessary to optimize writing conditions, processes, and products. To increase knowledge transfer, the question arose whether it was most effective to employ professional science writers and editors at WSL or whether an experienced scientist should be trained to become a science writer. The director of the institute supported the last-mentioned alternative because he had a scientist in-house who had a strong interest in knowledge transfer. The training process and the impact of this procedure on the institute's publishing performance will be described briefly.

Becoming a Science Writer

There are several ways to become a science writer. The education possibilities in journalism starting right after school or following a bachelor or master degree in sciences is not discussed here. Yet there are other ways to get trained differing in length and focus. Most of the courses are provided either by public institutions like universities and colleges of higher education (one to two semesters), by public or commercial adult education centers, or by publishing houses (journalist schools).

In 1999, WSL promoted the science writer's efforts to take a part-time education in journalism at the *State Adult Education Centre of Zurich*. To take an 18-month side-line education, some experience in publishing articles in the press was required. This arrangement enabled the science writer to continue most of his daily business as usual. The course provided knowledge in writing, editing, journalistic styling, freelancing, photography, Internet research, media sciences, and media law. As an important part of the training, in order to get as much practice as possible, each participant had to constructively criticize the manuscripts of the others. Another part of the training was to produce a company magazine together, including planning, writing, editing, and shooting photos.

Part of the educational program, it was required publishing at least one article in a national or regional newspaper during that time of the course. All the participants achieved this goal; some using a consumer's topic, some a social issue, and others a scientific one. Another important outcome of this education was the conceptual work and the launching of a forest science newsletter in winter 1999. This newsletter is still being published quarterly, and it is a visible success of what the institute had invested in the science writer's further education.

During the course, his writing and editing skills increased, which enabled him to get articles published in newspapers with which he had not previously had contacts.

Learning to Understand the Editorial Staff

As in other fields of work, it is a whole new ballgame to put newly claimed knowledge into practice successfully. To better understand the making of science pages, practical experiences within a newspaper's editorial office are needed. It is important to understand the strategic approach of a newspaper, how it is functioning, and how the editorial staff is realizing new project ideas. Fortunately the science writer got an opportunity to participate in a 6-week practical training at the science editorial department of one of the largest daily newspapers in Switzerland.

During this most instructive time, the science writer learned that the scientific content of an article is not the only important indicator for the editorial staff to decide whether or not an article is going to be published. First, an article gets examined for its news content, and then checked for its public concern. These are the leading factors for the editor in compiling the daily news. In other words, the more a popularized article on science shows how the reader possibly benefits from the new findings, the higher the interest of an editor to publish it. Another indicator within this process is how often a global topic like forest, animals, climate, etc. was covered by the newspaper itself during the last days or even weeks, or whether other newspapers or magazines have recently reported about the same topic. In the planning process for the next day's issue, topics from science always have to compete with up-to-date news (politics, economics, crime, sports, culture, lifestyle). Stories on research are often considered to be second rate because they usually address a small, if ambitious, target audience. To reach different target groups, the science writer has to focus his activities on different media (press, in-house productions, Internet).

Rising to New Challenges

After getting a number of articles published in different newspapers, the science writer wrote a 2-page article on "Storm damage, climate change and bark beetles in forests" and submitted it (Lässig and Wermelinger 2002) to the science editorial staff of the *Frankfurter Allgemeine Sonntagszeitung*, one of the leading Sunday newspapers in Germany. The scientific expertise, the complexity of the topic, the popularly written text, and the quality of pictures and graphs made a successful combination of science knowledge and customer-friendly reading. One year later the science writer contacted journalists of Swiss TV's science magazine. Together with three researchers, he managed to produce an 8-minute video, "Natural forests and scientific collaboration with Russia." During the following years, more assignments followed, one as a guest co-editor of a special issue of a German science magazine on "Storms" (Müller-Schärer et al. 2003), one as a chief editor of a brochure on "Scientific cooperation with Eastern Europe" (Lässig et al. 2005; fig. 2), and one as a science reporter for a Swiss Sunday newspaper. These examples show clearly that the media is accepting of a science writer, embedded in a net of specialized researchers, even though he works for a governmental research institution. It is important to note that unbiased writing or reporting is a prerequisite for cooperating with the media.

Writing and Editing—Opening Up of New Vistas

Publishing popularized articles on scientific topics in the newspapers is a very efficient way of transferring research findings to a broad audience. With an effort of between a few days and 1 week of writing, one can reach an audience of some hundred-thousand people. At the same time, it is not always easy to publish comparatively dry and unbiased facts from science in a world of political and economical changes.

Figure 2—Clipping from Lässig et al. 2005.

Concerning knowledge transfer, a research institute with around 500 employees doubtlessly accumulates an awful lot of information, which could easily be transferred by even more than one science writer. As proved by some of the research stations of the USDA Forest Service, up to four science writers and one or more editors are successfully optimizing their publishing activities.

Concerning WSL, the science writer, in addition to the public relations manager, enabled the institute and its scientists to publish more articles written in a popularized way. After the first editions of the forest science newsletter from WSL, the science writer also started to pre-edit his colleagues' manuscripts before they were submitted to a forest magazine. Editing the drafts helped increase the quality of the manuscripts as well as the number of manuscripts being accepted by the magazine. Moreover, the magazines' chief editor does not correct the scientists' manuscripts as intensively as he did years ago. The greater number of articles has two major effects: (1) the scientists are able to transfer more of their findings to landowners, foresters, and other practitioners; and (2) the institute's research will be perceived by a wider audience. But editing is a most time-consuming work. To limit the increasing time of editing, it could be worthwhile offering writing training for scientists.

Science writing is, also, increasingly used in the process of making Web pages. During the last decade, it got quite popular to present science findings on the Internet. But the writing of good Web texts is a challenging job. The wording must be short and compact, but still correct and complete, and the layout should be pleasing to the eye as it clearly and effectively transfers the content. It is a real challenge to express the complexity of research projects and findings in a few paragraphs in a way that develops interest in a specific subject. It is highly recommended to motivate a few scientists at an institute's location to be trained in Web editing. The science writer took one training course, again, at the *State Adult Education Center of Zurich*. After finishing this course he now is better able to support and develop the content of new customer-friendly Web sites, Web pages, and Web projects. Concerning the making of Web pages, another important skill is layout. The WSL, today, employs three professional part-time Web publishers and one technical Web developer to develop sophisticated computer applications. Together with science writers and Web publishers from the research stations in Freising/Munich and Freiburg, Germany, and Vienna, Austria, a team of WSL specialists recently developed the Web site www.waldwissen.net that provides up-to-date knowledge from forest science to practitioners in the alpine region.

Just a First Step

During recent years, it became obvious that it was worthwhile for WSL to train scientists in different fields of science writing, Web editing, and Web publishing to improve knowledge transfer as well as public perception.

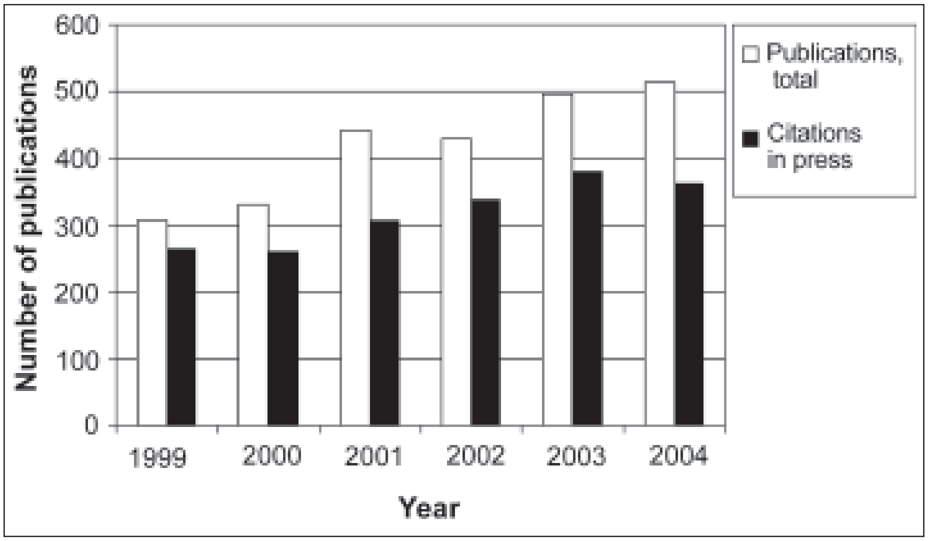

Figure 3—Number of publications and number of citations in articles published in Swiss newspapers (Swiss Federal Institute for Forest, Snow and Landscape Research was cited completely) Source: Swiss Media Databank, covering all major newspapers and magazines in Switzerland.

Besides the increase in the number of the peer-reviewed papers between 1999 and 2004 (+ 57 percent), there was also an increase in the number of nonreviewed papers of 132 percent. The number of books, proceedings, and newspaper articles, however, increased just slightly (fig. 1). All publication categories together showed a rise of 68 percent, and the citations in the press, which could just partly be influenced by the institute, rose by 37 percent (fig. 3). It would be incorrect to argue that these increases came just because of the involvement of science writers and public relation specialists. It was, indeed, the scientists themselves who understood that it was particularly rewarding for them, and for the institute, to publish articles in diversified media, including the peer-reviewed journals, to reach a wider target audience. However, roughly 5 to 10 percent of the total number of publications was published in collaboration with either the science writer or the public relations specialist.

It is obvious that the know-how of writers and editors was essential for the further success of the institute in both transferring its knowledge to the practitioners as well as placing newsworthy articles in the media. If an institute does not incorporate this knowledge, it should not be surprised that its outreach and knowledge transfer activities are ineffective. To optimize the communication of its findings, a research institute today has to serve dual duty. On one hand, it has to present its findings on an international scale to get the reputation from abroad and, on the other hand, it has to communicate with practitioners as well as with the public. The latter challenge could be easier achieved if an institute has science writers in-house. They are usually much better informed about ongoing projects and are at least sometimes more highly esteemed by the scientists than the journalists. Because of their knowledge of current research and of journalistic techniques, in-house writers and editors also help bring researchers in contact with journalists from the newspapers.

Scientists, science writers, and editors very much appreciate the increased possibilities of making the institute's scientific work better known to a larger audience. Out of this awareness, writing and Web publishing skills might become even more attractive to scientists in the future. Some of them have already taken short trainings in writing, editing, Web publishing, communication, and teaching. In addition, it is very motivating to realize that, for the next 4 years, the supervisory authority is striving for the goal of intensifying knowledge transfer in government-funded research.

Conclusion

Science writers and editors, while doing the writing, directly promote the transfer of scientific knowledge from an institute. But they also help to efficiently pre-edit manuscripts for technical magazines and intensify the relations with the editorial staff of media. But science writing does not just enlarge the number of articles in the newspapers. It also supports creating new publications like newsletters, technical bulletins, fact sheets or even Web sites and e-learning tools.

Compared to the large treasury of forest-related knowledge in the German-speaking countries, it seems that science writing is only in its initial stages at the research institutes. Today, most of them are publishing their own newsletters or technical bulletins written in a popularized style, and foresters and other practitioners use these publications to put new knowledge into realization. But there is still a huge amount of knowledge to be displayed.

As to the strategy of further educating the scientists within one's own institute, there is no doubt that not only is it feasible, it is even promising for a research institution to popularize research findings by using its own people. To translate this idea into practice, it is often assumed that some of the research institutes need to engage more science writers. As an alternative, the new and successful path WSL has taken could be recommended to other institutes. Science writers with in-house scientific experience as well as popularized writing skills and who also have a high rate of acceptance by their colleagues can easily understand their scientist colleagues and, therefore, quickly help to improve both the institute's knowledge transfer as well as the public's perceptions of the institute's research.

Unfortunately, European forestry as well as the research institutes are in the tough situation of strict budget cuts at this time. Even if there is a strong conviction to intensify the activities in knowledge transfer, it will be difficult right now to invest more funding and manpower into extension activities and communication. Therefore, the above-mentioned multinational initiative of publishing forest-related science findings on the Internet (www.waldwissen.net) might be the most time- and cost-saving intention in this direction, using as much synergy as possible. Irrespective of the mode of publishing (print, broadcast, or Internet), science writing is definitely a promising way to transfer knowledge from natural and forest sciences to regional, national, and international audiences.

Acknowledgments

I express my gratitude to Dr. Ruth Landolt and Fredi Lüthin, both WSL, for their support and assistance in providing the data necessary to prepare figures 1 and 3. I also thank Dr. Alois Kempf, WSL, for his support in providing the results of a search on the publication statistics of 1992, 1997, and 2002 in *Web of science.* Finally, I thank the two anonymous reviewers who helped me very much to improve the manuscript.

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Combine Digital Media Technologies to Produce an Interactive Distance Learning Tool

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Abstract

The Rural Technology Initiative implemented a Web-browser-based distance-learning tool to convey information across the Internet, on closed networks, and on local computers by using a free Microsoft® PowerPoint® add-in (Microsoft Producer®) to combine video, audio, slides, images, HTML links, and an interactive table of contents. The Microsoft Producer software provides the workspace to import and combine the different media sources into a single project. Once the different media sources are imported into the project, they can be easily dragged and dropped onto a timeline to be edited and, when PowerPoint slides are included, synchronized with the corresponding video.

The final multimedia publication allows the end user to simultaneously view a video presentation and the corresponding slides. Delivering these combined media over the Internet and through closed networks in a dynamic and interactive form is possible through the use of streaming video. The table of contents, extracted from the title of each Microsoft PowerPoint slide, is shown under the video screen. A mouse click on any title in the table of contents will advance or reverse the video to the respective slide. Also included are control buttons to pause and restart the video at any point in the presentation. These options allow users to skip around in the presentation and view the presentation on their own timeframe, providing a truly interactive aspect to a distance-learning tool.

This combination of media and its application as a distance-learning tool across multiple delivery platforms is important in its potential to improve the effectiveness of information dissemination. It increases the accessibility of information presented at seminars, conferences, and workshops by making it available to worldwide and distant audiences.

Keywords: Digital media, streaming video, distance learning, Microsoft Producer.

Introduction

The Rural Technology Initiative (RTI) implemented a Web-browser-based distance-learning tool to convey information across the Internet, closed networks, and on local computers using a free Microsoft® PowerPoint® add-in (Microsoft Producer®) to combine video, audio, slides, images, HTML links, and an interactive table of contents. This combination of media and its application as a distance-learning tool across multiple delivery platforms is important in its potential to improve the effectiveness of information dissemination.

Combining Digital Media Technologies

The Microsoft Producer software provides the workspace where multiple media sources, including video, audio, PowerPoint slides, images, and HTML links, can be combined and published into a single project. Once the different media sources are imported into the project, they can be easily dragged and dropped onto a timeline to be edited and, when PowerPoint slides are included, synchronized with the corresponding video. Thirty-eight

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templates are included in the existing software, providing different media combination options such as video screen size, resizable slide viewing area, table of contents, and HTML links. The entire process of editing and combining the media can be done very rapidly; a 1-hour presentation can be made available on the Internet within 4 hours.

Publication of the single project can begin when the timeline edits are finalized and the table of contents correctly displays the project's navigation. Microsoft Producer includes a Publication Wizard that gives step-by-step options to help tailor the final publication to best match the intended audiences' connection speeds or viewing platforms. A project can be published at a higher speed and resolution for an audience using a broadband connection or at a lower speed and resolution for an audience using a dial-up modem. There is also the option to publish the project for local playback or from a CD-ROM, which provides the highest quality resolution of video, audio, slides, and images.

The final multimedia publication allows the end user to simultaneously view a video presentation and the corresponding slides. The table of contents, extracted from the title of each slide, is shown under the video screen. A mouse click on any title in the table of contents will advance or reverse the video to the respective slide. Also included are control buttons to pause and restart the video at any point in the presentation. These options allow users to skip around in the presentation and view the presentation on their own timeframe, providing a truly interactive aspect to a distance learning tool.

Multiple-Delivery Platforms

The ability to publish a project at multiple levels of speed and resolution makes the output accessible to an array of end users through several platforms: the Internet, closed networks, and local computers or CD-ROMs. Delivering these combined media over the Internet and through closed networks in a dynamic and interactive form is possible through the use of streaming video. Streaming video is served up to coincide with the PowerPoint slides by using a streaming media server—a specialized piece of hardware and software that accepts requests for video files, knows about the format, bandwidth, and structure of those files, and in many cases, pays attention to the performance of the player that is receiving the video. Streaming servers deliver the correct amount of data necessary to play, pause, stop, and move to particular parts of the video file, at precisely the rate needed to play it on the user's media player.[3]

The files published by Microsoft Producer can also be downloaded onto and viewed from a local computer or burned to a CD-ROM and watched from a local CD drive. Viewing the combined video, audio, slides, images, and table of contents from a local computer results in the highest quality and fastest response to user controls, given the lack of band width or Internet connection congestion issues. The HTML links to Internet and network locations, however, will not be accessible if the user is off-line.

This flexibility in multiple delivery platforms increases the size and diversity of the potential audience for any given presentation. Additionally, it increases the accessibility of information presented at seminars, conferences, and workshops by making it available to local and remote audiences.

Applications of the Technology

The RTI first applied this combined interactive media at the RTI Annual Review, held at the University of Washington in January, 2003. Digital video footage was recorded at each presentation, synchronized with the corresponding Microsoft PowerPoint slides by using Microsoft Producer, and published to the RTI media server. Within 2 days, all of the presentations from the review were streaming from the RTI Web site.

[3] Bouthillier, L. Streaming vs. downloading video: understanding the differences. http://www.streamingmedia.com/article.asp?id=8456&page=2&c=11 (as of 05/05/2005). (July 22, 2003).

The speakers and audience members from the review provided both enthusiastic and critical responses. The ability to rapidly reproduce an entire seminar, or even one presentation, through a medium that conveys speaker oration, body language, and informative slides proved to be an enticing concept. The criticism stemmed from the low quality of video, owing almost entirely to the poor lighting during the recording.

The outreach potential of the new technology encouraged the purchase of lighting, a canvas backdrop, and portable audio devices to improve the video and audio quality. This proved to be successful and added consistency and quality to the combined multimedia product.

Since the initial trial of this combined digital media technology, RTI has applied this tool as a vehicle to deliver a host of forestry-related information. The initial concept of quickly reproducing individual presentations and entire conferences for rapid dispersal was realized when over 100 different productions were streaming from the RTI Web site. These productions can be used by the speakers to improve their delivery, by conference attendees as a source of continued review, and as an easily accessible and sharable resource location. Because the publications are housed on the Internet, they can also be discovered by otherwise unaffiliated persons via Internet search engines.

This technology can also be applied to a field trip setting by capturing the speaker with a portable digital video camera while taking digital still photos of the various discussion topics. A slideshow of the discussion topics can then be made with the digital stills in Microsoft PowerPoint to be synchronized and published in the same manner as a formal presentation. An instructional tutorial is another application that would allow the user to focus on concepts or repeat directions when necessary. This interactive combined media technology fits well with RTI's goal to increase access to forestry technology and information. It should not be expected to replace personal contact, yet rather be used as a powerful supplementary outreach tool.

Costs and Limitations

The application of combined digital media technology has its costs and limitations. The initial cost is the purchase of equipment (see table 1). This cost is highly variable because of the many grades of equipment and the intended quality of the final product. There is also a substantial amount of work that goes into recording and production that will differ in cost depending on the salary and efficiency of the individual working (see table 2). The cost of the software is usually negligible owing to the fact that most organizations and institutions run Microsoft Windows® on their local and network computers. A major contributor to RTI's decision to use Microsoft Producer was its availability as a free add-in to Microsoft PowerPoint.

The main limitation of this technology is that the process is purely Microsoft based. The final combined digital media product is built to work in Microsoft Internet Explorer®; although it works in several different Web browsers, there is often limited to no interactivity between the table of contents and the user. Additionally, some Web browsers will not open or play the final production. This technology, as used by RTI, is also PC-based, and does not consistently work well with Mac computers. The cost to produce a comparable product that would work across all computer and browser platforms would be substantially increased, both in the equipment and production time. Because RTI monitors the operating system and browser use of all Web site visitors, and knows that 95 percent of the visitors use Microsoft Windows and 85 percent use Microsoft Internet Explorer, it was decided that this limitation was acceptable for the purpose of using combined digital media as a distance-learning tool.

Measuring the Results

The RTI has adopted the process of combining several forms of digital media into one interactive distance learning tool. Over 100 presentations given in lectures, meetings, studios, and conferences have been recorded,

Table 1—Estimated cost of equipment needed to record, produce, and serve combined digital media as a distance-learning tool

Equipment	Estimated cost
	Dollars
Digital video camera	400 - 2000
Tripod with remote	100 - 200
Wireless microphone	200 - 800
9-volt rechargeable batteries and charger	50
Lighting and stands	800 - 2000
Canvas backdrop and stands	300
Video editing workstation (PC computer)	2000
Streaming media server	2500
Web server	2500
Software—Microsoft Windows 2000 or XP	100
Total estimated cost	\$8,950 - \$12,450

Table 2—Estimated amount of time and related cost to record, edit, and produce a 1-hour presentation

Record and production activity	Estimated time
	Hours
Record a 1-hour presentation	1
Transfer presentation to computer	1
Synchronize and edit in Microsoft Producer[a]	1 – 4
Publish project to local computer or network location[b]	1 – 2
Total estimated time for a 1-hour presentation	4 – 8
Estimated cost at an hourly rate of \$15	\$60 - \$120

[a] Variable owing to efficiency and skill of editor.
[b] Variable owing to the number of different speeds in which the final project will be published (56 kbps, 100 kbps, 150 kbps, 300 kbps, and/or 800 kbps).

edited, and published to stream from the RTI Web site (http://www.ruraltech.org/video/). The user statistics recorded for the RTI media server are used to gain a general understanding of the success of specific presentations or entire collections. In 2004, the number of unique visitors to access video from the media server was almost 600, and doubled to nearly 1,300 in 2005. The ability to sort the videos by the number of times they were accessed by a unique visitor makes it possible to rank the presentations and can be used to gauge the success of the presentations and the interactive distance learning tool. This is not a perfect source of feedback, however, as it lacks user response with regard to how well the technology worked for them. Given the high cost associated with an actual survey and the difficulty in contacting the multitude of users that have accessed video from the RTI media server, however, the use of media server statistics has been deemed an acceptable measure for RTI's purpose.

Other forms of feedback encourage the continued investment into this combined digital media as a distance learning tool. The Digital Information Specialist at RTI trained staff members at Washington State University (WSU) Cooperative Extension and Montana State University (MSU) to use this technology, enabling both institutions to provide additional learning tools to their constituents. That WSU Cooperative Extension has hundreds of video presentations streaming from their Web site is testimony to their perceived value of this technology. Personal contact with the recording and editing staff at MSU continues to be positive; faculty interest and funding there has increased enough to justify the purchase of a new digital video camera, lighting, and a Web server. Lacking a formal survey, these sources of feedback, along with a multitude of unsolicited responses, are enough to merit continued support and use of this technology by RTI.

Conclusion

The power of this distance-learning technology is in the capability to combine several digital media into one interactive package. The ability to publish this combination of video, audio, slides, images, HTML links, and an interactive table of contents at multiple levels of quality over the Internet, on closed networks, and to local computers makes this tool accessible to a wide variety of audiences. The short amount of time between recording a presentation and serving it over a network guarantees the timeliness of the information being published. And the interactive aspect of on-demand streaming video allows multiple users to watch and navigate through a presentation at their own paces.

The RTI perceives that the potential application of this technology to increase the audience of lectures, conferences, workshops, and fieldtrips, and to be used as an instructional device and a presentation critique, outweigh its costs and limitations. This interactive distance learning tool has already helped RTI better attain its goal to increase the accessibility of forestry technology and information, and the technology will continue to be improved to make it more streamlined, more user friendly, and more accessible.

Tree Judging: A Quantifiable, Hands-on Tool to Teach Forest Genetics and Applied Silviculture

Christopher C. Schnepf[1]

Abstract

Whether it be traditional silvicultural practices such as precommercial thinning or more complex ones such as variable-retention timber harvesting, foresters want to leave trees with specific characteristics that meet silvicultural objectives. Frequently the choice of individual leave trees is left to loggers or seasonal employees with little formal training related to the objectives. This presentation will feature a hands-on exercise that teaches participants how to evaluate trees of varying quality according to specified criteria. The method has been adapted from techniques that have been used to judge livestock and yields numerical scores of how well participants' choices compare with the instructor's. The technique can be adjusted to teach a wide variety of criteria, from traditional timber production to wildlife tree acceptability, and has been used by University of Idaho Extension to train family forest owners, loggers, and youth on leave tree quality. In 2004, the method was used with 250 loggers, 88 percent of whom indicated they would choose better leave trees as a result of the training.

Keywords: Genetics, silviculture, selection, judging, leave trees.

Quality Leave Trees?

Silvicultural practices ranging from precommercial thinning to variable-retention timber harvests require trees with characteristics that meet silvicultural objectives. Increasingly, individual leave tree choices are left to loggers (particularly for mechanized harvesting) or seasonal timber markers with little specific training related to the objectives. Historically, loggers often focused primarily on the quality of trees cut, rather than the quality of trees left, to maximize their return from a given timber harvest. Focusing on which trees to leave and why is a different focus for many loggers. Education programs that help loggers and timber markers understand fundamental principles of what kinds of trees to leave and why, then allow them to do a guided practice, are likely to improve silvicultural outcomes.

Tree Judging

For many years, judging contests have been a ubiquitous teaching tool in youth programs in animal science (e.g., 4-H and Future Farmers of America). With livestock judging, four (sometimes more) cattle, sheep, or other livestock are lined up and judged according to bone structure, muscle quality, and other criteria. Tree judging has been adapted from these livestock judging contests. It is an educational tool that has been particularly popular with loggers and others who have more hands-on learning styles.

Setting Up Trees for Judging

To set up a tree-judging activity, the instructor starts by choosing a set of four trees (often called a "class" in livestock judging). Ideally the trees can all be seen from one spot. For learners who are new to the activity, it is best to start by choosing a set of trees that are the same species and age class. The method is also a little easier in recently thinned stands, as crowns are easier to see. Pines *(Pinus* spp.*)* are also a little easier to judge, as they keep

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fewer interior needles, making bole and branching characteristics more visible.

The individual trees in the set of four can be identified in various ways, but it is often convenient to identify them with different numbers of bands of flagging wrapped around the stems; that is one flag band for tree no. 1, two flag bands for tree no. 2, etc. (fig. 1). Within these four trees, try to include a range of characteristics to choose for or against, such as: forking; crown ratios; crown dominance; crown vigour; crook, sweep, taper in the bole, etc.

After selecting the trees, the instructor ranks them by using an established set of criteria. For example, if tree no. 3 was the best, tree no. 4 was the second best, tree no. 1 was third, and tree no. 2 was the worst, the ranking would be “3-4-1-2.”

Along with the ranking, the instructor makes three cuts (penalties) between the four trees to weight the ranking differences. For example, if the top tree is much better than the 2nd, you might make a cut of six points; if the top tree is only slightly better than the 2nd, that cut may be 1 point. Similar cuts are made between the 2nd and 3rd ranked trees, and the 3rd and bottom ranked tree. The total of all these cuts cannot be more than 15 points. If cuts total 15 points, the middle number cannot be larger than five. If cuts total 14, the middle number cannot be larger than 8.

Once the ranking and cuts have been determined, you can derive scores from all the possible ways the set of four trees might be ranked by a learner. Sliding sets of cards (Plager 1975) are available to determine scores from 1 to 50 for all the possible different rankings and cuts (fig. 2). We also have a spreadsheet that calculates these scores.[2]

After the trees have been arranged, we typically create a scoring sheet that lists all the possible combinations of rankings (fig. 3). The scoring sheet has a column of rankings for each set of trees that is judged. Participants circle their corresponding ranking for the set of trees. When the sheets are turned in, the participants' rankings can be scored relative to the judge's key.

Tree Judging

After setting them up, the learners judge the trees. In some livestock judging activities, participants also write down their reasons for their rankings. In competitions, evaluating reasons helps break ties. If numerical scores are not needed for evaluation, encouraging the participants to discuss their decisionmaking with each other often results in participants having active debates about how to apply the criteria used to rank trees and aids learning. Regardless of which approach is taken, after the learners have made their choices, the instructor provides their rankings and cuts and discusses the rationales used to make them.

Variations

Tree judging is a fairly simple frame that can be used to teach a wide variety of genetic and silvicultural issues and contexts. For example, if your focus is on precommercial thinning, you can work on sapling trees. If you wanted to focus on one issue learners are having trouble understanding (e.g., crown vigor), you choose the appropriate trees and have them ignore every characteristic save that one.

The instructor can also make the exercise more complex by combining criteria. For example, we have flagged different species and had participants rank them according to species' long-term adaptation to that site as well as growth and form. With more sophisticated groups, you could deal with multiage stands and discuss the relative ability of individual trees to release (from competing vegetation), given their silvics and the site, etc.

Tree judging can also focus on nontimber silvicultural objectives. For example, one could flag and rank wildlife snags or trees that have other specific wildlife values (e.g., roosting trees or varying degrees of bark attached).

[2] To request a copy of this spreadsheet, e-mail cschnepf@uidaho.edu.

Figure 1—Flags used to identify trees in judging activity.

Figure 2—Cards used to calculate scores for judging contests.

Idaho State Forestry Contest, 2003

Please circle your ranking:

Preferred ponderosa seed trees (red/white)		**Preferred lodgepole seed trees (pink)**		**Preferred species to <u>PLANT</u> (fushia/black)** (most preferred–highest rank, least preferred–lowest rank)	
Ranking	*Score*	Ranking	*Score*	Ranking	*Score*
1-2-3-4		1-2-3-4		1-2-3-4	
1-2-4-3		1-2-4-3		1-2-4-3	
1-3-2-4		1-3-2-4		1-3-2-4	
1-3-4-2		1-3-4-2		1-3-4-2	
1-4-2-3		1-4-2-3		1-4-2-3	
1-4-3-2		1-4-3-2		1-4-3-2	
2-1-3-4		2-1-3-4		2-1-3-4	
2-1-4-3		2-1-4-3		2-1-4-3	
2-3-1-4		2-3-1-4		2-3-1-4	
2-3-4-1		2-3-4-1		2-3-4-1	
2-4-1-3		2-4-1-3		2-4-1-3	
2-4-3-1		2-4-3-1		2-4-3-1	
3-1-2-4		3-1-2-4		3-1-2-4	
3-1-4-2		3-1-4-2		3-1-4-2	
3-2-1-4		3-2-1-4		3-2-1-4	
3-2-4-1		3-2-4-1		3-2-4-1	
3-4-1-2		3-4-1-2		3-4-1-2	
3-4-2-1		3-4-2-1		3-4-2-1	
4-1-2-3		4-1-2-3		4-1-2-3	
4-1-3-2		4-1-3-2		4-1-3-2	
4-2-1-3		4-2-1-3		4-2-1-3	
4-2-3-1		4-2-3-1		4-2-3-1	
4-3-1-2		4-3-1-2		4-3-1-2	
4-3-2-1		4-3-2-1		4-3-2-1	

Score: **Score:** **Score:**

AVERAGE:

Figure 3—Example of a scoring sheet used by participants in a tree-judging activity.

We typically use tree judging after introducing participants to the core concepts by using other curricula on choosing leave trees (Schnepf and Brotherton 1995, Schnepf 1999). But tree judging could also be used outside the context of formal education programs (e.g., calibrating leave tree choices between foresters and timber marking crews)

Tree Judging Can Generate Outcome Data

Many policymakers want evidence of outcomes from funds expended on technology transfer. Tree judging can provide quantifiable evidence of learning, particularly when you use it as a pre/post test with an educational program. To document outcomes, stay consistent in the difficulty level of sets. Making sets progressively more challenging (as is commonly done when setting up a set of trees in a field program to maintain learner interest) may make for negative outcomes! Doing more repetitions over time should increase scores.

Conclusion

Tree judging is a simple but effective tool to teach applied forest genetics or any other topic that requires skill to distinguish between varying qualities of trees. It can yield numerical scores of how well participants' choices compare with the instructor's and has been used extensively by University of Idaho Extension to train family forest owners, loggers, and youth on leave tree quality. Tree judging is particularly effective with hands-on learners. In 2004, the method was used with 250 loggers who all judged 10 sets of trees each. Eighty-eight percent indicated they would choose better leave trees as a result of the training.

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Case Studies

Promoting Reduced-Impact Logging in Tropical Developing Countries: A Success Story of Technology Transfer

Dennis P. Dykstra[1]

Abstract

Industrial timber harvesting operations commonly employ heavy machinery and thus have the potential to inflict significant damage on soils, streams, and residual vegetation. Impacts associated with such operations have been especially troubling in many tropical countries, where mature trees often have large crowns capable of destroying other trees when they fall; soils remain wet for much of the year and are highly susceptible to significant compaction and erosion; loggers typically have little education, are poorly trained, and often must work and live in arduous, unhealthy conditions; and remote locations make oversight by government agencies difficult. Beginning in the early 1990s, the Food and Agriculture Organization of the United Nations (FAO) launched a concerted effort to develop and promote codes of forest harvesting practice that would provide guidelines for planning and controlling logging operations in tropical forests in order to reduce environmental impacts. This effort included research to define and validate reduced-impact logging practices and technologies; publication and distribution of a "model" code of forest harvesting practices; development and promotion of regional codes of practice; and provision of technical assistance to individual countries to develop and implement national codes of practice. Although FAO provided the initial stimulus for the effort and has remained a central player, much of the work has been done by a wide variety of research institutes and universities; nongovernmental organizations; industry associations; government technical-assistance programs; and international agencies such as the International Tropical Timber Organization, the International Labor Organization, and the World Bank. This paper provides an overview of this global effort and suggests reasons it has been successful in transferring knowledge and technology from industrialized countries to tropical developing countries.

Keywords: Reduced-impact logging, code of forest harvesting practice, environmental impacts.

Introduction

Over a period of several years leading up to the United Nations Conference on Environment and Development (UNCED), which was held in Rio de Janeiro, Brazil, in June 1992, the Forestry Department of the Food and Agriculture Organization of the United Nations (FAO), based in Rome, Italy, began work on programs designed to recognize the connection between environmental protection and sustainable economic development of poor countries. The UNCED was an enormously important conference, involving official delegates from 178 countries, heads of state of more than 100 countries, a large number of delegates from UN agencies and related organizations such as the World Bank, and representatives of more than a thousand nongovernmental organizations (NGOs). Hundreds of journalists covered the 12-day summit, both for television and for print media, and as a result it was front-page news around the world. A collection of international documents and agreements that resulted from the conference is accessible online from Columbia University's Center for International Earth Science Network (CIESIN 2005).

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The FAO was involved in UNCED at every level, from the political to the operational. Beginning around 1990, each operating unit within FAO was encouraged to develop a program of work consistent with the ideas that were to be raised at UNCED. As part of this planning process, the Forest Harvesting and Transport Branch, a small unit of the FAO Forest Products Division, proposed a program of work entitled "Environmentally Sound Harvesting in Tropical Forests." The proposal was accepted in 1991. I was hired, first on a consulting basis during the summer of 1991 and then as a full-time forestry officer in early 1992, to implement the program together with Branch Chief Rudolf Heinrich, an Austrian forest engineer who at that time was already a 20-year veteran of FAO. The program is described in Dykstra and Heinrich (1992).

This paper provides an historical overview of an effort to promote what began as "environmentally sound forest harvesting" and has now become commonly known throughout the tropics as "reduced-impact logging," or RIL. The paper considers some of the reasons the effort has been successful and also examines missteps that might easily have consigned it to the dustbin of international forest history.

Tropical Forests

Foresters have recognized for 150 years or longer that tropical forests are fundamentally different in many ways from temperate forests (Brandis 1897). Among other things:

- Tropical forests commonly exhibit an extraordinarily high degree of speciation—that is, many tree species are often present on each hectare of forest and the management requirements for these species (or for cohorts of species) may differ markedly. By comparison, temperate forests usually have a relatively small number of tree species per hectare, many of which will respond in similar ways to a given management regime.
- Most natural forests in the tropics have only a few trees per hectare that reach commercial size and are of species that can be utilized profitably by the timber industry. Temperate forests, on the other hand, often have many stems of commercial trees per hectare. The difference is significant—as much as two orders of magnitude or more.
- The volume of commercial timber that can be harvested from each hectare of tropical forest is usually much lower than in temperate forests, often by one or two orders of magnitude. This makes logging operations in tropical forests much more expensive, per cubic meter of timber harvested, than similar operations in temperate forests.
- Mature trees in tropical forests often have large, heavy crowns that are capable of destroying or severely damaging other trees when they are felled. To some extent this is also true in temperate forests, especially those dominated by broadleaved tree species. Typically, however, tree crowns spread more broadly in tropical forests, and because they are often interconnected by strong vines, felling one tree may cause several adjacent trees to be pulled over or broken in what tropical foresters refer to as a "domino effect."
- Tropical forests are commonly inhabited by people. Many of these people, whose number is estimated to be around 1.6 billion, rely heavily on forest resources for their livelihoods. In some cases, these forest-dependent people may be recent migrants attempting to escape civil war, social unrest, or hoping to find land that can be cultivated. In other cases, they are indigenous people whose families may have lived within the forest area for generations. In either case, sustainable development as defined by UNCED requires that these people and their welfare be explicitly considered in forest management.

Reduced-Impact Logging as Silviculture

Logging by itself is not silviculture, just as silviculture by itself is not forest management. Nevertheless, logging is an essential part of both silviculture and forest management, and is one of the most important tools available to forest managers for influencing stand conditions. By the mid-1800s, Brandis (1897) had recognized the importance of careful logging as a component of silviculture. In Burma and later in India, he promoted the use of elephants over bullocks or horses for skidding, arguing that the elephants' large, padded feet minimized soil disturbance and compaction.

Following the end of World War II, mechanized logging equipment was introduced into tropical forests on a large scale. Within a few years, tropical foresters began reporting extensive damage to residual vegetation and soils as a result of these logging operations (e.g., Redhead 1960). These problems were partly attributed to the higher rates of production associated with the use of heavy machinery, but also to the fact that the people operating the machinery tended to be poorly trained and have no understanding of silvicultural requirements or the need for environmental protection.

In reviewing assessments on logging damage, one influential tropical forester (Dawkins 1958) went so far as to suggest that mechanized harvesting might be incompatible with the selection harvesting systems practiced in many parts of the tropics. Others, recognizing the impracticality of returning to the labor-intensive systems of earlier years, have focused on promoting technologies and practices that would permit the use of mechanized harvesting systems while reducing environmental impacts to a level compatible with sustainable forest management (e.g., Dykstra 2004, Dykstra and Heinrich 1992, Hendrisen 1989, Marn and Jonkers 1982). These methods and technologies have now become widely known as "reduced-impact logging," or RIL. There is no single, globally applicable definition of what constitutes RIL because many of the specific procedures, environmental standards, and types of logging equipment differ with local conditions. Nevertheless a RIL operation in tropical forests would normally include the following:

- Preharvest inventory and mapping of individual crop trees.
- Preparation of accurate, operational maps for all harvest areas.
- Cutting of vines where necessary in advance of felling operations.
- Planning, design, and construction of roads, skidtrails, and landings to provide access to the harvest area and to the individual trees to be harvested while minimizing soil disturbance and protecting streams and waterways with properly engineered crossings.
- Use of directional felling and bucking of logs in a way that optimizes value recovery.
- Winching of logs to skidtrails rather than driving the skidding machine to each log; limiting the operation of heavy equipment to skidtrails.
- When necessary because of soil conditions and topography, utilizing yarding systems that suspend logs partially or fully above the ground.
- Conducting postharvest assessments to provide feedback to the timber concession holder and logging crews, and to evaluate the degree to which RIL guidelines were followed.

Results: Adopting Reduced-Impact Logging

Although no one would claim that all or even a majority of logging operations in tropical forests now meet the standards of reduced-impact logging, an impressive amount of progress has been achieved in the relatively short time of about 15 years. A recent report by the International Tropical Timber Organization, for example, found that a "sea change" had occurred in the attitudes of timber companies in the Brazilian Amazon toward the adoption of RIL technologies (ITTO 2003). Whereas the general attitude had been very negative 5 years earlier, by 2003 a large number of companies had adopted RIL practices and were hiring foresters to supervise their logging operations. Even in industrialized countries, RIL is becoming recognized as a specific requirement of forest management; as an example, in a recent survey, 89 percent of logging operators rated training in RIL technologies as a medium- or high-priority need because of landowner demand (Egan 2005).

What Is Driving the Adoption of Reduced-Impact Logging?

The global effort to promote the use of RIL technologies in tropical forests arguably began with UNCED in 1992, although similar efforts had been attempted earlier. UNCED's strong focus on the problem of tropical deforestation resulted in a significant effort over a wide array of fronts to improve industrial forestry operations in the tropics. Table 1 provides a chronology of events that I consider to have been instrumental in promoting the adoption of RIL. Several factors were especially important:

- Adoption of the term "reduced-impact logging," to replace terms that had been used previously but were not as widely accepted such as "environmentally sound harvesting." In particular, "reduced-impact logging" resonated positively with environmental advocacy groups, which were more willing to accept the idea that logging impacts can be reduced than they were to acknowledge that logging could ever be considered "environmentally sound." It isn't certain who invented this term, but it was first popularized by Putz and Pinard (1993) in reference to a carbon-sequestration project put together by Jones (1995).
- Publication of the *FAO Model Code of Forest Harvesting Practice* (Dykstra and Heinrich 1996) in English, French, Spanish, and most recently in Chinese. This publication has been enormously influential in developing countries because of consistent, long-term support by FAO. Prior to its publication, there was some resistance within the FAO Forest Products Division to the concept of such a document. These objections were overridden by David Harcharik, who at that time was head of the FAO Forestry Department. Later the Director-General of FAO, Jacques Diouf, during his declaration at the 2002 World Summit on Sustainable Development in South Africa (Diouf 2002), explicitly identified the FAO Model Code as an example of a policy initiative that has been extraordinarily effective in promoting sustainable development. At least 40 countries have now developed national codes or guidelines based on the FAO Model Code. The FAO has since published more detailed regional codes of forest harvesting practice for Asia (FAO 1999) and Africa (FAO 2003) and is currently working on a regional code of forest harvesting practice for Latin America. The FAO has also published a series of "Forest Harvesting Case Studies" that have been influential in convincing tropical foresters of the value of RIL, and together with the USDA Forest Service and United States Agency for International Development (USAID), FAO has supported development of software that permits operators to rapidly conduct financial analyses of RIL as compared to conventional logging (Dykstra 2004).
- Complementary efforts by other international organizations, especially the International Tropical Timber Organization (ITTO), the International Labor Organization, and the World Bank, have contributed to the adoption of RIL and to its political acceptance among tropical countries. The ITTO in particular has been active in supporting projects to implement and evaluate RIL operations throughout the tropics.
- Efforts by regional organizations such as the Asia-Pacific Forestry Commission (APFC) to promote sustainable forestry practices and the adoption of RIL. The APFC in particular has been very active, with a strong program promoting the development of regional and national codes of forest harvesting

Table 1—Chronology of events related to the publication of the Food and Agriculture Organization Model Code of Forest Harvesting Practice and broad acceptance of reduced-impact logging in the tropics

Year	Event
1990	Fiji National Code of Logging Practice published with the assistance of the International Labor Organization.
1992	Food and Agriculture Organization (FAO) Program on Environmentally Sound Forest Harvesting initiated (Dykstra and Heinrich 1992).
	IUFRO conference on harvesting and silviculture held in Malaysia (Wan Razali et al. 1994).
1993	Discussion on reduced-impact logging (RIL) with U.S. representative to COFO, FAO's Committee on Forestry, which meets every 2 years; the representative indicated that the U.S. delegation could not support any resolution involving the words "harvesting" or "logging" due to sensitivities in the U.S. Congress.
	Austrian and Indonesian representatives to COFO jointly introduce a motion directing FAO to develop codes of forest harvesting practice relating to tropical forests.
	Sabah Foundation RIL project started (Jones 1995, Putz and Pinard 1993).
	The Tropical Forest Foundation (TFF) initiated its project on low-impact logging research and training in Pará, Brazil. This would eventually lead to publication of a comprehensive financial analysis of RIL (Holmes et al. 2000).
1994	Workshop on the STREK Project (Silvicultural Techniques for the Regeneration of logged-over forest in East Kalimantan), which was initiated in 1989 by CIRAD-Forêt (France) and the Indonesian Ministry of Forestry, held to review relationships between RIL and silvicultural practices.
	Draft of the *FAO Model Code of Forest Harvesting Practice* produced (Dykstra 1994) in spite of opposition within the FAO Forest Products Division. Two workshops were held to review the draft, in the Philippines and in Germany.
1995	Preliminary release version of FAO Model Code introduced at COFO by David Harcharik, newly appointed head of the Forestry Department at FAO, in spite of continued opposition within the Forest Products Division. Publication of the document was approved by COFO delegates.
	Code of Conduct for Logging of Indigenous Forests in Selected South Pacific Countries endorsed by the 26th meeting of the Asia-Pacific Forum (SPFDP 1995).
	FAO satellite meeting held at the IUFRO World Congress in Tampere, Finland (FAO 1997).
1996	FAO Model Code published (Dykstra and Heinrich 1996) in English, French, and Spanish. All versions are available both in print and online.
	RIL conference for Southeast Asia held in Sandakan, Sabah, Malaysia.
	Asia-Pacific Forestry Commission formation of an ad-hoc working group to develop a Code of Practice for Forest Harvesting in Asia-Pacific.
1997	First national code of practice known to be based on the FAO Model Code published in Guyana.
	IUFRO interdivisional conference on RIL hosted by the Bolivian Forestry Project sponsored by the U.S. Agency for International Development (BOLFOR) in Bolivia.

Table 1—Chronology of events related to the publication of the Food and Agriculture Organization Model Code of Forest Harvesting Practice and broad acceptance of reduced-impact logging in the tropics (continued)

Year	Event
1999	*Regional Code of Practice for Forest Harvesting in Asia and the Pacific* published (FAO 1999).
2000	Chinese translation of the FAO Model Code (Dykstra and Heinrich 1996) published by FAO.
	Special issue of the International Forestry Review dedicated to RIL (Commonwealth Forestry Association 2000).
2001	International conference on applying RIL held in Kuching, Sarawak, and Malaysia (Enters et al. 2002).
	RIL guidelines published for Indonesia (Elias et al. 2001).
2002	Draft national code of forest practice published in China with support from FAO and ILO.
	FAO Declaration at the World Summit on Sustainable Development, Johannesburg (Diouf 2002).
2003	International conference on codes of forest practice held in Japan (Japan Forestry Agency 2003).
	Regional Code of Practice for Forest Harvesting in Africa published in French (FAO 2003).
2002-2004	A financial-analysis software package, RILSIM, was developed and promoted by the USDA Forest Service, United States Agency for International Development (USAID), FAO, and the Asia-Pacific Forestry Commission (APFC) as a means of encouraging loggers in developing countries to adopt RIL methods (Dykstra 2004).
2005	According to FAO, at least 40 countries have used the FAO Model Code as a model in developing their own national codes of practice or guidelines related to forest harvesting.

practice; an information-sharing network (RILNET); the organization of international conferences on RIL and on sustainable forest management; a comprehensive program of training and awareness; and support for the development of tools to promote RIL, including the RILSIM software mentioned previously.

- Work by research institutions such as the Center for International Forestry Research, the French tropical forestry research organization CIRAD-Forêt, the Tropenbos Foundation of the Netherlands, and many national research agencies and universities in developing countries has legitimized RIL as a focus of research and development efforts.
- Development of practical, field-oriented training programs on RIL methods and technologies, most notably by the U.S.-based Tropical Forest Foundation (TFF) and its Brazilian subsidiary, Fundação Floresta Tropical (FFT), has been essential for promoting adoption of RIL. The TFF has now launched similar regional training programs for Africa and Asia.
- Implementation of projects to promote adoption of RIL by donor agencies for both multilateral and bilateral development-assistance programs such as Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) (Germany), USAID (United States), Japan International Cooperation Agency (JICA) (Japan), Department for International Development (DFID) (United Kingdom), Canadian International Development Agency (CIDA) (Canada), Swedish International Development Cooperation Agency (SIDA) (Sweden), and others.
- Active promotion of RIL by international environmental organizations such as the Worldwide Fund for Nature, IUCN (the World Conservation Union), the Wildlife Conservation Society, and Greenpeace; and by influential nongovernmental organizations

in tropical countries such as IMAZON (the Institute for Man and Nature) in Brazil and Forest Watch in Indonesia.

- Adoption of RIL as a requirement for certification of sustainably managed forests under the standards and guidelines of the Forest Stewardship Council, with similar requirements either explicitly stated or implied in other certification programs.
- Acceptance of RIL by influential industry organizations such as the Sarawak Timber Association in Malaysia and the Association of Timber Concession Holders in Indonesia; AIMEX (the Association of Timber Exporting Industries of the State of Pará) in Brazil; and the African Timber Organization and ATIBT (Association Technique Internationale des Bois Tropicaux) in Africa.
- Support for RIL concepts by government agencies in developing countries that have major areas of tropical forest. Of particular note in this regard are the governments of Indonesia, Malaysia, China, Fiji, Ghana, Congo, Gabon, Guyana, Bolivia, and Brazil, although many other countries have also endorsed the concept of RIL.

Concluding Remarks

Reduced-impact logging is clearly a concept whose time has come, at least for tropical forests. For the most part, RIL itself is not new; most of these technologies and practices have been developed in temperate forests and are used there as a matter of course, or as a result of forest practice laws that require them. The rapid rate at which RIL is being adopted in tropical forests, therefore, can be considered a success story in the transfer of technology from industrialized countries to developing countries. It's important to recognize that this success cannot be attributed to any single person, organization, or event, but rather to a combination of events, evolving public attitudes about forests, and an informal (and to some extent even unwitting) consortium of organizations and individuals.

I consider five complementary factors to have been particularly important in facilitating the widespread adoption of RIL practices in the tropics:

Champions. Since its introduction in the early 1990s, RIL has had numerous champions, both among individuals and among organizations. These champions represent a wide variety of viewpoints, from industrial forestry to conservation advocacy. Although they might disagree on many policy issues, the champions agree on the importance of RIL for the future of tropical forests, and as a result their combined voice has been very strong.

Policy support. The strong support of RIL by the major international development-assistance organizations, especially FAO, ITTO, and the World Bank, coupled with equally strong support from influential environmental organizations such as World Wildlife Fund (WWF), Wildlife Conservation Society (WCS), and IUCN, has led to very broad support at the ministerial level in a majority of countries where tropical forests represent a major resource.

Forest certification. By requiring the adoption of RIL as an essential prerequisite for certification of forests as being sustainably managed, certification bodies have provided a strong incentive to timber companies interested in selling forest products in markets that require certification. This has been cited as a major reason for widespread adoption of RIL in the Brazilian Amazon (ITTO 2003).

Training. Innovative approaches to on-the-ground training in RIL technologies and practices as developed by the Tropical Forest Foundation and by a variety of specialized consulting companies have been essential in getting RIL actually implemented. Many of these efforts have been supported financially by development-assistance organizations, particularly ITTO and the World Bank, as well as by bilateral aid agencies.

Lack of controversy. Although there has inevitably been some resistance to the promotion of RIL among advocacy groups that consider any logging in tropical forests to be unacceptable, by and large it has been surprisingly free of controversy. This has encouraged more rapid adoption by loggers than would have been the case if the concept of RIL itself had been controversial.

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Rural Technology Initiative Science and Technology to Assist Rural Forest Resource-Based Communities in Washington State, U.S.A.[1]

Donald P. Hanley,[2] Bruce R. Lippke,[3] David M. Baumgartner,[4] and C. Larry Mason[5]

Abstract

The Rural Technology Initiative (RTI) was established in January 2000 by a federal grant as a pilot project to accelerate the implementation of new technologies in rural forest resource-based communities. Increasing complexity from changing environmental regulations, such as the new Forest and Fish Agreement in Washington State, and the recognition that new research findings were well ahead of implementation, suggested the need for more rapid technology transfer. Efforts to mitigate the substantial widening gap between urban and rural incomes depend upon more successful technology transfer. University of Washington and Washington State University Extension developed RTI as a cooperative program with the support of a Rural Advisory Board. A direct congressional appropriation in 2000 and subsequent appropriations through the U.S. Department of Agriculture–Forest Service Cooperative Programs made funding possible. For additional information, please refer to the RTI Web site www.ruraltech.org.

Keywords: Forestry technology transfer.

Introduction

The state of Washington is located in the Pacific Northwestern United States and contains approximately 17 million ha of land area.

More than half of Washington is forested; ownership distribution is 55 percent government, 6 percent Native American, and 39 percent private (table 1). Approximately 100,000 family forest owners, also known as nonindustrial private landowners (NIPF) in Washington state control 1.2 million ha, or 19 percent, of the commercial forest land in the state. Recent harvest restrictions on federal forest lands intended to protect endangered species and to increase late-successional reserves have impacted rural communities. Since 1987, timber harvests have declined 95 percent on federal lands and 57 percent on state lands in Washington (Larson 2000). Nearly 9.2 million m^3 of timber was harvested off family-owned forests in 1999, accounting for 31.5 percent of the timber harvest in the state.

The disparity in personal income between rural Washington timber communities and urban areas has increased greatly over recent years and can be expected to widen further with new requirements to protect salmon habitat (Eddelson and Lippke 1999). Although urban

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[1] This paper is based in part and updated from Baumgartner, D.M.; Mason, L. 2003. Rural Technology Initiative (RTI): a pilot project to assist rural forest resource based communities in Washington state, USA. Presented at IUFRO Working Group 6.11.02 symposium: forestry and rural development in industrialized countries: policy, programs, and impacts. Rotorua, New Zealand.

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Table 1—Ownership of forest land and timber harvest for Washington state

Ownership	Forest ownership	Timber harvested in 1999	
	Percent of total	*Cubic meters*	*Percent*
Forest industry	20	12 417 874	42.5
Nonindustrial private	19	9 203 835	31.5
Native American	6	2 220 607	7.6
State	11	4 499 653	15.4
Federal	44	876 555	3.0
Total	100	29 218 526	100

Sources: U.S. Department of Agriculture 2000. Conversion based on 150 board feet per cubic meter.

areas are growing with new technologies, rural areas are hampered by difficulties in adopting new technologies. The forest sector may appear to be an overly mature, low-technology sector; however, in reality the ability to manage forests for increasingly complex wood product and environmental values is extremely sensitive to technology.

The availability of basic scientific knowledge needed to manage forests is far ahead of the capacity to convert the knowledge to useable technologies, to make the technologies accessible to rural areas, and to train people to use the technologies. Thus, there is a need for a strengthened network and service system of trainers and users with a focus on access and communication. Solutions to problems created by salmon listings, for example, require intensive training in managing riparian areas and use of forestry equipment in those areas, including specialized logging machinery, remote sensing devices, use of computer inventory tools, along with landscape management plans, financial analysis, planning packages, and product marketing.

Family forest owners, or NIPFs, are facing increasing complexity from changing environmental regulations, such as the new Washington State Forest and Fish Agreement and other forest practice regulations. Tribal forestry programs need better access to science and technology to expand education and career opportunities in resource management for tribal members. Forestry consultants that provide professional services for small landowners, tribes, and other rural forest landowners are expanding their skills through increased use of analytical and mapping software technologies. Rural educators need programs that link K-12 and community colleges to emerging technologies and scientific findings resulting from university research. Interested publics and policymakers need fast access to emerging scientific findings to aid successful land use planning. These groups and others are served by the programs developed as part of the **Rural Technology Initiative** (RTI).

The Rural Technology Initiative

In January 2000, the University of Washington College of Forest Resources (UWCFR) and the Washington State University Department of Natural Resource Sciences and Extension (WSUNRS) received a $900,000 Congressional Appropriation through USDA-Forest Service Cooperative Programs to create the RTI as a pilot regional network and service system to increase technology transfer to rural forestry communities. The mission of RTI is to **Empower the existing infrastructure to use better technology in rural areas for managing forests for increased product and environmental values in support of local communities.**

The RTI Partners

Interdisciplinary teams of faculty, staff, and graduate students from both universities have been assembled to undertake forestry technology research, development, and technology transfer. Each organization brings unique expertise and talents to the RTI partnership.

The University of Washington (www.cfr.washington.edu). Located in Seattle in western Washington, UWCFR was founded in 1907.

Washington State University (www.nrs.wsu.edu). Washington State University Department of Natural Resource Sciences, located in Pullman, Washington, in rural eastern Washington, is unique as the state's land grant university and as such, has three distinct mandates: teaching, research, and extension.

Extension Forestry (ext.nrs.wsu.edu). The WSUNRS Program is administered by Washington State University, which is located in Pullman, Washington. Extension forestry field/county educators are located in 8 of Washington's 39 counties and have local or area-specific responsibilities, whereas state extension educators have statewide responsibilities and subject matter leadership.

Extension forestry is a relatively small component of the overall extension system, which offers educational programs in five major areas: agriculture, natural resources, community resource development, 4-H and youth development, and home economics and human nutrition. To help improve NIPF, extension programs target (1) public awareness, (2) policy education, (3) program coordination, (4) professional education, and (5) forest-land management practices.

To understand extension in the United States, two aspects are particularly important: (1) Extension is unique among public natural resource programs because it considers the objectives of the individual forest owner before all others. It works with the owner to identify management alternatives that are in his or her best interests, recognizing that the side benefits will be more productive farms and forests, and a stable raw material supply for generations. (2) Extension in the United States is administered at the state level by land grant universities. This means that most Extension professionals are members of an academic institution rather than a straight-line government agency.

U.S. Department of Agriculture, Forest Service, State and Private Cooperative Forestry (www.fs.fed.us/spf/coop). Cooperative Forestry is a federal program administered by the USDA Forest Service, which by providing federal funding to RTI and other economic action programs, helps rural communities and businesses dependent on forest-based resources to become sustainable and self-sufficient.

Cooperators. The RTI cooperates with a host of federal and state conservation programs including the Multiagency National Fire Plan Implementation Community Assistance and Economic Action Program; the USDI Bureau of Indian Affairs and Bureau of Land Management; the Intertribal Timber Council; the USDA Forest Service; Natural Resources Conservation Service; the Stewardship Incentive Program; Small Forest Landowner Office and Forest Stewardship of the Washington Department of Natural Resources; the Washington Department of Community Trade and Economic Development; the Washington Office of Public Instruction; and others to promote better technology in rural areas to manage forests for increased forest products and environmental values in support of local communities.

The RTI Rural Advisory Board

A rural advisory board, comprising representatives of community groups, tree farmers, forestry associations, tribes, forest product manufacturers, conservation districts, community colleges and others was created to guide RTI priorities. This advisory board is instrumental in project development priorities. The RTI advisory board identified four initial priorities:

- Landscape management case studies of (1) Forest and Fish Agreement impacts on NIPF owners under a range of alternative strategies, (2) dry-site thinning to reduce forest fire risk and critical habitat management alternatives, and (3) carbon credit protocols.

- Training and assistance for forest-land owners, tribal foresters, forestry consultants, rural educators, and others in response to an RTI-conducted needs assessment.
- Scientifically credible habitat models for landscape management alternatives and monitoring programs to demonstrate treatment impacts.
- Value-enhancing certified data for managed forests.

The RTI's Rural Advisory Board includes member representatives from the NIPF owners Washington Farm Forestry Association, Association of Consulting Foresters, The Yakama Nation, The Colville Confederated Tribes, The Quinault Indian Nation, The University of Washington Olympic Natural Resources Center, American Forest Resource Council, Washington Contract Loggers Association, Washington Hardwoods Commission, Columbia Pacific RC&D, Northwest Forest Products Workers, United Brotherhood of Carpenters, Washington Association of Conservation Districts, Okanogan Communities Development Corporation, USDA Forest Service Cooperative Programs, Spokane Community College, and Green River Community College.

Needs Assessments

To understand better rural forestry technology needs, one of the first RTI projects was to survey Washington forest consultants and NIPF landowners. The needs assessment is summarized below:

RTI carried out needs assessments:

- Surveyed consulting foresters' needs, including training topics, level of training, and times and locations for delivery. With a 40 percent response rate, training topics considered important or very important included the following: regulatory interpretation; riparian protection; tax and estate planning; geographic information systems (GIS) instruction; global positioning system (GPS) instruction; unstable slope and road impacts on water resources; instruction in the Landscape Management System (LMS); spreadsheets and data management; and growth and yield. A majority of respondents felt that new technology can benefit their businesses by transferring skills needed to help landowners and managers more efficiently meet regulatory requirements at lower costs.
- Analyzed and interpreted data from two NIPF landowner surveys in Washington state preparatory to the development of a habitat conservation planning approach. Training topics considered important to very important were regulatory interpretation (95 percent), riparian protection (85 percent), tax and estate planning (83 percent), GIS (75 percent), GPS (68 percent), unstable slopes (63 percent), road layout (63 percent), LMS (60 percent), spreadsheets and data management (60 percent), and growth and yield (56 percent). The majority of respondents felt that new technology can lower costs and more efficiently meet regulatory requirements.

Analysis of other questions from these surveys indicated that respondents favored 2- or 3-day short courses that were affordable, user-friendly, and could be offered during the week at different locations around the state.

The Internet

The Internet is a powerful delivery mechanism for technology transfer. It is important for RTI to assist its customers in becoming better acquainted with the ease and value of the World Wide Web. However, many rural forestry landowners and some professsionals are new to the Internet. To help promote Internet use, all training materials used in RTI short courses include verbage to assist in Internet navigation. All RTI publications, announcements, and newsletters are distributed in hardcopy but are also available for download at no charge from the RTI Web site www.ruraltech.org. The RTI Web site also offers a number of other attractive options that are increasing in popularity. An interactive conversion calculator for forestry measurements is the most frequently used free service on the RTI Web site, but other features such as the free forestry image library or the user question and comment page are frequently visited as well. The RTI Web site is linked to the UWCFR and WSUNRS sites to provide an information suite that can be used by professional foresters, loggers, engineers, and landowners alike. Web site use has risen steadily to more than 5,500 individual nonuniversity visitors per month.

Interactive Streaming Video

Streaming video is a technology used on the World Wide Web to expedite the video viewing process and expand rural access to distance-learning technologies customized for use with low band-width. It allows the end user to start viewing a video file as soon as a connection is made to the media server. The actual process of streaming video over the Internet requires a complex system of events, but the underlying concept is simple. Instead of waiting for the entire video file to download before watching it, the user is able to watch smaller sections of the video right away while downloading the rest. This is accomplished by "streaming" the video file over the Internet in small pieces. A media player on a user's computer deciphers those streaming pieces as they are downloaded and presents them seamlessly to the viewer. The result is close to real-time viewing.

The RTI first experimented with interactive streaming video at the RTI Annual Review in January 2003. Digital video footage was taken of each presentation, synchronized with the corresponding PowerPoint® slides, and streamed from the RTI Web site. This triggered the realization that streaming video technology is a powerful tool for sharing information and ideas. It incorporates a speaker's oration with informative slides, and it makes them available to users with either a high-speed or dial-up Internet connection, as well as on CD-ROM. In little more than a year, RTI has gone from experimenting with streaming video technology to making it a major mode of outreach with skilled film crews at both Washington State University and University of Washington (fig. 1). This video technology dramatically increases the accessibility of information presented at seminars, conferences, and workshops and makes it available to a worldwide audience. Streaming video fits perfectly with RTI's goal to increase access to forestry technology and information. Washington State University Extension is using this new technology to reach and educate family forest landowners throughout the state. In 2003, RTI's interactive streaming video technology was used to expand the reach of a "Sudden Oak Death" conference. Currently there are over 180 presentations on the Washington State University Extension Forestry Web site (ext.nrs.wsu.edu) and over 200 on the main RTI Web site (www.ruraltech.org). Recently, a streaming video tutorial has been added, and workshops in the use of this technology will soon be offered to rural educators.

The RTI Projects

Listed below are some significant RTI projects. To accommodate space limitations, this is not a complete list. For additional information, please refer to the RTI Web site www.ruraltech.org.

Training and Technology Transfer

The RTI responded quickly and established a series of affordable short courses (6 to 8 sessions per year) in the use of forestry and mapping software technologies. All course offerings are certified for continuing forestry education credits from the Society of American Foresters and are presented by faculty and staff from UWCFR and WSUNRS.

Empowering Family Forest Landowners—Coached Planning and its Relationship to RTI

The Forest Stewardship "Coached Planning" shortcourse is an educational opportunity for family forest landowners (fig. 2). This informational, hands-on, practical

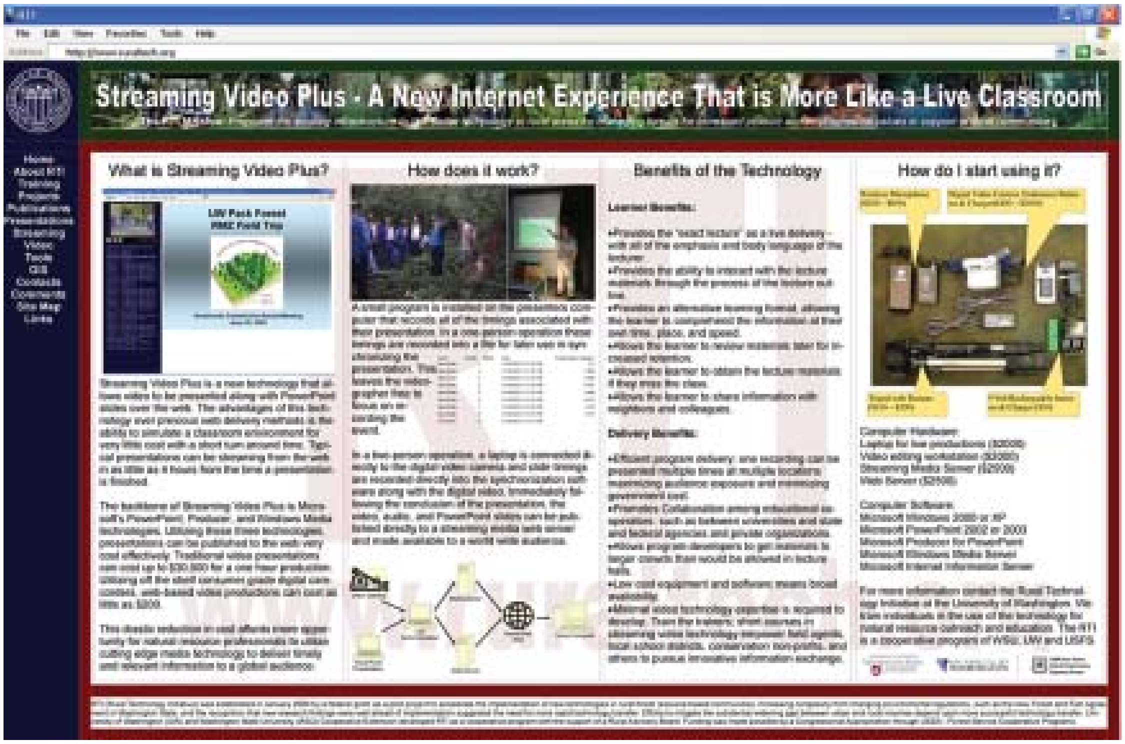

Figure 1—Web page view from the RTI Web site.

Figure 2—Coached planning participants

approach enables landowners to learn useful information about their land and its resources. Participants author their own forest stewardship plan with guidance and "coaching" by natural resource professionals, some of whom come from the RTI staff. Coached planning is important because it empowers landowners to make decisions about their land in a wise economic and ecological manner—decisions are based on their own ownership objectives, and thus the plan has a high probability of implementation. The Cooperative Extension Program in collaboration with Washington Department of Natural Resources Forest Stewardship Program, started coaching landowners in 1995, but since 2000, RTI technologies have been incrementally introduced into the curriculum with good response. The most popular software is the LMS, a powerful forestry program developed at the University of Washington with Forest Service funding support. The RTI adapted this software for use by small landowners through the development of user-friendly features such as the Inventory Wizard. Inventory Wizard allows users to easily enter field inventory data into LMS for inventory analysis, simulations of treatment alternatives, estimates of future growth and yield, and other outputs of interest including visualization of forest conditions. The LMS software is provided at no charge to all coached planning participants.

Since 1995, 80 eight-week coached planning sessions have been offered serving more than 1,400 family forest landowners. Over 700 stewardship plans have been prepared. We have received dozens of testimonial letters from satisfied landowners. We have implemented the use of the interactive streaming video as a teaching aid and have begun use of the Inventory Wizard and LMS to help develop management alternatives templates.

The Landscape Management System

The LMS brings together a user-friendly software package of growth-and-yield models, forest visualization capabilities, habitat indices, economic analysis, and more (fig. 3). Trainees learn how to model changes in

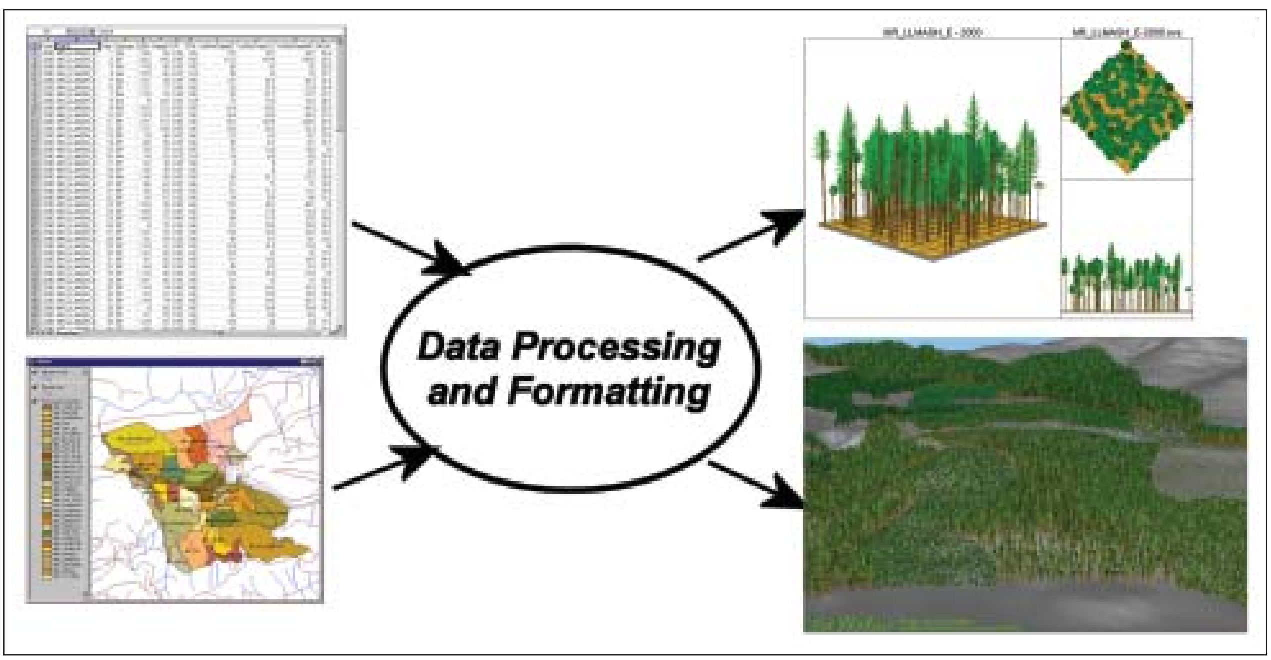

Figure 3—LMS brings together a user-friendly software package of growth and yield models, forest visualization capabilities, habitat indices, economic analysis, and more.

forest inventories over time and across large geographical areas. The LMS is distributed at no charge (lms.cfr.washington.edu/) through a partnership between the UWCFR and the Yale School of Forestry and the Environment. In the past year, the following updates are noted:

- Released LMS version 3. The new version is designed to increase user friendliness, such as the inclusion of the Inventory Wizard, Econometrics, Site Index Calculator, and Log Sort Wizard.
- Conducted numerous LMS training sessions for consultants, educators, small forest landowners, tribal foresters, and others.
- Developed a user-friendly LMS tutorial with software made available at no charge on CD or download from lms.cfr.washington.edu/.
- Developed templates for management alternatives that are being integrated with Washington State University/Department of Natural Resources coached planning classes to assist NIPF owners in developing forest stewardship plans.
- Introduced LMS 3 to family forest landowners and forest consultants with the expectation that they will help us integrate this software tool in management planning.

Geographic Information System and Global Positioning System Activities

The GIS is a specialized computer system made for the creation, storage, analysis, and display of spatially referenced information. The popular ESRI program ArcGIS is the software used in this training. The GIS helps forest landowners to plan harvest activities and road maintenance projects. The RTI has developed several GIS extensions that are downloadable from the Web site: "Pegger" for virtual road pioneering (fig. 4), "CulSed" for culvert location to reduce sediment at less cost, and "LMS Analyst," which creates stand attributes for mean slope, elevation, and aspect. The GPS is a utility used for a variety of purposes in forest and natural resource management. Features such as roads, streams, wetlands, stand boundaries, sampling plots, and bird nests can be mapped easily and with high accuracy and precision when GPS coordinates are transferred into GIS.

Roads Impacts

- Developed case studies that identify the cost of required changes to roads and culverts and consider road density planning for tree farms to identify preferred alternatives to comply with forest practice requirements.
- Estimated total landowner costs for culvert replacements that led to legislation more favorable to sustainable production.
- Produced an extension bulletin, Roads on Small Acreage Forests, which describes basic road principles for NIPF landowners.

Riparian Management

Strategies to maximize habitat opportunities for anadromous fish are required by both federal and state law but are often costly and may cause small forest landowners to seek financial relief by developing their lands for nonforestry use. To understand better the breadth of economic impacts to Washington's family forest landowners, RTI conducted case studies of actual landowner circumstances. These case studies have proven to be useful to landowners wishing to provide the Washington state legislature with credible estimates of real costs of regulatory compliance. Case studies also point out opportunities for the development of customized approaches that provide better habitat at reduced cost. Further study into riparian functionality will help landowners with the development of alternative plans. The RTI has assembled interdisciplinary teams of faculty and staff experts from UWCFR and WSUNRS to investigate canopy/sun relationships, course woody debris recruitment, and organic particulate delivery within forested riparian zones towards the development of user-friendly management templates to aid landowners in planning riparian harvest activities (fig. 5).

Figure 4—GIS extension are downloadable from website such as “Pegger” for virtual road pioneering.

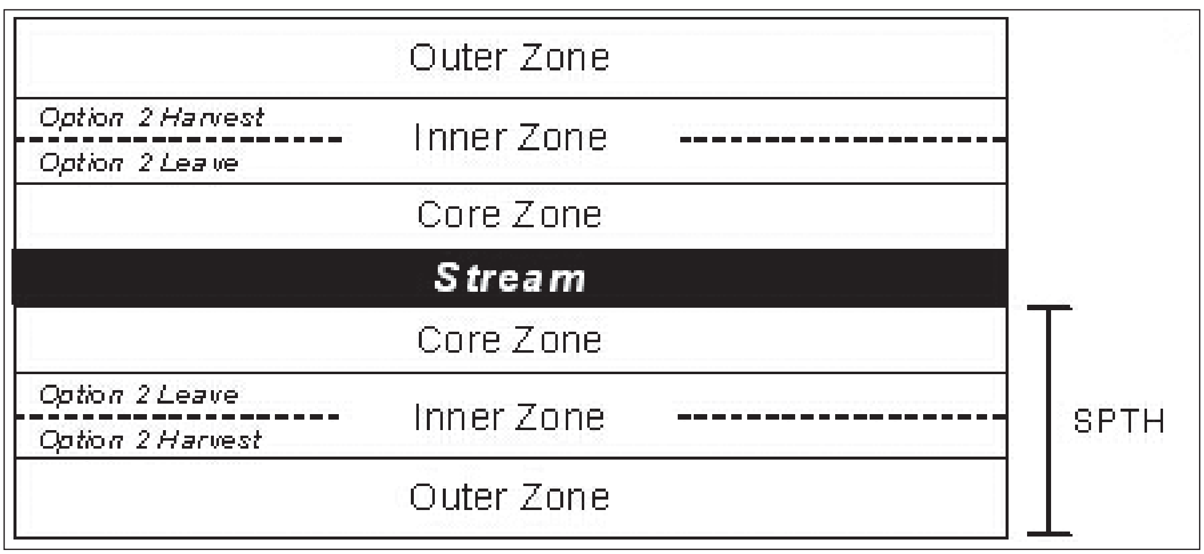

Figure 5—To understand the impact of new riparian regulations, in the state of Washington, the RTI analyzed impacts of management alternatives, such as the three-tiered zones approach offered here. SPTH = Site potential tree height.

- Analyzed impacts of management alternatives.
- Prepared economic impact case studies on small-sized forested parcels, analyzed the economic impact of a base case and four management alternatives allowed under the Forest and Fish Agreement. Total forest value losses ranged from 27 percent to 36 percent under the "best case" scenario, and from 45 percent to 83 percent under the "worst case" scenario indicating a broad disparity in landowner impacts.
- Developed an assessment procedure to evaluate alternative plans for effectiveness in achievement of desired future environmental conditions and economics sufficient for sustainable forest management.

Wildlife Management

Response of wildlife to forest management is another important consideration in the development of forest management plans. The RTI staff work to assist tribes, consultants, and landowners in the use of habitat suitability indices (HSI) to understand quantification of expected wildlife response to alternative harvest activities. Additionally RTI partially supports a wildlife habitat specialist at Washington State University that has primary responsibilities for small forest lands and habitats. Wildlife habitat management is a fully integrated topic in the coached planning curriculum as well.

Habitat Conservation Planning

The RTI has assembled an interdisciplinary team of faculty and staff that are working with small forest landowners (Family Forest Foundation, familyforestfoundation.org) as well as federal and state agency personnel in Lewis County, Washington, to develop a programmatic multispecies Habitat Conservation Plan (HCP). The HCPs are described under the Endangered Species Act as contractual agreements between landowners and the federal government where landowners volunteer protection, restoration, and enhancement of targeted habitat qualities in exchange for long-term management certainty. To date, HCPs have been too complicated and expensive to be accessible to small forest landowners. The creation of a programmatic HCP will bring together multiple landowners as one negotiating entity in a simplified regulatory process that will be the first of its kind in the Nation and will serve as a model for achieving sustainable forestry in other counties and states. Emerging forestry technologies, RTI scientific expertise, and a subsequent better understanding of adaptive management concepts have made this possible.

To develop credible data on the impacts of forest management on habitat and stream conditions, RTI:

- Developed models directly linking habitat-suitability measures to the evolution of forest stands under management.
- Convened a panel of forest scientists to plan the development of better models and to identify gaps in needed coverage. The panel circulated a draft plan identifying upland habitat, riparian zone habitat, and instream functionality and modeling needs.
- Used the Satsop Management Plan (Grays Harbor County) as a pilot test and case study for developing upland habitat models based on the Fish and Wildlife Habitat Evaluation Procedure. Using LMS, a range of management alternatives and resulting HSIs can be evaluated for their impacts over time.
- Evaluated instream functionality indicators identified by the National Council for Air and Stream Improvement, Inc. (streambank stability, sediment reduction, chemical removal, shade and temperature, large woody debris, particulate matter) in order to develop similar forest-dependent instream functionality measures linked to LMS.
- Developed management plans and assessment methods for a multi- and small-owner HCPs.

Carbon Sequestration

Global warming is thought by many to be occurring because of increases in atmospheric carbon associated with combustion of fossil fuels. An embryonic marketplace for the sale of "carbon credits" from forests dedicated to carbon storage is developing. Adjustments to forest management such as increased fertilization or longer rotations can increase carbon storage potential. For landowners to benefit from carbon credit sales opportunities, assessing forest carbon fluctuations will be needed. The RTI has collaborated with the Consortium for Research in Recyclable Industrial Materials (CORRIM) to development carbon assessment software to be used with forest inventory systems such as LMS. A sample assessment of carbon storage in forest biomass has been prepared for King County, Washington. Life Cycle Analysis (LCA) is used to demonstrate the importance of carbon reduction contributions by forest management. The LCA is a cradle-to-grave evaluation of the environmental implications of forest initiation, growth, harvest, product streams, product substitutions, decay, and other considerations. The CORRIM conducted years of research that has now been connected, with the help of RTI resources, to the LMS software so that LCA considerations will add new information quality to selection of best management practices.

Forest Fire Risk Reduction

Large areas of forest land in the inland West are overstocked with small-diameter suppressed trees. These forests have unprecedented fuel loads and are at a high risk of catastrophic forest fire. Rural communities, most at risk from forest fires, are often economically depressed. However, removal of many small-diameter trees is known to be costly. Opportunities to reduce costs and increase fuel reduction activities are linked to such questions as: (1) How might harvest units be designed to reduce or eliminate operational cost deficits? (2) How might evolving markets and increasing public interest in cogeneration, carbon sequestration, and fire safety investments influence values? (3) What are the marginal costs of alternative residual density targets? (4) What are the impacts on desired future environmental conditions that result from harvest alternatives? (5) How might answers to the above questions help administrators and field personnel to better customize project design to fit local forest and community needs? The RTI, working with National Fire Plan partners, developed a parametric sensitivity analysis to address the above questions for a range of market and stand conditions that can be customized to local circumstances. Although more work is needed, this preliminary analysis is providing the basis for development of thinning/fuel reduction instructional materials and training modules that better estimate marginal tradeoffs associated with treatment alternatives. Working with the USDI Bureau of Indian Affairs, RTI has begun a training program for fire risk analysis and fuels reduction planning on tribal forests.

Increased numbers of intense crown fires are symptomatic of a changed management paradigm, e.g., fire suppression and insufficient attention to stand structure. RTI:

- Evaluated the impact of alternative fuel reduction treatments on fire risk.
- Developed tools linked to LMS that support development of fire risk reduction strategies.
- Demonstrated that the benefits of fuel treatments that reduce fire risk, when nonmarket benefits (saving habitat, firefighting and relocation costs, fatalities, facilities losses, carbon, and water) are included, are much greater than the public cost of treatment.
- Demonstrated that archival evidence of pre-European east-side forests can serve as a measure of crowning potential for east-side forests. Developed metrics will be used to provide guidance to land managers in designing future landscapes to sustain biodiversity goals and reduce fire hazard.

Special Forest Products Quality Control

Markets in special forest products (SFPs) or NTFPs can be better served if the quality, efficacy, and safety of medicinal botanicals and herbal nutrient supplements can be assured. High-quality and consistent SFPs have customarily brought a higher market value. Clearly, the harvesters need advanced technologies for quality control and standardization for routine practice. However, owing to the traditionally high cost of such technologies, and overall low income among the rural SFP community, these technologies are unaffordable. The main objectives for the project were to (1) improve and guarantee both sustainability and profitability of the herbal medicine and dietary supplement industry by implementing an affordable, easily available, standardized tannin analysis technology; (2) develop a database on tannin content for several of the most profitable medicinal herbs, such as St. John's Wort and Echinacea; and (3) provide front-line technological support for Pacific Northwest SFP industries through scientific recommendations aimed at the improvement of standardized growing, harvesting, and processing methods. The RTI support for initial work was leveraged to secure supplemental funding to convert laboratory bench-top tannin assay procedures into a Tanalyzer Technology—a hand-held digital device providing multiple sample screening for tannin directly in the field.

Conclusions

Since its beginning in January 2000, RTI has trained over 500 consultants, extension agents, tribal foresters, rural schoolteachers, and family forest owners in the use of forestry software products. Mentioned above are some, but not all, of the projects undertaken by RTI. An interdisciplinary team comprising biologists, engineers, programmers, silviculturists, GIS specialists, mensurationists, and economists has been assembled from faculty, staff, and graduate students at the RTI centers created by this unique partnership of Washington's premier resource science universities. More than 30 faculty members from University and Washington State University have contributed to the rapid development of RTI programs. Scholarships and research assistantships have been provided to worthy students creating double benefit. Research findings have been used by the state legislature to understand the complexities of rural forestry challenges and to support subsequent beneficial policy adjustments. The RTI personnel have become frequent presenters at association meetings, community get-togethers, and symposia throughout the Pacific Northwest.

English Equivalents

1 hectare (ha) = 2.47 acres

1 cubic meter (m^3) = 35.3 cubic feet (ft^3)

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WWW.FORESTKNOWLEDGE.NET: A Joint Internet-Based Information Platform Transferring Forest Knowledge in the Alpine Space

Reinhard Lässig,[1] Martin Moritzi,[2] Marcus Schaub,[3] and Roderich von Detten[4]

Abstract

In view of the various challenges affecting forests and forest ecosystem management, the precious natural heritage of forests and forestry in the Alpine region is becoming increasingly imperiled. To deal with these challenges, the self-organized cooperation of all involved partners in the field is indispensable. The transnational cooperation of exchanging professional knowledge and know-how is necessary to keep the natural heritage attractive, to maintain its management as economically profitable, and to guarantee its protection. A broad participation of all stakeholders is required.

In connection with storms, avalanches, and climate change effects, for example, and in an environment of structural transformation and economic challenges, it is highly ambitious to manage forests in a multifunctional way. To reach this target, professionals need up-to-date knowledge that, in part, comes from forest research. Compiling the supply of strictly user-oriented information is, sometimes, beyond the capacities of single institutions. To obtain synergies, it is important to combine and disseminate existing knowledge on a transnational level.

In this context, the development of a multilingual, Internet-based information platform enables central cohesion and a supply of existing knowledge and know-how. The Web site WWW.FORESTKNOWLEDGE.NET[5] is intended to be the first transnational Web site in Europe that aims to supply practical knowledge on forests in a user-oriented way. Based on the initiative of four research institutes in southern Germany, Switzerland, and Austria, this offer of information is being developed in a close relationship of research and practice. The coordination of knowledge transfer under the direct involvement of user-groups thereby replaces the top-down approach with methods of participation and dialogue between research and practice.

Keywords: Forest research, knowledge transfer, Internet, information platform, Central Europe.

Introduction

In supporting decisionmakers in forest administration, applied research, and practical forest management who face complex management decisions, the relevant institutions in the broader alpine space (fig. 1) are confronted with specific challenges. To the same degree that the existing problems exceed institutions and boundaries at a general level, the supporting measures have to be transboundary, user- and problem-focused. A cooperation between the forest research institutes of the alpine space,

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[4] Forest scientist, Forest Research Institute of Baden-Württemberg, D-79100 Freiburg i.Br., Germany.

[5] WWW.FORESTKNOWLEDGE.NET was originally developed in its German version, WWW.WALDWISSEN.NET. In this article, the English name is used.

Figure 1—The Alpine region has seven countries with more than 40 million residents and 100 million visitors annually from numerous countries visiting the largest recreation area of Europe. They benefit from the forest as a place of recreation, an attractive landscape, or a protective mountain forest. Many of these forest services are free of charge, or at least low in price, although the maintenance of healthy, vigorous, and profitable forests is costly. Therefore, a common goal is to strengthen an efficient and competent forestry.

the state forest services of the involved countries, and the primary federations of communal and private forest owners is, by all means, necessary.

The necessity for improved transnational knowledge transfer arises from the specific tasks within which forestry in the alpine space is confronted. The situation can be characterized by specific and often demanding conflicts in the main functions that forests are supposed to fulfill (protection, recreation, and income), the decreasing relevance of forests as a factor of income and employment, an ongoing crisis of earning capacities of forest enterprises, and increasing pressure on highly sensitive forest ecosystems in a rapidly changing environment.

The preservation of healthy, efficient, and, at the same time, profitable forests in the alpine region decisively depends on efficient and competent forest management; therefore, the invigorating and further development of forest management competence can be regarded as a main task in the present and future. A sustainable transnational knowledge transfer efficiently addresses the main tasks in forestry:

- Forest management; commercialization
- Forest utilization and technology
- Law, politics, and public relations
- Natural risk management
- Biodiversity/protected areas
- Silviculture
- Forest protection
- Forest ecology, nutrition, and soil management

In the project "Knowledge Network Forestry in the Alpine Space," organizations that acquire knowledge and their main user groups meet this challenge. Thus, they agreed on this innovative joint project to allow them a more direct and intensive exchange of professional knowledge and practical experience. The forest owners and experts play a key role in conserving the manifold values of intact and healthy forests in the alpine region as they manage the forests in a proper, natural, and sustainable way. Therefore, stakeholders such as forest owners associations, forestry societies, and forest services are involved in this project.

Objectives

The main objective of the forest knowledge Web site is to improve communication between forest research institutions and forest managers. The overall aim is to strengthen the specialized knowledge and the decision-making authority of actors in forestry in the alpine space (fig. 1). As one of its activities, it has therefore built up a user-focused information platform—a joint information server called "WWW.FORESTKNOWLEDGE.NET."

The leading goals of the forest knowledge Web site are to:

- Intensify knowledge transfer to practitioners
- Enhance communication between researchers and practitioners
- Present more scientific results and products internationally

- Cooperate with forestry and forest owners
- Make the public more aware of forests and forest research
- Use synergies and bundle informational power of the participating organizations

The target group of this project primarily includes specialists who appear as actors in forest management: members of the state forest services and experts in or owners of communal and private forest enterprises. Further potential addressees include interested conservationists or experts from nongovernmental organizations connected with forestry, as well as teachers, scientists, etc., with basic knowledge in forest management. No limitations are made in terms of possible target groups, as the system is conceived as accessible without special authorization.

Concept and Realization

The buildup of the information and communication platform WWW.FORESTKNOWLEDGE.NET originates from an initiative of the directors of the Bavarian Institute for Forest and Forestry (LWF) in Freising; the Forest Research Institute of Baden-Württemberg (FVA) in Freiburg i.Br.; the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf; and the Austrian Federal Research and Education Centre for Forest, Natural Hazards and Landscape (BFW) in Vienna. In 2002, these institutions decided to increase practice-oriented knowledge within their institutes and make it easily available to their target audience while facilitating the transnational exchange of know-how. A task force of experts from these four research institutes developed the concept for WWW.FORESTKNOWLEDGE.NET that was transferred via the Internet platform to the public. At the WSL, the needs of the target audience were evaluated and selected forest practitioners were surveyed leading to WWW.WALDWISSEN.CH, a prototype of WWW.FORESTKNOWLEDGE.NET. With an online test at WWW.WALDWISSEN.CH, visitors could participate in an electronic survey over a period of 5 months. The output and the verbal feedback of this survey indicated a high customer satisfaction and a real desire for a knowledge platform for forest practitioners.

In 2004, on behalf of the FVA, LWF, BFW, and WSL, the transnational expert information system WWW.FORESTKNOWLEDGE.NET was developed by the WSL section Informatics, based on the open source Content-Management-System “Silva,” a product by Infrae (http://www.infrae.com)—a software development company based in Rotterdam, the Netherlands. Silva is based on the open source Web application server “Zope” (http://www.zope.org) written in Python, an object-oriented scripting language. Silva as user interface separates the public WWW.FORESTKNOWLEDGE.NET layout from the editing area. Features include a multiversion workflow system, access management, and integral WYSIWYG editor (**W**hat **Y**ou **S**ee **I**s **W**hat **Y**ou **G**et). Content is stored in the programming language XML, independent of layout and presentation. The central server, which makes all the expert contributions available is located at WSL, but editing is decentralized via the Internet. On 16 February 2005, the partner organizations presented WWW.WALDWISSEN.NET, the German version of WWW.FORESTKNOWLEDGE.NET, to the public.

Public relations is at the beginning of the planned intensification of the knowledge transfer complemented with a coordinated offer of activities during the next 3 years. Therewith, it is the first time that a transnational tool for exchanging professional knowledge and experience will be made available to the forestry community in the alpine region. Knowledge that so far has only been available on a local or regional scale will be easily and transnationally accessible and used via the World Wide Web. In addition, the alpine-wide collaboration aims to make the population more sensitive and perceptive to the various problems, risks, and solutions in forestry by informing on a more frequent basis about forestry issues.

Content

The new Internet Platform WWW.FORESTKNOWLEDGE.NET (fig. 2) gives the user condensed knowledge about forestry and is easy to browse with a mouse click. At the end of April 2006, 1,150 articles with over 4,000 pictures and graphs were online. The unique quality about this platform, especially for the Central European forestry community, is the condensed offer of quality-assured knowledge out of the field of forestry from the seven alpine space countries. Many of the easy-to-understand and attractively illustrated articles are processed according to journalistic guidelines and refer to over 2,000 extended, detailed, and pdf-formatted available articles and links (fig. 2). As shown below, the entire pool of knowledge is divided into 11 areas of expertise. The subjects are further divided on a second navigation level (fig. 3):

Forest ecology:
- Tree species
- Biodiversity
- Soil science and site mapping
- Climate
- Nature reserves
- Plant ecology
- Fungi and lichens
- Animal ecology
- Forest ecosystems

Silviculture and planning:
- Agroforestry
- Tending
- Silvicultural systems
- Forest planning
- Risk management
- Plant production
- Protection and mountain forest
- Forest genetics
- Transformation of forest
- Regeneration
- Growth and yield

Forest and wildlife:
- Hunting practice
- Hunting law
- Wildlife biology
- Game damage
- Wildlife management

Natural hazards:
- Erosion
- Flood
- Crisis management
- Snow
- Protection forests
- Rockfall
- Torrent and torrent regulation

Forest protection:
- Abiotic damages
- Insects
- Invasive species
- Competitive vegetation
- Rodents
- Plant protectants
- Fungi and nematodes
- Pest control

Forests and society:
- Research programs
- Forest history
- Balance of services
- Guiding principles and criteria
- Nature protection
- Public relations
- Law
- Nonmarket goods
- Forest ownership
- Forest programs

Environment and landscape:
- Carbon dioxide and climate protection
- Landscaping and spatial development technology
- Forests and landscape Management
- Water protection

Inventory and monitoring:
- Ecosystem monitoring
- Forecast models
- Forest development
- Forest inventory

Timber and markets:
- Forest products
- Wood energy
- Timber storage and conservation
- Timber markets
- Transport and logistics
- Raw timber and classification
- Processing and technology

Management:
- Controlling and operation
- Analysis
- Profit and loss account
- Subsidy
- Investment
- Marketing
- Organization/employees
- Planning and control
- Monitoring systems
- Associations

Forest technology:
- Information technology
- Forest machinery
- Timber harvesting
- Calculation aids
- Impact assessment
- Forest labour
- Forest roads/opening

Figure 2—Homepage of WWW.FORESTKNOWLEDGE.NET.

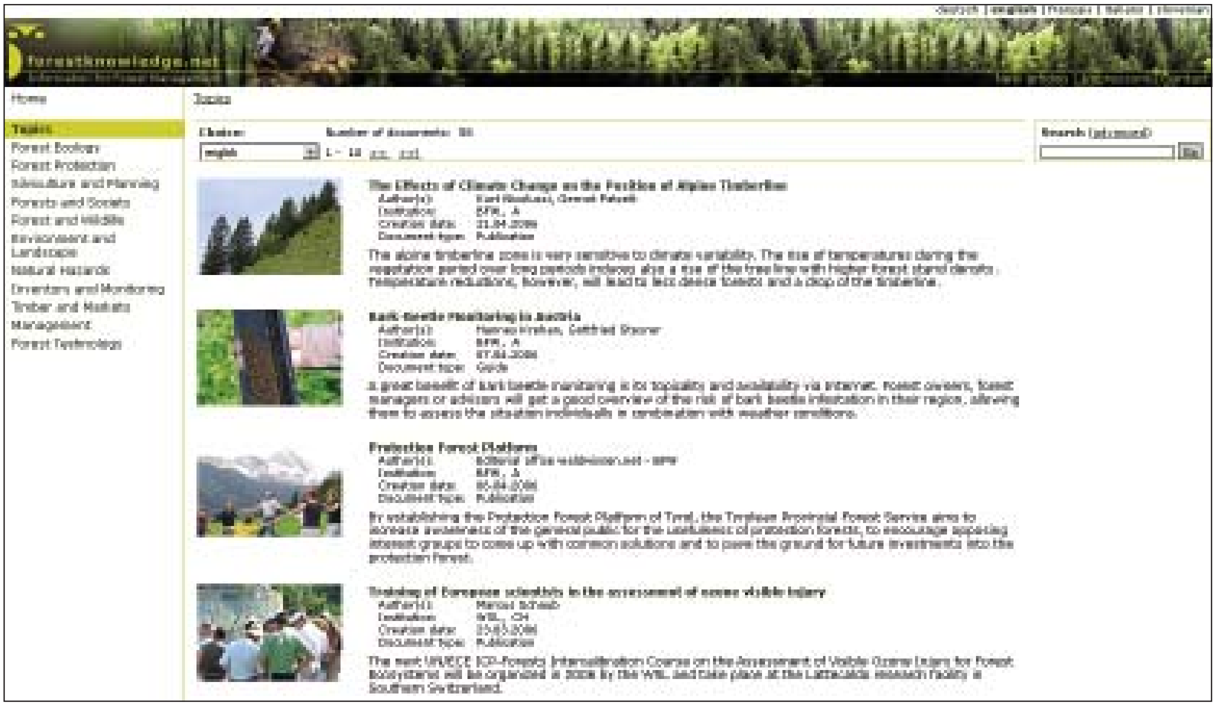

Figure 3—Topics of WWW.FORESTKNOWLEDGE.NET.

There are, for example, findings and practitioners' experiences available without any intensive searching, as well as information about the processing and stocking of windblown or bark beetle lumber, the most recent forest technical developments, rare animal species, medical plants and immigrating organisms, and current problems of hunting (fig. 3). The home page is updated on a weekly basis to stay up to date and attractive.

Alternatively, unique documents may be found within seconds with the help of a full text search, and the articles may be filtered as to place of origin, language, or type of document. In the near future, several subject files will be put together to provide the online user with background information about the current state of art, particular themes, and the most recent events. The subject files and the single subject pages are linked to allow the interested user to continue to click through related pages.

The Web site WWW.FORESTKNOWLEDGE.NET offers contributions in French, Italian, Slovenian, English, and German even though not all articles are translated into all languages. The navigation and some examples have been translated into all languages since February 2005. Currently, articles with German content still dominate. More articles will be translated between 2006 and 2007, and the multilingualism poses a great challenge regarding personnel and finances. The selection of the articles to be translated is based on the anticipated regional interests of the users.

Since 2004, four editorial offices in Freising, Freiburg, Vienna, and Birmensdorf have been editing the contributions for WWW.FORESTKNOWLEDGE.NET. In the future, the research institutes in Grenoble (France), Ljubljana (Slovenia), and Villazzano (Italy) will provide articles as well. Further research institutes, in particular from Germany, have showed their interest in collaboration shortly after WWW.FORESTKNOWLEDGE.NET went online. Forest Economy Switzerland, the Swiss Forestry Society, and SILVIVA Environmental Education, that represent large user groups from the areas of forest ownership, forestry, and educational professions, provide extensive knowledge, which is incorporated into the system of www.forestknowledge.net via the editorial office of the WSL. These organizations will provide, among others, numerous practice-oriented articles from professional journals. In addition, the Swiss partners will participate in the organization of seminars and transboundary excursions.

Transnational articles written by well-recognized scientists from the various research stations assist in ensuring the direction and professional quality of the knowledge transfer and define the thematic and current emphasis.

Future

On February 16, 2005, the partner organizations in Vaduz (Liechtenstein) presented the Internet platform www.forestknowledge.net to the public. The presentation was scheduled for the beginning of the planned intensification of transferring knowledge from research to practice and will complement a coordinated offer of activities and events during the next 3 years. Herewith, a transnational offer of knowledge and experience exchange will be available to the forestry community in the alpine space. Knowledge that was so far only available on a local or regional scale will be able to be used efficiently and transnationally via the Internet. In March 2005, more than 12,000 users visited the Web site; in April 2006, it was already more than 35,000. Furthermore, the alpine-wide collaboration will increasingly inform the population about forest issues and make the public more perceptive to the various problems, risks, and solutions in the area of forestry.

Being an information platform at its online start, www.forestknowledge.net will be enhanced to become a communication platform in the near future. Forest owners and, in general, people focused on forestry will then be able to exchange their information at one or several forums and pass on their experiences or suggest forest management problems for discussion. An alpine-wide calendar of events will describe meetings of differing size and topic, seminars, workshops, excursions, and other activities.

To assure forestry people and forest owners are addressed in a user- and issue-oriented way, the persons in charge of www.forestknowledge.net will take the needs of the user groups into consideration as accurately as possible. Needs assessments, surveys, and workshops were recently conducted. Once they have been analyzed, they will enable a direct exchange about aims and necessary measures of the knowledge transfer in the future.

www.forestknowledge.net will be extended continuously by the four research institutes mentioned above. Integrated in the KnowForAlp-initiative, the Internet portal will be significantly co-financed by the European Union within the framework of the Interreg IIIB-program until the end of 2007. The efforts of the four Swiss partners are supported by the Velux foundation, Zurich, and the Swiss Agency for the Environment, Berne. The Web site is accessible on the Internet free of charge.

The Landscape Management System: Emerging Technology for Integrated Forestry Applications

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Abstract

Natural resource professionals face the staggering task of assimilating vast amounts of disparate information to coordinate management activities and predict interactions along broad temporal and spatial scales. Further complicating such an undertaking are dynamic changes in natural conditions and in public values. The Rural Technology Initiative at the College of Forest Resources, University of Washington, in cooperation with the USDA Forest Service and the Yale School of Forestry and Environmental Studies, has developed a publicly-available computer program, the Landscape Management System (LMS). The LMS can process vast amounts of information to evaluate stand- and landscape-scale silviculture options for short- and long-term forest planning. The LMS system assists land managers by accurately modeling changes in forest-land outputs in response to variable management influences and goals. The software provides a platform for the integration of component capabilities that include growth and yield models, interactive stand treatment programs, tabular and graphical analytical outputs, and stand and landscape visualization programs. Data sources necessary for LMS include stand inventory information (tree-based measurements), landscape data (slope, aspect, elevation, site quality), and geographic information system spatial data (stand boundaries, streams, roads, etc.). The LMS can be used to project stands and landscapes forward in time, predicting potential future stand and landscape forest conditions including treatment of stands through harvesting, regeneration, and other activities to simulate potential management practices. The LMS is designed to provide a user-friendly "click-and-go" interface. This powerful forestry software is available for use by individuals with minimum computer skills and limited financial resources. Consequently, LMS has proven to be beneficial not only as a powerful analysis tool for forestry professionals but also as a communication tool with stakeholder groups embarked on the often conflict-vulnerable process of consensus building. Visualization and the analytical information provided by LMS leads to better communication between various stakeholder groups. The LMS is available for download free to the public thanks to a forestry research partnership among the University of Washington, Yale University, and USDA Forest Service. The Web site address is http://lms.cfr.washington.edu/.

Keywords: Forest management, growth modeling, visualization, software integration.

Introduction

The management of natural resources is complex, and protection of those resources requires an increasing amount of analysis. Processes, applications, and communication tools need to be developed to streamline the development and evaluation of management plans for our forested landscapes. Management planning can be improved by software systems capable of automating the information flow between various disparate applications. These software systems should provide a variety of

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outputs that improve the communication of the consequences of our management actions. The Landscape Management System (LMS) is one such system (fig. 1).

Description of Landscape Management System

The LMS integrates forest inventory information, growth models, visualization, and analytical tools into a framework for investigating stand- and landscape-level management alternatives (McCarter 2001, McCarter et al. 1998). It automates the tasks of formatting inventory information, sending the information to growth models, implementing treatments to simulate management or disturbance, formatting information for visualization, and providing base and summarized information to analytical tools for further analysis.

The LMS integrates existing growth and yield models and visualization tools with focus on the flow of information back and forth among component tools. The Forest Vegetation Simulator (FVS) (Dixon 2002, Wykoff 1986, Wykoff et al. 1982) and Organon (Hann 2003, Hann et al. 1997) are the growth models used by LMS. The software uses the Stand Visualization System (McGaughey 1997) for stand-level visualization. For landscape-level visualization, LMS uses EnVision (McGaughey 1998, 1997; Wilson and McGaughey 2000).

The LMS facilitates communication of management consequences by providing a variety of tools that present the results of management decisions. Use of visualization is an effective method for evaluating how forests change in response to growth and management. Visualization creates pictures, which allow for nontechnical audiences to evaluate and discuss how forests are expected to change. The LMS also provides a wide variety of tabular information that can be used to evaluate the outcomes from a quantitative perspective. The combination of tabular, graphical, and visualization outputs provide a broad spectrum of options when trying to communicate how forests are changing.

Development and support of LMS has been funded through a research partnership between the USDA Forest Service, the University of Washington, and Yale University. The majority of the funding was provided by the Forest Service through Research and Development, National Forest System, and State and Private Forestry. Additional aspects of the software were developed through individual research projects or case studies with federal agencies, state agencies, and private companies.

Data Requirements

Use of LMS requires a considerable amount of information about forested landscapes. This information is organized around stands of similar ecological and historical conditions. The LMS requires stand-level and tree-level information for each area to be considered by the system.

The stand-level information is used by growth models to localize predictions of growth for trees in a specific inventory. The stand-level information does not generally change over time. This information includes site quality variables (i.e., slope, aspect, elevation, site index, and habitat type), stand age, and stand area.

The tree-level information used with LMS consists of a tree list for each stand on the landscape. The tree list contains information on individual trees with expansion factors for each record that represents the number of trees per acre. This information is best acquired from forest inventory plots but can also be derived from summarized diameter class data. The tree list must include species, diameter, and trees per acre as a minimum. Providing height and crown ratio will improve simulation results, but the values can be automatically estimated by using the provided growth models.

The LMS can use additional spatial information to support landscape-level visualization. The landscape visualization tools require a representation of elevation data (elevation model) and a map of stand boundaries as

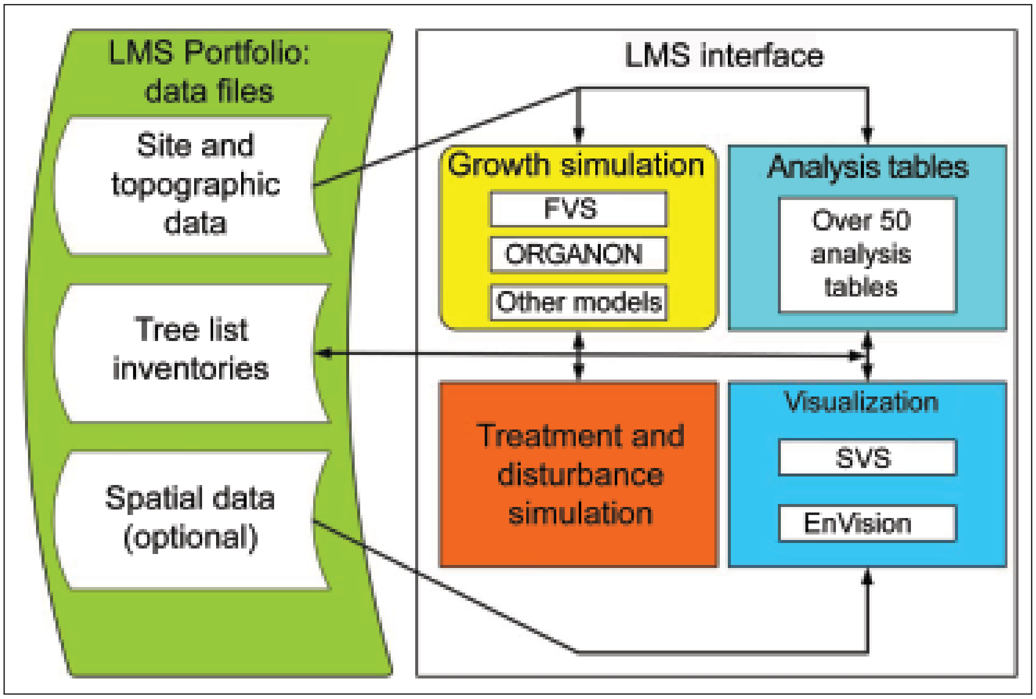

Figure 1—Landscape Management System conceptual design.

the minimum for creating visualizations. Additional spatial information can be displayed in the visualization if desired.

History of LMS

The LMS was first created in 1994 to automate many of the computing tasks necessary while teaching a broader approach to stand-level management to university and midcareer continuing education students. The software has evolved to address emerging management issues and to keep pace with component and Windows updates (table 1).

The LMS 1.0 was developed for Microsoft Windows® 3.1. This version is no longer available or supported. One of the features that users liked was the buttons used for running the application. The LMS 1.0 successfully integrated growth models and visualization tools into a single, but somewhat awkward interface. The application had limited flexibility, and it was difficult to enhance or modify the system. It used many small text files for storing inventory information, which resulted in the use of an excessive amount of disk space. It was difficult to get inventory data into the system. There was no feedback between components of the system, and errors were not reported to the user. The LMS 1.0 was a proof-of-concept application that demonstrated that a system integrating tree-list growth models and visualization tools could be constructed and had utility.

The LMS 2.0 represents a rewrite of the original LMS system and many components to move the software beyond Microsoft Windows 3.1 to Microsoft Windows NT® and beyond. The LMS 2.x contains the same basic features as the previous version integrating growth and yield models, visualization, and analytical tools. The LMS 2.0 includes the FVS and Organon growth models. It uses SVS and EnVision for stand- and landscape-level visualization. It is integrated with Microsoft Excel® for output tables. It also includes the Inventory Wizard

Table 1—Landscape Management System versions and dates released

LMS version	Release date
LMS 1.0	1994-2000
LMS 2.0	2000-2005
LMS 2.0	Aug 2000
LMS 2.0.42	Feb 2001
LMS 2.0.45	Jun 2002
…	…
LMS 2.0.45 Release 9	Nov 2004
LMS 2.0.45 Release 10	Apr 2005
LMS 3.0	2005-Present
LMS 3.0 - Beta 3	Apr 2005
LMS 3.0 - Beta 4	May 2005
LMS 3.0 - Beta 5	Aug 2005
LMS 3.0	Dec 2005

(Zobrist et al. 2004) for data input and a series of embedded analyses (Carbon, Economatic, Wildlife Habitat, etc.). The LMS 2.0 is limited in the size of portfolios that it can process because of the text files used to store inventory information. It remains difficult to get inventory data into the system. Program enhancements require major modifications to the software, limiting the ability to enhance the system without affecting other portions of the system.

The LMS 3.0 represents a new approach to integrating system components providing enhanced simulation and treatment capabilities and supporting multiple interfaces, application automation, and tabular outputs to Excel or Access. The LMS 3.0 can process larger landscapes, running growth simulations more than five times faster than previous versions, growing 100 stands one growth cycle in less than 15 seconds on a 1.5 GHz computer.

Enhancements to LMS 3.0

The latest version of LMS represents a new approach to the problem of integration of the system components. The overall objective of the system has been to integrate a variety of applications, none of which were designed to communicate with one another. For LMS 3.0 a more flexible, modular, robust, scaleable, and supportable system is being designed.

All components of the system are now being developed as Windows Dynamic Linked Libraries. This allows for the isolation and encapsulation of functions within the system into the individual components. The component manager automatically links available components into the running interface. Each component is responsible for its own configuration and any component-specific data. Base components provide portfolio and inventory (tree, snag, understory) information and interfaces to a core of growth models, treatment, visualization, and tabular output components. This modular design also makes multiple interfaces possible. Three interfaces are under development: default (full featured), K-12 (simplified for teaching), and ArcGIS® (provide LMS functions from within GIS software).

To improve simulation performance and accommodate larger landscapes, all native file formats in LMS 3.0 are binary files. This provides better speed (reduces parsing of text files) and security at the cost of some file size. With hard drive space becoming relatively inexpensive, disk space is no longer a limitation. The system is also being designed to minimize file creation and activity. These changes have resulted in an increase in simulation speed from 5 minutes 47 seconds for LMS 2.0 to 1 minute 13 seconds for LMS 3.0 for a 200-stand, 30-year simulation on a 1.5-GHz computer. Enhancements to simulation capabilities include the ability to accommodate a whole-tree growth model, inclusion of additional growth models, increased treatment capabilities, and the addition of pre- and postmodels for additional processing of simulation results.

The new version of LMS has two methods for creating output tables: basic and advanced. Tabular output can be sent to Microsoft Excel® or Microsoft Access®. Basic Analysis tables are predefined tables implemented by using the Python (http://www.python.org/) scripting language. Additional basic analysis tables can be added to LMS but require programming capability by the table developer. The Python script includes an interface definition, which indicates to LMS which information (stand level, tree inventory, etc.) should be retrieved for use by the script. The script then processes the requested information and returns the resulting tabular information back to LMS for display.

Advanced analysis tables allow users to create their own tables or modify existing tables containing any variable known by LMS. Advanced analysis tables can be created with basic inventory information (stand, trees, snags, and understory) or summarized information. New tables are created selecting from available variables, no programming is required. Both basic and advanced analysis tables can be customized (add tables, remove tables, modify variables in tables) for each user of the computer allowing for users to have their own unique and customized list of analysis tables available for their use.

The LMS comes with a series of companion tools that provide data entry and advanced analysis capabilities. The Inventory Wizard (Zobrist et al. 2004) guides users through the process of assembling the forest inventory data needed to run LMS. Field cards can be printed and used for data collection. The data can then be entered into the computer through a series of user-friendly on-screen forms. The data are then automatically formatted and loaded into LMS. The Inventory Wizard has been instrumental in the adoption of LMS by nonindustrial small forest landowners.

The LMS-FFE add-on provides the ability to evaluate fire risk on forested landscapes. The Fire and Fuels Extension (FFE) (Reinhardt and Crookston 2003) has been developed by the U.S. Department of Agriculture, Forest Service and linked to the FVS. The LMS supports the use of the FFE to FVS (FFE-FVS). The LMS-FFE add-on includes FVS variant files with FFE support, the LMS-FFE Configuration Tool (for configuring the use of FFE), additional LMS table for FFE outputs, and the Fire Scoping Tool. The Fire Scoping Tool is used to examine summarized forest inventory information, stand attributes, and fire potentials to better understand potential fire risks and their relationship to stand structures on the landscape. It allows the user to identify stand types that represent high fire risk and then to evaluate the effectiveness of treatments to reduce the fire risk of those stands.

The LMS includes a variety of tables to evaluate the impacts of forest management activities on wildlife. Two approaches to modeling habitat impacts are used to create LMS habitat analysis modules. First, habitat suitability modeling provides an estimate of habitat quality (an index from 0.0 to1.0) and quantity (i.e., area of the landscape consolidated into a single metric known as a "habitat unit") for each species of interest. Additionally, structure-based habitat models associate particular species with forest structural conditions. Habitat suitability models are analyzed to assess the tradeoffs in habitat units, whereas structure-based habitat models can be used to estimate abundance/shortage of structure types (and by proxy habitat quantities) across large landscapes over time for alternative management approaches.

The LMS also includes a biomass and carbon life cycle assessment analysis to assess forest carbon storage, substitution, and displacement over time under different management alternatives. Estimates of changes in the amount of carbon stored over time in the standing forest are calculated by using biomass to carbon conversion factors specific by species for tree bole, bark, foliage, limbs, and roots. Estimates of carbon stored in harvested wood products are also calculated. Estimates of carbon emitted to the atmosphere from harvesting and manufacturing operations are considered as reductions to carbon stored in wood products. Estimated as well is the amount of carbon not emitted owing to displacement of fossil fuels in energy generation by wood used in a wood boiler, and substitution of wood for steel construction materials.

The LMS includes an easy-to-use economic and financial analysis. Economatic takes management simulation data directly from LMS and automatically computes a variety of economic values, including discounted cashflow, equivalent annual annuity, soil expectation value, forest value, and internal rate of return. Users can customize costs, prices, tax rates, and other input parameters. Results are summarized at both the stand and landscape level in a series of tables and charts. Economatic is implemented by using a Python program that summarizes inventory information and then inserts the results into a Microsoft Excel template.

Outreach and Technology Transfer

The LMS outreach and technical transfer activities are a fundamental component of the total effort relating to the product for over 5 years. The objectives of these outreach and technology transfer activities are to increase product usage, improve technical product quality, augment research efforts by users, catalyze synergy across user groups, enrich academic teaching, and secure funding for the product's future development and technical support.

Audiences

In general, it is believed that use of the product can make a measurable improvement in all areas of natural resource land management. With this paradigm in place, the audiences regularly targeted for use of LMS are far reaching. They include undergraduate and graduate students at various universities; the faculty members associated with these student teachings; researchers at governmental, academic, and nongovernmental organizations; natural resource conference and symposia attendees; land management agencies on state and federal levels; land management units within tribal governments; for-profit and not-for-profit land management corporations; family forest owners; and K-12 educators and their students. Some users of LMS are outside North America and some apply LMS to international land management projects.

Methods

Venues and avenues where LMS is showcased and taught are broad. Developing effective and cost-effective technology transfer and outreach opportunities to a wide audience has required both traditional and innovative approaches. Below is a list of these approaches, followed by brief descriptions of those that have had the greatest overall impact on product dissemination efforts, and quality improvement and product development.

- Promotion through Rural Technology Initiative (RTI) and LMS Web pages
- Workshops
- Demonstrations
- Consultations and customized in-service training
- Training sessions
- Educational partnerships
- Technical support by phone, in person, and by e-mail
- Professional continuing education
- Graduate and undergraduate teaching
- Conference/symposia presentations and posters
- Published papers, journal articles, extension publications
- Internet broadcasts—streaming video
- Rural Technology Initiative annual reviews.

Demonstrations

Rural Technology Initiative staff makes over 50 demonstrations of LMS and related applications each year. These demonstrations are to university classes, scientific and professional meetings, RTI technical reviews, interested cooperators, midcareer professional training, forestry consultants, landowners, and others. There are also a variety of streaming video presentations available (www.ruraltech.org) that discuss various aspects and analyses by using LMS. These demonstrations are used primarily to raise awareness of the existence and capabilities of the software. A number of demonstrations have led to subsequent training sessions customized to requesting persons or organizations.

Training Sessions

The RTI has been sponsoring 8 to 10 training sessions per year on LMS and related technologies. These training sessions are typically hands-on sessions that last 2 days. These have targeted small landowners, state agencies, tribes, and federal agencies. In addition, we have partnered with Washington State University Extension to present inventory and LMS at coached forest stewardship planning sessions to help small private owners. Long-term impacts from training sessions are mixed, with many participants not able to take advantage of the software because of time or technical constraints. Some feedback is very encouraging, however, with stories of landowners using LMS to make pictures of how they want their forest to look and providing those to their consulting foresters. In addition, a number of management plans have been developed by family forest landowners with LMS.

Educational Partnerships

The RTI has developed educational partnerships to further forestry education and assist in the use of LMS in education. We have worked with Community Colleges (Green River, Spokane, Peninsula, Wenatchee Valley, Skagit Valley, Heritage, Northwest Indian College, Mount Hood, Central Oregon, Chemeketa) and university extension departments (Penn State University Cooperative Extension and Outreach, Washington State University Cooperative Extension) to deliver improved education experiences using the software. In addition, we are working with Yale University, Pisgah Forest Institute (http://www.brevard.edu/pfi/), and Cradle of Forestry in America (http://www.cradleofforestry.com/) to develop a simplified interface more appropriate for school-age children (K-12).

The LMS has also been used for teaching or research at the following: University of Florida, University of Maine, University of Massachusetts, Michigan Technical University, University of Missouri, University of New Brunswick, Pennsylvania State University, University of Washington, Washington State University, West Virginia University, and Yale University.

Technical Support

Technical support is provided to the growing number of universities, community colleges, state agencies, federal agencies, tribes, timber companies, and small landowners who use the system. The LMS is supported by phone and email. The RTI currently has three staff members that answer LMS technical support questions on a part-time basis. Over 200 consultations take place each year with questions including CD-ROM requests, installation issues, capability questions, usage questions, data conversion issues, documentation improvements, bug reports, and feature requests.

Evaluation and Product Evolution

Methods used to evaluate the quality of the product and the efficacies of outreach and technology transfer have been both formal and informal. Those that have provided significant information about the product and outreach efforts are:

- Post workshop evaluations
- Professional continuing education evaluations
- Academic teaching of graduate and undergraduate students
- Educator feedback
- User emails originating as product technical support
- Anecdotal evidence
- Market research

Users of the product are, for the most part, quite forthcoming with their feedback about the product usability, technical "glitches," value of its outputs, and potential for improvements. All of these bits of information, whether through emails, personal conversations, or formal evaluations, combine into a data set that is used when strategically planning the evolution of LMS both in the short and long term.

There are a number of commercial products that are designed to accomplish a subset of the outputs that LMS offers. Many of these products are routinely promoted at conferences and technology fairs, as well as in the form of advertisements in journals, magazines, and via email promotion. Users of these products often describe what those products can and cannot do compared to LMS. This information is obviously considered valuable from an LMS product development perspective. However, because clients who have made an investment in such a product are not likely to discontinue its use, consideration is given to how LMS can be used in collaboration with these products.

Challenges to Technology Transfer

The first and greatest challenge to LMS, on all levels, is the level of computing access that is available to users. Windows 2000 or newer operating system running on a Pentium III 800 Mhz. or faster, 128MB RAM minimum, and 60MB hard disk is recommended. In additional, super video graphics array or better video hardware with a minimum of 32MB of memory with 2D hardware acceleration for stand-level visualization and 3D OpenGL hardware support for landscape visualization is recommended. These operating system and hardware requirements are not excessive for new computers, but many members of the target audience may be limited by their existing computer resources and may not be able to invest in new hardware.

The second challenge that faces users of any computer-based tool is their comfort and experience using computer applications in general. The LMS requires some level of familiarity with several software products such as Microsoft Excel. To make the most effective use of LMS, a comprehensive understanding of Excel and many of its data analysis features is needed. In addition, the ability to use graphical and presentation software can greatly improve the presentation of results provided by LMS.

Finally, all software development efforts can be derailed quickly when having to rely on a shifting operating system platform with feature and security enhancements introduced on a regular basis. Any software that hopes to stay current and usable in today's evolving computer environment needs continual testing and adjusting to keep it usable as operating environments evolve.

Challenges to Outreach

Some audiences are literally hard to reach; rural landowners by their very nature are rural. Laboratory teaching environments are in high demand and access to them can be limited. Data sets provided by LMS learners, no matter how robust, are often not immediately compatible with what is required in LMS. Data collection and cleaning efforts must be expended prior to coming to an LMS training session if the experience is to be fully successful.

Areas for Outreach and Technology Transfer Improvement

More can and should be done to assure that outreach and technology transfer of LMS is comprehensive and effective. Funding limitations prevent much of this work from taking place. Without regard to the barrier that funding creates, a short "wish list" of desired evaluation methods include:

- Pre- and postevaluations that measure distinct learning parameters
- Feedback from users' interactions with online tutorials
- General surveys of user groups on specific utilization and features
- Survey users' levels of technology access to determine how best to support their LMS utilization
- Independent evaluation of LMS from the user's perspective

Conclusions

The LMS is proving to be a useful platform for comparative analysis of alternative management approaches. It provides a simplified interface to growth and yield modeling, allowing more use of these technologies. The integration of visualization software with LMS is a powerful tool for communicating the impacts of management decisions on forest stands and landscapes. It has become very useful in educational environments where concepts of land management can be demonstrated by using visualizations and the changing forest conditions simulated over time. Additional analyses represented by the LMS companion tools are becoming increasingly important as more demands are placed on our natural resources. The development of more effective ways to move inventory information into the system, improved evaluation of growth estimates, and delivering desired technical support and outreach functions continue to be challenges.

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The Wildland-Urban Interface Professional Development Program

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Abstract

The dynamic characteristics of natural resource issues in the wildland-urban interface demand new skills from natural resource professionals. To help provide these skills, the USDA Forest Service, Southern Center for Wildland-Urban Interface Research and Information partnered with the University of Florida, School of Forest Resources, the Southern Group of State Foresters, and the U.S. Fish and Wildlife Service to create "**Changing Roles: A Wildland-Urban Interface Professional Development"** program. The program is designed for natural resource professionals working in the interface. It consists of four training modules: (1) interface issues and connections, (2) managing interface forests, (3) participating in land-use decisions, and (4) communicating with interface residents and leaders. The modules are being used by natural resource agencies across the South to help them solve challenging interface problems.

Keywords: Wildland-urban interface, training, professional development, natural resource agencies.

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Introduction

"Changing Roles: A Wildland-Urban Interface Professional Development" program is a set of training modules designed to provide new tools and needed information to natural resource professionals working in interface areas in the Southern United States. The wildland-urban interface is any area where increased human influence and land-use conversion are changing natural goods, services, and management. The Southern Wildland-Urban Interface Assessment by the USDA Forest Service, Southern Research Station, found that natural resource professionals often feel frustrated and sometimes helpless in the face of rapidly changing land use in the interface (Macie and Hermansen 2002). The complex issues in the interface affect how interface forests can be managed, how natural resource professionals communicate and work with interface residents and community decisionmakers, and how managers respond to and assist the development of local land-use decisions and regulations that affect natural resources.

The Program

To provide resource professionals with the skills needed to help them respond to interface challenges, the USDA Forest Service's Southern Center for Wildland-Urban Interface Research and Information partnered with the University of Florida, School of Forest Resources and Conservation and the Southern Group of State Foresters to create a professional development program. The training program includes four modules: (1) introduction to the range and complexity of wildland-urban interface issues, (2) communication skills for working with interface residents and community planners and leaders, (3) strategies for influencing the development of local policies and plans that affect natural resources, and (4) tools for effectively managing natural resources in the wildland-urban interface, particularly for enhancing forest health and meeting multiple landowner objectives. The U.S. Fish and Wildlife Service produced a video supplement to introduce training participants to wildland-urban interface issues. The video also serves as an outreach tool for resource professionals working with interface landowners.

Each of the training modules includes a trainer's guide; PowerPoint® presentations; case studies with examples of challenges, success stories, and scenarios from across the South; fact sheets with important points for participants; interactive exercises that enable participants to apply what they learn; and evaluation materials. The program is designed to be flexible, allowing trainers to select materials that meet their needs and enabling them to design programs of various lengths. The program will be distributed to state forestry agencies and other natural resource agencies across the Southern United States. It was designed to be flexible, allowing trainers to select materials that are most relevant and appropriate for their needs. Trainers can put together an introductory 2-hour program or a more comprehensive week-long course, depending on their needs and time available. Many of the materials are also suitable for using with other audiences such as extension agents, landowners, or community leaders.

The program materials are available for download from interfacesouth.org, the Web site of the Southern Center for Wildland-Urban Interface Research and Information. The Web site also provides trainers and participants with additional opportunities for feedback and a forum to share how the materials are being used. This encourages trainers to exchange ideas, learn from other's experiences, and maximize the value obtained from using the materials.

"Changing Roles" is designed to provide essential skills to enable natural resource professionals to respond to the challenges of a rapidly changing landscape. By working with landowners and assisting local leaders with community development and resource management decisions, resource professionals can help reduce problems in the wildland-urban interface.

Implementation

A training-of-trainers workshop was conducted for 50 state foresters, extension specialists, and other natural resource professionals to introduce these materials and support them through the process of designing workshops for their colleagues. Feedback from the training workshop suggests that the professional development program accomplished the desired goals. Workshop participants commented on the usefulness of the exercises, fact sheets, and case studies that accompany each module. Most recognize that it will take time to become comfortable with the material; but they also acknowledged that some sections are easy to use immediately. The material is perceived as relevant and not similar to existing materials. Participants rated the materials 4.6 on a 5-point scale where 5 is "very relevant to the work of my agency or organization." They also rated the materials 2.6 on a 5-point scale where 5 is "very similar to resources I already have." Workshop participants are likely to use the materials with others, share them with other trainers, and help train their staff. Respondents rated these latter three questions 4.2, 4.3, and 4.2, respectively, on a 5-point scale where 5 is "very likely."

Respondent comments also reinforced our belief that state agencies have different needs and capacities for using this material. Some states may wish to participate in a followup regional workshop put on by local trainers. Some states may wish to team up with other state agencies or extension faculty to organize a training program. Other states may have additional needs.

We are working with the Southern Wildland-Urban Interface Council to help design opportunities to support natural resource agencies in the South as they wrestle with the changing opportunities, changing landscape, and their changing roles.

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Measuring Best Management Practices Knowledge and Implementation Among Catskill/Delaware Watershed Nonindustrial Private Forest Landowners

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Abstract

The Catskill/Delaware watershed of the New York City Water Supply System is a regional example where nonindustrial private forest (NIPF) landowners play a major part in maintaining the quality of the system's water. About 75 percent of the heavily forested Catskill/Delaware watershed is privately owned. Yet the extent to which these owners help protect the United State's largest surface water storage and supply system is not extensively regulated. Rather, system managers seek to foster water quality stewardship among NIPF owners through education, technical assistance, and costsharing. Forestry education and outreach programs in this watershed promote forestry "best management practices" (BMPs) as a way for NIPF owners to manage forests while simultaneously protecting water quality. This study measured the diffusion of BMPs among Catskill/Delaware watershed NIPF owners by using a mail and field survey. For comparative purposes, a parallel evaluation was completed outside the watershed in Oneida County, New York, which has limited education and outreach opportunities for NIPF owners when compared to the Catskill/Delaware watershed. Diffusion of innovation was used as the theoretical construct for the study. We were particularly interested in the knowledge and implementation stages of diffusion. Mail survey results indicated BMP knowledge in the Catskill/Delaware watershed surpassed that of Oneida County. However, field surveys on property owned by mail survey respondents that harvested timber during the past 3 years indicated no difference in BMP implementation between the two. This result suggests that higher levels of knowledge in the watershed sample have not generally influenced BMP implementation.

Keywords: Nonindustrial private forest land, diffusion of innovation, New York City water supply system, best management practices.

Introduction

Throughout most of the 20th century, New York City (NYC) residents, commuters, and tourists have benefited from some of the purest drinking water in the Nation. As we enter the 21st century, land use changes in NYC's heavily forested surface water supply system threaten the quality of its water supply (NYC DEP 2002). Worldwide, large cities and rural communities are striving to balance economic development and long-term prosperity with environmental quality and protection. The NYC water supply system is a high-profile example of a working forested landscape where nonindustrial private forest (NIPF) landowners hold the key to water quality.

This paper presents the results of a study designed to assess the current state of forestry "best management practices" (BMP) knowledge and implementation among NIPF owners in the Catskill/Delaware watershed of NYC's water supply system. The BMPs are simple, "on-the-ground" practices that effectively reduce soil erosion and the subsequent sedimentation of water bodies resulting from timber harvest operations (Martin and Hornbeck

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1994). The BMPs consist of techniques and guidelines for ensuring proper skid trail and forest road slope and placement, along with the suitable construction and positioning of log landings and stream crossings to reduce the potential for significant erosion and sedimentation. Of particular importance to water quality are the correct installation and maintenance of water diversion devices such as water bars, broad-based dips, and diversion ditches to control the flow of water over exposed soil on skid trails, log landings, forest roads, and stream crossings. The use of BMPs by NIPF owners in NYC's water supply system is critical because it helps strike a balance between commercial timber harvests and water quality protection. What makes this case unique is that in lieu of stringent regulations, NYC water supply managers rely on voluntary education, technical assistance, and cost-sharing as the means for increasing BMP knowledge and implementation among NIPF owners.

This paper provides an overview of NYC's water supply system, followed by a discussion of the collaborative management agreement currently in place in the Catskill/Delaware watershed and the role of the Watershed Forestry Program in organizing NIPF owner education, technical assistance, and cost-sharing there. The research question, theory base, and design are presented next. This is followed by a presentation of the study results and a discussion of their relevance and contribution to NIPF owner education, technical assistance, and cost-sharing within the Catskill/Delaware watershed.

The Context: New York City's Water Supply System

New York City's water supply system encompasses about 5180 km^2 of land within three major watersheds, making it the largest unfiltered surface storage and supply system in the United States. The system provides, on an average day, 5.1 billion liters of clean drinking water to 9 million residents in the greater NYC area, as well as 1 million tourists and commuters. The Catskill and Delaware watersheds, located in the Catskill Mountain region of New York state, supply approximately 90 percent of NYC's water and make up nearly 4250 km^2 of the system. About 45,000 full-time residents live within the boundaries of these two watersheds. The older and suburbanized 971 km^2 Croton watershed 65 km north of Manhattan, supplies about 10 percent of NYC's water and houses approximately 160,000 full-time residents. About 75 percent of the entire water supply system is forested, with almost 75 percent of the area owned by NIPF owners (NYC DEP 2002).

The important role of NIPF owners in the protection of NYC's water supply stems first and foremost from the simple fact that they own the majority of land in the system. Other large metropolitan surface water supply systems—such as Boston, San Francisco, and Seattle—differ in this regard because the cities own and administer the majority of the land in their systems. Protecting NYC's water quality, on the other hand, is as much a responsibility of watershed NIPF owners as it is NYC's water supply managers. Without their cooperation, the quality of the water supplied by this high-visibility system may suffer.

Surface Water Treatment Rule and Memorandum of Agreement

In 1989, the U.S. Environmental Protection Agency (EPA) promulgated the Surface Water Treatment Rule pursuant to the Federal Safe Drinking Water Act Amendments of 1986. The ruling stated that all surface drinking water sources must undergo filtration. This was particularly problematic in the Catskill/Delaware watershed (watershed). Building a facility capable of filtering the 4.6 billion liters of drinking water extracted each day from this system proved to be a monumental hurdle for NYC's water supply system managers. Cost estimates for such a facility ran as high as $8 billion to build and $300 million a year to operate.

The rule, however, also afforded the option of requesting a Filtration Avoidance Determination (FAD), which would allow surface water supply system managers to circumvent filtration in the watershed. According to the rule, a FAD would be awarded if and only if managers were able to demonstrate that they were capable of directing human activities and controlling contaminants within their respective system. Thus, NYC could either construct a costly filtration plant or enact policies to meet FAD requirements; in the end they sought to direct behavior.

Water supply managers released a draft watershed protection plan to the public in September 1990 that included, among other components, revised watershed regulations not updated since 1953. The draft regulations sparked considerable opposition from local watershed communities, especially farmers and the local forest industry, who asserted that regulations would jeopardize their continued economic viability (Watershed Forestry Task Force 1996). Emerging from this conflict was a protracted negotiation process between NYC and the watershed communities. The signing of the NYC Watershed Memorandum of Agreement (MOA) in 1997 ended years of talks between upstate watershed advocates and NYC. The MOA closely outlined the city's long-range watershed protection plans and ultimately enabled the NYC Department of Environmental Protection (DEP) to receive a FAD from the EPA (NYC DEP 2002).

The MOA was hailed as a great civic achievement, the product of a historic urban-rural collaboration. At its core, the agreement called for a 10-year, $1 to $2 billion investment by NYC in watershed stewardship, which was to be achieved not through stringent regulations, but education, technical assistance, and cost-sharing (Gray 2003, Platt et al. 2000). Absent of rigid regulations on land use, the management strategy outlined in the MOA entails a noncoercive method that, among other things, seeks to expand the voluntary use of BMPs by NIPF owners.

The Watershed Forestry Program (WFP) was fashioned during the development of the MOA to oversee efforts to encourage water quality protection in watershed forests. The program is based on the premise that a well-managed working forested landscape provides the most beneficial land cover for water quality protection. The challenge for the WFP is to ensure local protection of water quality when most watershed residents, at best, distrust, at worse, hold animosity toward NYC. To overcome this impediment, the WFP partnered with local forestry and environmental organizations to promote voluntary forest management planning at a grassroots level. The WFP encourages BMP implementation by coordinating stepped-up extension efforts focusing on NIPF owner outreach and education, while also offering subsidized written management plans, technical assistance, and some cost-sharing for owners.

In addition to their focus on NIPF owners, the WFP also coordinates and provides forest and water quality training and continuing education for forestry practitioners working in the watershed. The program recognizes that a sensible approach for improving the implementation of forest and water quality management practices on watershed NIPF targets not only owners but also foresters and loggers. Often referred to as the "private forest management triangle," these three components can each independently affect the implementation of BMPs on NIPF. Although the WFP acknowledges that watershed foresters, loggers, and NIPF owners all have a hand in forest and water quality management, they also hold the position that NIPF owners are of particular strategic importance because they are ultimately responsible for management activities on their property. As such, they have developed a robust program specifically designed to foster voluntary BMP implementation on the part of watershed NIPF owners.

Research Question

The research reported in this paper focuses on NIPF owners and their contribution to forest management and water quality protection in the watershed. This focus is of great importance for NYC's water supply system managers and the WFP, especially given the critical role of NIPF owners in maintaining NYC's ability to deliver top-notch water to its residents, commuters, and tourists. In particular, this study sought to answer questions about how much watershed NIPF owners know about BMPs and whether or not they are implementing them.

Theory Base

Diffusion of innovation is the process by which an innovation is communicated through certain channels over time among the members of a social system (Rogers 1995). Rogers (1995) developed a theoretical, cross-cultural model of diffusion of innovation with broad applicability, outlining how a new idea, object, concept, or practice spreads throughout a group of people. In theory, individuals experience a series of actions and make decisions over time leading to the adoption or rejection of an innovation. Of particular importance to this paper are the knowledge an individual possesses about an innovation and their subsequent implementation of the innovation. Knowledge is conceptualized as an individual's awareness of an innovation and familiarity with how it works and is used. Implementation represents the actual use of an innovation. Although diffusion theory does not suggest that knowledge predicts implementation, we sought to test for a significant relationship between them as a means for better understanding voluntary BMP implementation by watershed NIPF owners.

Methods

A two-phased "ground-truth" method was used to measure BMP knowledge and implementation. A mail survey was used to collect data on BMP knowledge, and a field survey was conducted to measure BMP implementation. The study collected data in both the watershed and Oneida County New York. Oneida County is located approximately 110 km north of the watershed and served, in essence, as a control for mail and field survey data testing. The population frame for this research consisted of owners holding 10 or more acres of forested property. The 10-acre threshold was based on the minimum acreage for the National Tree Farm Program and the WFP management plan program (Tree Farm 2003, WFP 2001).

Diffusion literature was used to validate the content of the survey. Face validity was achieved through a panel of experts. These individuals helped choose themes and create a strategic purpose for the survey. The mail survey's reliability was tested in a pilot study of 31 NIPF owners not included in the study.

Double stratified random sampling was used to ensure spatial and acreage heterogeneity. Spatial diversity was achieved by stratifying the study's population frame based on watershed basin. Next, acreage diversity was achieved by stratifying each basin cohort by parcel size. The following acreage categories were used for stratification: 10 to 19, 20 to 29, 30 to 39, 40 to 49, 50 to 74, 75 to 99, 100 to 149, and 150 acres or more. These acreage categories were used to stratify the random sampling of NIPF owners in Oneida County.

The mail survey was a Likert-type instrument that used three scales to measure BMP knowledge. Each Likert scale consisted of six possible responses on a bipolar continuum, where a response of "1" equals "strongly unaware" and "6" represents "strongly aware." This scale, which does not include a neutral response, was selected primarily to decrease "lazy" responses. All surveys were administered following Frankfort-Nachmias and Nachmias (2000), which recommends using four successive mailing steps (two surveys, each followed by a reminder card).

The first knowledge scale consisted of four statements intended to measure each respondent's awareness of BMPs. The six statements in the second scale were intended to gauge each respondent's knowledge about the basic functions of BMPs. The statements specifically focused on the relationship between forests and water quality, and the potential impact of timber harvests on water quality. The third scale comprised six statements intended to measure a respondent's knowledge about how BMPs are implemented. The means of these scales were summed and averaged to calculate an overall BMP knowledge score. Respondents were also asked to recall their use of technical assistance and education prior to receiving the survey and indicate if they have a written forest management plan for their NIPF.

The mail survey was used to obtain access to NIPF that had recently been harvested. Respondents from both the watershed and Oneida County who had harvested timber on their property in the past 3 years were asked if they would allow a graduate student to conduct a field evaluation on their property. The respondents who agreed to the evaluation became the sample for the field survey.

Schuler and Briggs's (2000) BMP compliance evaluation, the New York state BMP field guide, expert input, and multiple field tests were used to develop the field survey. A point system was used to assign a BMP implementation score. This system included four mutually exclusive categories: 0 = "BMP not used"; 1 = "BMP used with major deviations"; 2 = "BMP used with minor deviations"; and 3 = "BMP used and correctly applied." A census of each harvested site was conducted. Each evaluation consisted of BMP implementation measurements on all log landings, forest roads, skid trails, and stream crossings. Summing the scores for each measurement and averaging the results determined the overall BMP implementation score.

A single researcher conducted field surveys. To prepare for the survey, the site's topography and water bodies were identified by using topographical maps. A clinometer was used to assess slope grade; distance and area measurements were taken with a measuring wheel and used to weight scores, where a longer skid trail or larger landing was weighted more heavily than a shorter or smaller counterpart when computing segment scores. The BMP implementation scores were tallied on a blank survey during the visit and were weighted and calculated afterwards.

Independent t-tests were used to test mail and field survey data. Knowledge and implementation data were first factored by a respondent's location (i.e., watershed or Oneida County) and tested for statistical significance. The implementation scores for skid trails, log landings, and water diversion devices was then factored by a respondent's location and tested for statistical significance. Watershed data were then separated and BMP knowledge was tested for statistical significance when factored by the respondent's participation in technical assistance and education and BMP implementation when factored by use of a written management plan.

Results

Six hundred and forty-five surveys out of the 700 mailed were successfully delivered to NIPF owners in the watershed. Two hundred and seventy-five out of 645 were returned for an adjusted response rate of 43 percent. One hundred and eight mail surveys out of 115 were successfully delivered to NIPF owners in Oneida County. Fifty-four out of 108 were returned for an adjusted response rate of 50 percent. The Cronbach Alpha score for each knowledge scale was above .80, indicating strong inter-item correlations for the mean scores used to tabulate overall knowledge (Carmines and Zeller 1979). Seventy-one percent of the NIPF owner respondents that had harvested timber on their property in the previous 3 years agreed to allow a field visit. Field surveys were ultimately conducted on 31 harvested NIPF parcels in the watershed and 13 harvested NIPF parcels in Oneida County.

Table 1 presents overall BMP knowledge mean scores for watershed and Oneida County NIPF owner respondents. The summed mean for watershed respondents is significantly higher than the mean response for Oneida County respondents. Table 1 also presents BMP implementation mean scores for surveyed NIPF harvests in the watershed and Oneida County. There is no statistical difference between the implementation means.

Table 2 contains the mean scores for the log landing, skid trail, and water diversion device BMP implementation evaluations for surveyed harvests in the watershed and Oneida County. No statistical difference exists between the means. The log landing and skid trail means represent each harvest's summed and weighted score for that particular component of the implementation evaluation, whereas the water diversion device means were computed by using specific scores related to the implementation of these devices across all field survey components (i.e., skid trails, forest roads, log landings, and stream crossings). Forest roads and stream crossing scores were not included as stand-alone components in this analysis because of low sample sizes owing to the irregularity with which they were encountered.

Table 3 illustrates the differences in BMP knowledge between watershed NIPF owner respondents who had used forestry technical assistance and education and those who had not, and differences in BMP implementation between watershed NIPF owners with and without written management plans. The summed BMP knowledge mean for watershed respondents that used technical assistance and education is significantly higher than the mean response for those watershed respondents that did not. The tabled results also indicate that written management plans, regardless of their sponsorship (i.e., New York State, WFP, Tree Farm, etc.), significantly increase BMP implementation mean scores on watershed NIPF.

Discussion

Although the difference in BMP knowledge between watershed and Oneida County NIPF owners is an interesting result, the similarity in BMP implementation between the two is a more notable outcome. Why does the implementation of BMPs on Watershed NIPF fail to surpass implementation rates on Oneida County NIPF? This question is particularly striking when considering the low implementation rates for water diversion devices across all implementation evaluations. There are at least three possible explanations for this disparity.

First, BMPs are a preventative innovation. Rogers (1995) describes preventative innovations as those that are adopted at one point in time to avoid an unwanted event in the future. These innovations typically have a slow rate of adoption because individuals often have difficulty observing or understanding the advantages of using such an innovation. Just because a watershed NIPF owner knows about BMPs does not mean they are able to observe and understand the preventative nature and advantage of BMPs. Their inability to adequately absorb these concepts may therefore lead to lower implementation rates.

Another possible explanation for the disparity between BMP knowledge and implementation among watershed NIPF owners is related to economics. Arguments for rejecting BMPs are frequently associated with the cost of their use (Schuler 1999). For example, using BMPs was shown to reduce the net revenue for a timber harvest by 59 percent in the Midwest (Ellefson and Miles 1985). Anecdotally speaking, informal conversations with loggers and foresters often indicate that the reduction in net revenue from a timber harvest influences an NIPF owner's decision to use BMPs. Despite their knowledge of BMPs, some watershed NIPF owners may decide against using them because of the associated or

Table 1—Independent t-tests of (BMP) best management practice knowledge and implementation by location of NIPF owner respondents

	Location	Sample size	Mean	Standard deviation
BMP knowledge	Watershed	234	4.14[a]	1.05
(scale: 1 to 6)	Oneida	49	3.19[b]	.70
BMP implementation	Watershed	31	1.75[a]	.46
(scale: 0 to 3)	Oneida	13	1.60[a]	.32

Note: Means with the same letter are not significantly different ($\alpha = .05$).

Table 2—Independent t-tests of (BMP) best management practice implementation on landings and skid trails and water diversion device implementation, by location of NIPF owner respondents

	Location	Sample size	Mean	Standard deviation
BMP implementation landings	Watershed	31	1.89[a]	.50
(scale: 0 to 3)	Oneida	13	1.76[a]	.36
BMP implementation skid trails	Watershed	31	1.56[a]	.47
(scale: 0 to 3)	Oneida	13	1.44[a]	.39
Water diversion device implementation	Watershed	31	.28[a]	.51
(scale: 0 to 3)	Oneida	13	.04[a]	.10

Note: Means with the same letter are not significantly different ($\alpha = .05$).

Table 3—Independent t-tests of watershed (NIPF) nonindustrial private forest owner respondent (BMP) best management practice knowledge by (1) forestry technical assistance and education use and (2) use of a written management plan

		Use	Sample size	Mean	Standard deviation
BMP knowledge (scale: 1 to 6)	Use of technical assistance and education by watershed NIPF owners	Yes	38	5.03[a]	.79
		No	191	3.96[b]	1.01
BMP implementation (scale: 0 to 3)	Use of written management plan by watershed NIPF owners	Yes	9	2.28[a]	.38
		No	21	1.52[b]	.29

Note: Means with the same letter are not significantly different ($\alpha = .05$).

perceived costs—particularly in light of the expenses tied to the implementation and long-term maintenance of water-diversion devices.

Lastly, the nature of the private forest management triangle may contribute to lower implementation rates. As described earlier, this triangle represents the relationship between NIPF owners, loggers, and foresters in the management of NIPF. Though NIPF owners are considered the strategic decisionmakers in the triangle, foresters and loggers are also influential players. It is entirely possible that some of the less desirable BMP implementation scores on watershed NIPF were related to poor performance or lack of implementation on the part of foresters and loggers.

Conversely, some good news about BMP knowledge and implementation in the watershed does exist. The BMP knowledge was higher among watershed NIPF owners that reported using forestry technical assistance or education. Furthermore, BMP implementation was higher on NIPF harvests where the owner stated that a written management plan exists. These two results are significant given that watershed NIPF owners who use forestry technical assistance and education are more likely to have a written forest management plan (Munsell and Germain 2004). These results illustrate that the combination of education, technical assistance, and management planning by the WFP and others are critical in the push to maintain a working forested landscape that simultaneously provides high-quality drinking water.

Implications

With nearly 3900 km^2 of forest land in NYC's water supply system, the importance of forest management that is compatible with water quality is paramount yet also challenging because approximately 75 percent of the system's forest land is NIPF. The results of this research suggest that there is a need to place stronger emphasis on promoting management plans and consistency in implementation. Efforts are already being made on this front. To check for consistency in follow-on activities, the WFP is currently conducting field surveys on NIPF managed with plans that they have subsidized. Continuing ground-truth research, such as the study reported in this paper and the work being conducted by the WFP, will provide constructive insight into the relationship between BMP knowledge and implementation among watershed NIPF owners.

However, this information must also be put to use. It is imperative that new knowledge is used to develop innovative, yet practical education, technical assistance, and cost-sharing approaches so that a more consistent process of innovation diffusion occurs in the watershed. In light of the results presented in this article, watershed outreach and education programs must first continue striving to reach the greatest number of owners possible. They must also work in a variety of ways to help these individual owners clearly see the merits of BMP implementation—both from a personal and social perspective. Greater efforts to subsidize the actual implementation of BMPs may pay dividends as well. This is especially true when considering the possibility that implementation costs are often a limiting factor. Lastly, the process of BMP implementation is one that involves multiple parties. Fostering a private forest management triangle that effectively works together toward the consistent implementation of BMPs should remain a primary goal of watershed managers and education and outreach programs.

Water supply managers and forestry education and outreach specialists have made great strides in NYC's water supply system. As a result, the system stands as a positive example of urban-rural collaboration centered on forest and water quality management. Yet, there is still more work to do. Research is needed to better understand the role of foresters and loggers in the management triangle and to learn more about how biophysical, social, and economical context affects forestry practices on watershed NIPF owners. An aggressive and adaptive education and outreach approach must also remain strong so that such information can be effectively synthesized and communicated to watershed audiences holding the key to water quality in NYC's supply system. This approach and what is learned in following it will not only benefit NYC's water supply system, but other working forested landscapes as well.

Acknowledgments

The authors wish to thank the USDA Cooperative State Research Education and Extension Service, Edna Bailey Sussman Foundation, and the C. Eugene Farnsworth Memorial Fellowship for their support. The authors would also like to thank the Watershed Agricultural Council in Walton, New York, for their assistance.

English Equivalents

1 kilometer (km) = 0.6215 mile
1 square kilometer (km^2) = 0.386 square mile
1 liter (L) = 0.265 gallon

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Using Web-Based Technology to Deliver Scientific Knowledge: The Southern Forest Encyclopedia Network

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Abstract

Forest science, like any science, is a continuous process of discovering new knowledge, reevaluating existing knowledge, and revising our theories and management practices in light of these changes. The forest science community has not yet found the solution to the problem of getting continuously changing science efficiently and effectively into the hands of those who need it in their daily work, the forest practitioners. The Forest Encyclopedia Network or FEN (www.forestencyclopedia.net) represents a new approach to the synthesis and delivery of forest science knowledge. The USDA Forest Service Southern Research Station, the Southern Regional Extension Forestry system, the USDA Forest Service State and Private Cooperative Forestry Program and the Southern forestry university community are all engaged in building and testing this new science delivery concept. The network currently has four encyclopedias in various stages of completion: The Encyclopedia of Southern Appalachian Forest Ecosystems, The Encyclopedia of Southern Fire Science, The Encyclopedia of South-Wide Forest Science, and The Encyclopedia of Southern Bioenergy. This paper will describe the history, current status, and future plans for the FEN project.

Keywords: Knowledge management, World Wide Web, hypertext encyclopedia.

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Background

It has long been recognized that knowledge has great value. Until fairly recently, however, most people did not think in terms of “managing knowledge.” They felt that knowledge was a personal asset, the sum of our experiences, education, and our informal community of friends and colleagues that help us perform better in our complex world (Plunkett 2001).

As computer technology improved and became cheaper in the early 1990s, researchers in academia, government, and private industry began to explore the gains that could be made by organizing knowledge, codifying it, and sharing it more widely. The early innovators began to demonstrate that actively improving the management of knowledge could improve the ability of scientists to deliver their research results into the hands of users (Rauscher 1987), help government cope with downsized budgets and increased work (Plunkett 2001), and assist private industry with gaining and maintaining competitive advantage (Heinrichs et al. 2003).

We can define knowledge management as the systematic strategy of creating, conserving, and sharing knowledge to increase the performance of individuals, companies, or nations (Heinrichs et al. 2003, Plunkett 2001). The Forest Encyclopedia Network (FEN) was designed as a system for managing knowledge for the forestry community, based on Web technology, which is both maintained and distributed over the Internet.

Forest science poses a number of challenges to knowledge management. Certainly one challenge common to science in general is the way in which scientific knowledge largely resides in highly technical, narrowly focused research publications. More particular to forest science is the array of disciplines on which it is based. Southern forestry brings extra challenges including its rich and evolving scientific literature and its diverse mix of landowners. Some 5 million private landowners control the forests of the South, with government managing just 11 percent (Wear and Greis 2002). Getting information to this large, diverse audience is a challenge that inspired us to develop FEN.

Web technologies offer a number of features useful for knowledge management and distribution. These include a rich set of development tools, universally available access, and an easy-to-use interface. Of special attraction is how links between pages can help organize large amounts of information into a hypertext and how Web standards permit the display of various media in an attractive and interactive interface. The FEN exploits these features, building on earlier efforts in forestry. These include Rauscher (1987), who introduced the concept of modern knowledge management to the natural resource field. Rauscher (1991) followed with the first electronic hypertext encyclopedia called "The Encyclopedia of AI Applications to Forest Science." Other hypertext products for nonnetworked personal computers followed in rapid succession (Rauscher et al. 1997, Reynolds et al. 1995, Thomson et al. 1993).

With the growth of the Internet, knowledge management systems using Web-based hypertext gained an enormous competitive edge over stand-alone systems. In a pioneering effort, Thomson et al. (1998) combined knowledge-based systems processing and hypertext markup language (HTML) to provide forest tree disease diagnosis over the Internet. Anyone with a Web browser could now access the diagnostic software. Examples of Internet-based knowledge management systems for natural resource management can be found at FEN where a growing number of scientific encyclopedias can be found (Kennard et al. 2005).

Approach

The FEN facilitates the transfer of usable knowledge from scientific experts to managers, policymakers, and natural resource professionals. Users of the site are offered what adult educators call a self-directed learning tool where individuals can obtain information on an as-needed basis.

A typical encyclopedia project begins with the development of the "core material." It is directed by one or more subject matter experts who act as the managing editors. These editors are responsible for creating an information architecture, identifying the content and engaging authors to write needed synthesis pages. They are also responsible for guiding the peer-review process for each section. Assistant editors work with the managing editors to ensure that the content material gets properly placed into the hypertext encyclopedia and that the figures, tables, and citations are all properly linked. Finally, technical specialists are responsible for maintaining the common computing infrastructure and making improvements in page design, workflow, and system function.

All of the various encyclopedia projects share the same computing infrastructure to reduce implementation costs. Once the "core material" for an encyclopedia is in place, it moves to a continuous update mode where various authors submit new or revised material to keep the content current and expanding.

Content

The FEN offers concise, authoritative syntheses of knowledge tied to the scientific literature on which it is based and organized to meet user needs. Content is often drawn from existing review documents but if necessary is custom written for the encyclopedia. Content can be in several forms, including narrative text pages, citations, data tables, and figures. Each page is embedded in a subject matter outline that provides context and enhances understanding.

Content is arranged as a set of narrowly focused Web pages, each tied to a rich set of related information. Arranging content into a large set of tightly focused Web pages makes it easier for users to find specific content relevant to their needs. A search for the term of interest brings the user to a particular page, and the navigation pane places the page in context and identifies pages with related content. Arranging content in this way also makes it easier to delegate authoring and revision processes, speeds downloading of content by the user, and makes it easier to reuse the same content in different contexts.

Quality of content is ensured through the same means used in more traditional scientific publications. All content includes author attribution and full citations. All content must also pass anonymous peer review before being published on the Internet. Updates to the content must undergo the same peer and editorial review as original content.

A hierarchical information architecture organizes this wealth of information. Every page clearly displays to the user where the current page resides in that hierarchy and offers navigation options to other portions of the hierarchy (see fig. 1). These supplement the hyperlinks provided in the body of the content. The hierarchy is easily extended and modified to adapt to evolving content and user needs. Indeed, although not yet implemented, the system can permit users to select alternative architectures, rearranging the navigation structure to better suit particular needs. Alternative architectures could be offered to facilitate reuse of the same content for specific workshops or courses, for special-purpose collections, or to highlight specific topics.

The four encyclopedias at FEN together offer about 1,700 pages of content, over a thousand images, and over 7,000 citations. By sharing a common set of development tools, the individual encyclopedias at FEN can share content and operate more efficiently. However, each encyclopedia retains its own management and information architecture.

Contributors

Creating and maintaining encyclopedias takes a great deal of effort and thus requires contributions from a wide array of institutions and individuals.

The FEN was created as a collaboration of the USDA Forest Service Southern Research Station, the Southern Forestry University community, the USDA Forest Service State and Private Cooperative Forest Program and the Southern Regional Forestry Extension System. The first two organizations have conducted forest research and the latter have worked closely with landowners and managers to use resulting information to improve forest practices in the South. This multiagency collaboration draws on the strengths of all parties to improve how scientific information is summarized and delivered to the broader forestry community.

Funding from these sponsoring organizations has been augmented by grants from USDA's National Research Initiative and Bioenergy program, the National Fire Plan, and the Joint Fire Science Program.

Editors for the various encyclopedias in FEN design the information architecture for each encyclopedia, identify source materials, and recruit authors and peer reviewers. Editors also edit content for consistent style and formatting and add hyperlinks when necessary.

Authors write original content either expressly for an encyclopedia or for more traditional outlets. Authors are generally experts in their field. Various federal and state agencies and nonprofit organizations have contributed authors. The majority have come from universities and the Southern Research Station.

The FEN currently has an editorial board of nine editors and is drawing on content from over a hundred corresponding authors.

Process

Specialized software tools and efficient project organization are needed to coordinate the efforts of numerous editors and authors across diverse organizations and locations. The FEN uses a customized content management

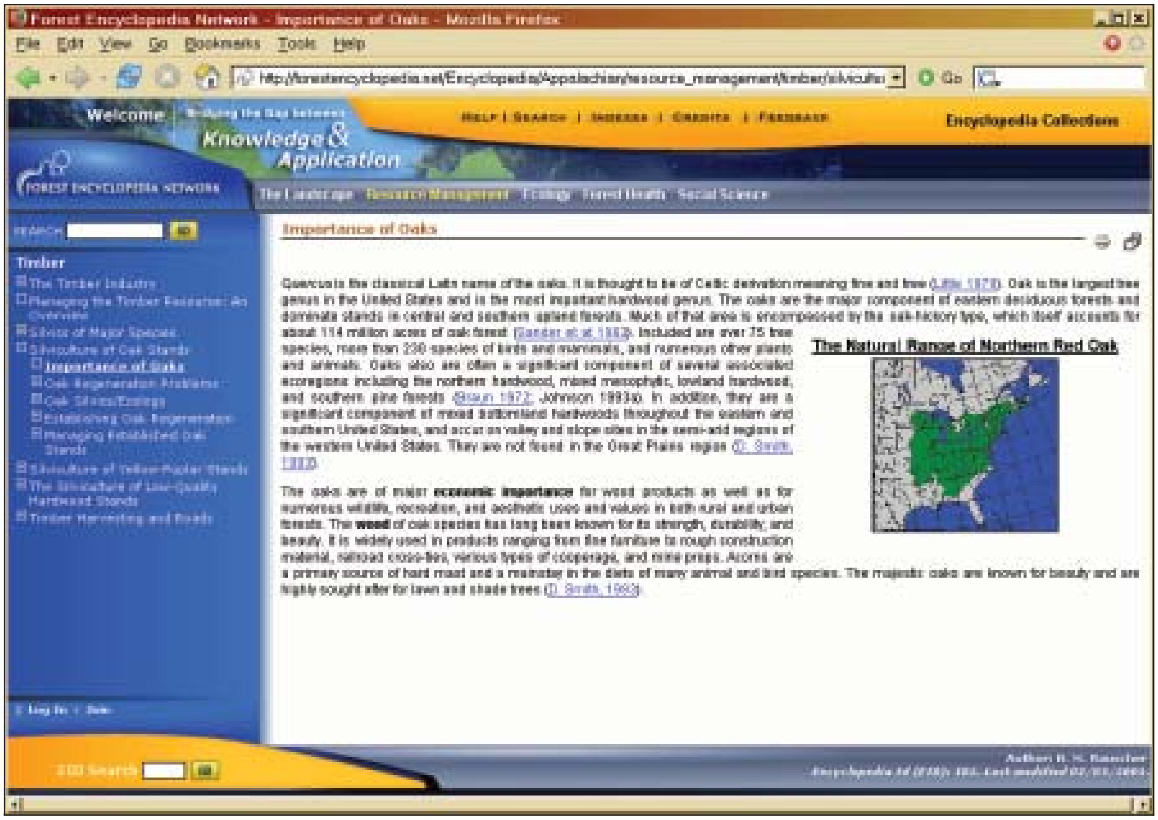

Figure 1—Sample content page in the Encyclopedia of Southern Appalachian Forest Ecosystems showing top-level (near top) and lower level (left side) navigation options.

system (CMS) based on the Content Management Framework of Zope, itself an open source Web development environment (Learner 2002). Jordin and others (2003) provided technical details. This paper will focus on current workflow and features.

Customized CMS software simplifies Web authoring and citation management, standardizes page design and display, enforces role-based security, and manages the flow of work from content creation through peer review, editing, and publishing.

The FEN leverages Web technology and the Internet not only for distributing its content but also for managing it. Editors, authors, and peer reviewers can all perform their tasks from anywhere on the Internet by using commonly available browsers. This capability makes it easier to recruit talent regardless of their location.

Role-based permissions allow editors to perform tasks different from those of authors or peer reviewers. They also control access to information. For example, to ensure the anonymity of the peer-review process, editors can see the identity of peer reviewers but authors cannot. Each individual can be assigned authority over portions of content. Identities are confirmed by ID and password combinations.

The content management system manages content as an object-oriented database, assembling Web pages dynamically when requested. This allows the navigation options to dynamically reflect existing content and makes it much easier to change the information architecture. The system automatically generates a table of contents and lists of figures and tables, as well as a search index. Improvements to the user interface are applied easily and consistently across the site.

Predefined workflows ensure that content moves from authoring through peer review and editing, with editorial approval prior to publishing on the public site. Task lists are generated for each individual with email notification of newly added tasks. Published pages that are undergoing revision remain visible to the public until the revised content is approved for publication.

Hyperlinks are automatically adjusted when content is moved in the information hierarchy to prevent dead links. Advanced portal tools permit construction of alternative displays and functions for different user groups or preferences.

Implementation

The FEN is the result of both insightful design and experience. In April 2000 it began with a single encyclopedia—the Encyclopedia of Southern Appalachian Forest Ecosystems, abbreviated ESAFE (Kennard and others 2005). The first managing editor of ESAFE was Deborah Kennard. When Kennard moved to managing the Encyclopedia of Southern Fire Science, Michael Rauscher took over as managing editor of ESAFE and Patricia Flebbe, David Wear, Kenneth Cordell, and Dennis Ward became section editors. The ESAFE was published in 2004 following full peer review. It demonstrated the feasibility of using a Web-based organization and delivery platform for scientific knowledge.

The ESAFE provided a number of lessons. Its logistic underpinnings were woefully inadequate for managing the content of multiple authors and did not provide the flexibility to evolve with content over time. It did, however, prove its utility to customers, as expressed through a customer survey conducted in 2002. Visitors to the site appreciated the content, organization, and navigation but wished to see improved access to the underlying scientific publications, more content and more illustrations. Their suggestions were incorporated into the present product.

The success of ESAFE encouraged the establishment of other encyclopedias. The Encyclopedia of Southern Fire Science, edited by Deborah Kennard and Cynthia Fowler, was second to the network and is now largely complete. A third encyclopedia, the broader Encyclopedia of Southern Forest Science, is well underway. It will draw initial content from two publications offering a combined 1,000 printed pages of peer-reviewed content (Rauscher and Johnsen 2004, Wear and Greis 2002). Editors are Mike Rauscher and John Pye, with completion expected by 2006. The most recent encyclopedia, still in its early stages, is the Encyclopedia of Bioenergy/Bioproducts (Smith, in press)[2]. Its managing editor is C.T. Smith and is scheduled for completion by late 2006. We expect to shift to maintenance activities on the first two encyclopedias around mid-2005. Several additional projects are under evaluation.

At present, each encyclopedia has its own content and information architecture. Revisions currently unfolding will allow the same content to be used in multiple encyclopedias, facilitating the creation of broader collections of information as well as the reuse of specific content wherever it is appropriate.

Challenges

The FEN is a new approach to the delivery of scientific knowledge to users. Project members have successfully launched four encyclopedias on various topics and guided the software infrastructure through three major revisions. Many challenges have been overcome to prove that the encyclopedia approach is indeed a viable scientific knowledge management and delivery mechanism. Some challenges remain.

One continuing challenge is motivating scientific experts to synthesize scientific information and provide it in appropriate form to the editors. The FEN must find ways to demonstrate the worth of the contributions of authors and editors in a way that is recognizable and

[2] Smith, C.T. Knowledge products to inform rural communities about sustainable forestry for bioenergy and biobased products.This was a power point presentation at the conference.

valued by their peers. The Director of the Southern Research Station has indicated he supports allowing its scientists to claim encyclopedia contributions as a peer-reviewed product in their performance evaluations. A marketing effort is currently underway to persuade the scientific community that contributions to the encyclopedia are an excellent way to get research results into the hands of users while earning a peer-review credit for their own career enhancement. Page activity reports can also provide authors and their supervisors feedback on the utility of their work.

Writing style is another challenge. Most scientists are more familiar with writing in the lengthy, linear style common to traditional journals than the punchy, conclusion-first style needed in the hypertext world of the Internet. Forest Encyclopedia Network's editors can assist the authors with this transformation. Closely related to writing style is inclusion of graphics, another area where the assistance of editors and graphics support staff could improve migration of material to the Web.

Just as writing styles need to change, so too must content. Procedures must be developed to identify obsolete content, enlist authors to update it, and provide proper attribution to what in some cases may be minor revisions. One option FEN is exploring is an archiving system that would allow visitors to "peel back" current contents to reveal previous versions, showing what previous authors wrote on the subject. This could show visitors how scientific understanding and its expression in the encyclopedia have changed over time. Most Web sites focus on delivering current information. Designing an interface that shows change in content over time without confusing the audience would be a substantial achievement.

Another challenge is refining how we promote the encyclopedias to potential users. Although promotion can include traditional outlets like trade journals and conferences such as this one, additional avenues need to be explored including link promotion, improving the ranking of key content by commercial search engines, and sharing of FEN content with broader collections.

Particularly critical is the use of the encyclopedia content by extension professionals. Extension specialists should be able to easily take encyclopedia content and use it in various forms to support end-user training and education programs. The FEN collaborators are currently designing a marketing program to improve the visibility of FEN among extension specialists and natural resource managers and to encourage their advice on how to improve its content and delivery.

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Got Science? Getting Science to People Who Care About Forests

Valerie A. Rapp[1] and Sherri Richardson-Dodge[2]

Abstract

The Pacific Northwest (PNW) Research Station is part of the research branch of the USDA Forest Service. We want policymakers, nongovernment organizations, teachers, reporters, forest landowners, and others to rely on us as a source of credible, reliable science information. These people are interested and often very influential in forest management, yet they have differing levels of expertise. One part of PNW Research Station's communications strategy was to build people's awareness about new forest science and technologies. Therefore, we added two publication series to our portfolio, products that would be readable and attractive but also technically sound. The first reader-friendly publication series, *Science Findings*, is a 6-page, newsletter-style publication delivered monthly. Readers can skim it in 5 minutes or read it closely in 20 minutes. The second series, *Science Update*, is a 12-page, color, quarterly publication. It is a synthesis of research related to pressing issues. Over 8,000 people receive free subscriptions to these two publications, and thousands more download them from our Web site. In the severe fire season of 2002, these two publication series played a vital role in getting scientific information about fire risk in Western forests into public discussion about the issue. Keys to success with reader-friendly publications are discussed in the paper. Policymakers, agency executives, and others have told us they use these accessible publications as a vital information source.

Keywords: Science communications, reader-friendly publications, newspapers, fire risk.

The American national forests cover 77.3 million ha (191 million acres), and these national forests are valued for their water, forests, wildlife, beauty, recreation, and other resources. From the beginning of the Forest Service in 1905, agency leaders set out to learn more about how forests worked so these highly valued resources could be managed well.

The Pacific Northwest (PNW) Research Station is part of the research branch of the Forest Service. Our scientists conduct research in the spruce (*Picea* spp.) and aspen (*Populus tremuloides* Michx.) forests of Alaska, the ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) forests and rangelands of the dry, interior Northwest, and the Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and hemlock (*Tsuga heterophylla* (Raf.) Sarg.) forests of the coastal Northwest. In addition to their well-known work on old-growth forests, these scientists are studying young forests, sustainable forestry, fish and wildlife, rural communities, and more.

We at PNW Research Station want to be recognized as the go-to people in the region for the best information on forest science. Our forest sector includes private forest lands as well as national forests, state forests, and tribal forests, and includes policymakers and managers of those lands. Our congressional representatives and senators care a great deal about these forests,

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as do the citizens in their districts (fig. 1). We have a very articulate and involved public with a wide range of viewpoints, and of course we have the media. We want all of these people to rely on us as a key source of credible, reliable science information, yet these interested people have widely differing levels of expertise.

To meet these goals, the PNW Research Station developed a comprehensive communications strategy (Miner 2005). The communications strategy is based on an understanding of how people learn about and then decide to use new concepts, knowledge, and technologies, a process known as the diffusion of innovations (Rogers 2003). Diffusion begins with awareness, continues with persuasion, and then moves into adoption, where people take action to adopt and use new ideas or technologies. Publications, mass media, and electronic media can be very effective in the first stage of building awareness. Persuasion and adoption often require additional methods such as workshops, training, field trips, and consultation.

One part of the communications strategy was to do more to build people's awareness about new forest science and technologies. The PNW Research Station has long had a solid base of peer-reviewed scientific publications, but these reached a limited audience. To reach more people, more often, with more of the Station scientists' new findings, we added two new publication series to our portfolio, products that would be readable and attractive but also technically sound. This paper focuses on these publication series, the *Science Findings* and *Science Update*, as case studies, so that others can create similar publications as technology transfer tools for their programs. Note, however, that these shorter, readable publications are effective in part because they are parts of a well-thought-out strategy and an extensive portfolio.

Science Findings

The first publication series, *Science Findings*, was started in 1998. The *Science Findings* is a 6-page,

Jamie Barbour

Figure 1—A group of people discuss what should be done after the B&B Fire burned through part of the Deschutes National Forest in central Oregon—whether timber should be salvaged and what the restoration plan should be.

newsletter-style publication delivered monthly (fig. 2). Readers can skim it in 5 minutes or read it closely in 20 minutes. Each issue focuses on one research topic, and the scientific work featured must be peer-reviewed before it's accepted for *Science Finding*s. Information is set within the context of relevant management issues, but is not highly time-sensitive. Topics are selected through a yearly call for submissions from Station scientists; a panel recommends finalists to the Station Director, who makes the final selections.

A managing editor and freelance writer work with the selected scientists to develop each issue. The writing is engaging, with titles like, "Sex and the Single Squirrel: A Genetic View of Forest Management in the Pacific Northwest," and "Out, Out, Dam Spot! The Geomorphic Response of Rivers to Dam Removal." Within the publication, key findings and management implications are highlighted in text boxes so they are easy to find. The PNW Research Station communications staff handles the editing and layout, and printing is done through the Government Printing Office.

Science Update

The second publication series, *Science Update*, was started in 2002. The *Science Update* is a 12-page, color, quarterly publication (fig. 3). A reader could skim it in about 5 minutes, but it would take half an hour or more to read the entire publication. Each one is a synthesis of our current scientific information related to an emerging or pressing natural resources issue in the Pacific Northwest. The Station Director and Communications and Applications Director choose the topics based on their perceptions of important or controversial issues facing forest policymakers.

The *Science Update* is managed and written by a staff writer. Each issue is a synthesis of work from several scientists, sometimes using in-press manuscripts or newly completed analysis that is still in-house. Titles suggest the synthetic or overview character of the publication, such as "Invasive Plants in 21st Century Landscapes" and "Ecosystems and People: Managing Forests for Mutual Gains." The format is highly visual, with color photos, computer graphics, tables, and sidebars, both to clarify scientific points and to make the publication more attractive. Key findings are highlighted, management implications are discussed, and the sidebars present case studies and background information. Because the publication is a synthesis and sometimes describes new work, the manuscript is peer reviewed.

Getting Scientific Information Into Discussions

Over 8,000 people receive free subscriptions to these two publications, and thousands more download them from our Web site. We distribute hundreds more copies at conferences and meetings. The more telling results, perhaps, are that key opinion leaders in federal and state agencies, leaders of nongovernment organizations, and university professors often request extra copies of particular issues, which they distribute to others at meetings, workshops, and classes. (We do not endorse particular workshops, and ask that people use the publication the way it is intended: as scientific information, not as advocacy.)

What we really want to accomplish, however, is not just to distribute thousands of copies of publications. The publications are successful only if they bring solid, relevant scientific information into natural resource discussions. Below, we discuss an example of *Science Findings* and *Science Update* publications helping deliver our science message about fire risk into public discussions.

One of the big stories in the Western United States in recent years has been fire risk in Western forests. In the winter of 2002, the Station Director asked for a *Science Updat*e on fire risk in east-side forests, which are in the dryer inland region east of the Cascade Range crest in Oregon and Washington.

The fire risk debate in a nutshell was that some people said wildfires were worse than they ever were

Frank Vanni

Figure 2—The monthly *Science Findings* keeps foresters, elected officials, and others in touch with new work by Station scientists on a wide range of research topics.

Frank Vanni

Figure 3—The quarterly *Science Update* presents credible information on controversial issues in natural resources. It stimulates thinking and provides references for indepth exploration.

before and we needed to reduce fuels in Western forests. Other people said the fuel reduction argument was just an excuse for logging. Elected officials were telling the Station Director that they wanted science information they could be sure was correct before they moved ahead with new laws and policies, and they were looking to PNW Research Station as a credible source of information.

The topic of fire risk was selected in the winter of 2002. As it happened, summer 2002 was marked by severe, persistent drought across much of the United States and turned into the West's worst fire season in years. Nearly 2.8 million ha burned, compared to a 10-year average of 1.6 million ha. Over 2,300 buildings were burned by wildfires, with another 110,000 structures threatened but successfully protected by firefighters. The 2002 fire season was especially memorable for its large timber fires. The states of Colorado, Arizona, and Oregon each recorded their largest fire of a century.

Summer 2002 was a teachable moment when people who didn't read science journals or pay attention to forestry cared about fire risk in forests. In the Pacific Northwest, the teachable moment came in July when lightning strikes started hundreds of fires, including the Biscuit Fire (fig. 4). The Biscuit Fire turned out to be the largest fire of all in a season of large fires, burning over 200 000 ha in southwest Oregon and northern California.

Our *Science Update* on fire risk came out just as the Biscuit Fire was exploding in southwest Oregon. Reporters from the *Oregonian*, the largest newspaper in Oregon, had our *Science Update* and followed up with calls to the scientists and to our communications group. On July 24, 2002, the front page of the most widely read newspaper in Oregon featured our science information showing how lethal fire severity today has greatly expanded from historical conditions.

The article used a graphic from the *Science Update*. This graphic, initially published in a peer-reviewed journal article, features one particular subwatershed in northeastern Oregon (Hessburg et al. 2000). It shows how the area likely to have lethal fire severity today has greatly expanded from the historical condition. The average flame length today would likely be high over much of the watershed, compared to average flame lengths under patchier historical conditions. The *Oregonian* article continued inside with quotes from PNW Research Station scientists and discussion of their work.

The information had gone from science journals to the front page of the daily newspaper. But it got there only by going through an intermediate publication that translated the esoteric language of journals into more accessible language and a reader-friendly format.

In August the *Oregonian* followed up with articles on the price tag of fuel reduction work and on the Station's climate change research. Other reporters saw these stories and developed their own stories. All the media coverage eventually looked at many aspects of the issues: the raging fire season, changed ecological processes in forests, fire effects on wildlife and streams, thinning treatments and effects, small-tree economics, postfire salvage, postfire invasive plants, and the effects of climate change on forests. These stories drew on recent issues of *Science Findings* as sources.

One limitation of a short, reader-friendly publication is that each issue can only tell a small part of the story. Fortunately many issues of *Science Findings* were out there, and issues of both publications continued to cover relevant topics after the summer was over, when people were trying to make sense of it all and figure out what to do. For example, a later issue of *Science Update* tackled questions about the economics of fuel treatments to reduce fire hazard and the challenges of balancing costs and results at the landscape level.

Fire risk in Western forests is one of those major natural resource issues where public understanding and discussion are crucial for progress on the ground. The *Science Findings* and *Science Update* don't lower the fire risk, but they can make a vital contribution to shaping the solutions.

Tom Iraci

Figure 4—The Biscuit Fire was front-page news in summer 2002 in Oregon. The fire's devastating effects spurred people's interest in scientific information about fire risk in western forests.

Keys to Success With Reader-Friendly Publications

The organizational context is important for a reader-friendly series of publications to be successful. First, your organization must recognize the importance of communications in scientific research. At PNW Research Station, a link between our executive leadership and our communications program was critical for the adequate investment of time and money.

Also, the reader-friendly publications must be part of an overall communications strategy that covers all the stages of the diffusion of innovations process. At PNW Research Station, a communications portfolio with multiple products helps to build awareness about new findings and ideas, the first stage of diffusion. Along with *Science Findings* and *Science Update*, the portfolio includes peer-reviewed technical publications, Web pages, CD-ROMs, and online databases.

Publications alone, however, are seldom enough to get new science adopted in everyday forest management. Personal contacts have always been and will continue to be central to the persuasion and adoption phases of the diffusion process. To meet these needs, the PNW Research Station's communications strategy includes an active program of workshops, field trips, and special events, with the involvement of many partners.

At the level of the publication series, the overall key to success is that reader-friendly publications must be consistent, reliable, and credible. The quality of the science, the writing, and the graphic design all need to be excellent (Blum and Knudson 1997). To ensure your science is accurate, work closely with scientists and get peer review of your manuscript. It's also important to get these products out on a regular schedule with consistent quality.

Other keys to success are related to audience, language, and narrative. Your decision on what audience to target matters, because audiences such as government policymakers, watershed councils, and field managers have different needs and backgrounds. At PNW Research Station, we cover only research relevant to management or to pressing natural resource issues in the *Science Findings* and *Science Update*. Because of this decision, some fascinating Station research does not get covered in these two series.

To be easily read, publications need to be written in clear language. Scientific terminology and concepts should be defined; even college-educated audiences do not know the meanings of many terms well understood inside the scientific community. Sidebars are a good place to explain basics. More knowledgeable readers can skip the definitions, and other readers will appreciate the explanation. The *Science Update* on fire risk had a sidebar defining terms such as "fire intensity" and "fire regime." You may need to address popular misconceptions about a subject. For example, in a later *Science Update* on how climate change will affect forests, a short sidebar explained what computer modeling can and cannot do. It should go without saying, of course, that words like "facilitation" and "implementation" should be eliminated.

Only essential data and numbers should be included in a publication for general audiences. The *Science Update* on fire risk did not attempt to present the extensive data from various studies on thinning treatments to reduce fire hazard, but it did present a table summarizing the principles of FireSafe forests, alongside text with additional explanation about the different types of thinning treatments and how they could be used. A "further reading" section at the end provided sources for detailed information. Although the reader-friendly publication cannot present all the complexity and nuances of a subject, it should not gloss over scientific uncertainty or overstate the evidence.

The average reader's attention span is short. Summaries, bullets, sidebars, and eyecatching photos with succinct captions are good techniques that help people find key points even if they only skim the publication. These techniques also make it easy for people to show the key points to others. Both *Science Findings* and *Science Update* begin with an "In summary" section on the first page, so that a person can find out immediately what that issue offers.

The final key to success is narrative. Reader-friendly publications need to tell a compelling story. Scientists tend to be uncomfortable with the idea that they're telling a story, but people make sense of facts by connecting them with narrative. A narrative, or a storyline, is the only way to connect data into something meaningful and significant (Cronon 1992). You will be most successful in reader-friendly publications if you get comfortable with the idea that you're telling a story. Some possibilities for narrative include telling the steps a scientist went through in finding research answers or explaining how concepts about an issue have evolved as new information has been learned.

Telling the story of a scientific issue requires moving away from journal language and toward the language of ideas, interpretation, and translation. The reader-friendly publication explains, step by step, the new understanding that emerges from the findings of individual studies. The publication should discuss the significance of the research, but avoid advocacy.

Conclusion

Policymakers, university professors, agency executives, and others have told us they use the *Science Findings* and *Science Update* publications as a key information source. For example, research on climate change and forests, management of second-growth forests, fire risk, and invasive plants has been widely distributed and discussed through these two publications. For many managers, the *Science Findings* and *Science Update* are the only PNW Research Station publications they read regularly.

Scientists whose research has been featured have been invited to present their findings to federal agency heads, state commissions, city clubs, and other groups. Media stories about science from the PNW Research Station have increased significantly since *Science Findings* and *Science Update* were started, from an average of fewer than 10 per year before 1998 to 41 in 2004, 89 in 2005, and 47 in just the first 4 months of 2006 (Sands 2006). For both publications, we've received compliments from diverse groups, including environmental organizations and timber industry groups. We feel this shows that well-explained science is appreciated by people with very different viewpoints.

Reader-friendly publications can help in getting science to people who care about forests. In a crowded world where people's needs and healthy forests are both important, this task is an important part of the communications job.

English Equivalent

1 hectare (ha) = 2.47 acres

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Reaching Out to Family Forest Owners: An Examination of Information Behaviors by Attitudinal Type

K. Julie Richter[1] and Bernard J. Lewis[2]

Abstract

Information behavior refers to a person's ongoing relationship with information; it includes a person's self-perceived information needs, information seeking, passive acquisition of information, information avoidance, and information use and transfer. The objective of this study was to describe the information behavior of family forest owners with regard to how they learn about forest ecosystems and natural resource management. A mail survey was sent to a random sample of family forest owners in the eastern Ozarks of southeastern Missouri. By using a cluster analysis, a typology of family forest owners was created based upon four sets of attitudes: reasons for owning land, landownership values, attitudes relating to collaborative stewardship, and community values. This resulted in two distinct attitudinal types of family forest owner: the legacy owner, for whom the land is a relatively important part of one's personal and family identity, and the detached owner, for whom it is significantly less important. The two types were compared in terms of demographic and landownership characteristics, management behaviors, and information behaviors. Results show that family forest owners who identify strongly with their land also tend to use significantly more sources of information to learn about their land. In addition, these owners are significantly more influenced by other people when making decisions about their woodland. Although these results are not directly applicable to family forest owners in other geographic areas, it is believed that an increased awareness of the different styles of information behavior and their connection with an owner's attitudes can lead to improved outreach and assistance for family forest owners.

Keywords: Family forest owners, information behavior, attitudinal typology, market segmentation, nonindustrial private forest land (NIPF).

Introduction

With 42 percent of U.S. forest land controlled by over 10 million family forest owners (Butler and Leatherberry 2004), reaching out to this ownership group is critically important to ensuring the sustainable management of the Nation's forest resource. It is even more crucial in Missouri, where 74 percent of the state's 6 million ha of forests are controlled by family forest owners. Previous research has examined the connection between knowledge and management behavior (e.g., Egan and Jones 1993), program participation (e.g., Nagubadi et al. 1996), and adoption/diffusion (e.g., West et al. 1988) in the forest owner population. However, studies examining the information behavior of the owners are virtually nonexistent in the literature. Information behavior refers to a person's ongoing relationship with information; it includes a person's self-perceived information needs, information seeking, passive acquisition of information, information avoidance, and information use and transfer (Case 2002, Wilson 1999). Whereas active information seeking often occurs in the event of a looming decision, information behavior is ongoing and affects not only discrete decisions but also a landowner's everyday relationship with the land. The objective of this study

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was to describe the information behavior of family forest owners with regard to how they learn about forest ecosystems and natural resource management.

Study Area

The study area lies in the eastern Ozark Highlands of southeastern Missouri, in the lower Midwestern United States. The area encompasses approximately 708 000 ha and is defined by two contiguous watersheds, namely the Upper Black and the Upper St. Francis. The reason these watersheds were chosen for the study is twofold. First, the area has a low degree of fragmentation, both in terms of property ownership and contiguous forest cover. Over 90 percent of the study area is forested, and it is part of the largest block of forest land in the Ozarks and one of the largest in the Midwest (Nigh and Schroeder 2002). Second, the level of urbanization in the study area is relatively minimal.

Methods

Survey

A mail survey was sent to a random sample of 739 family forest owners who owned at least 0.4 ha of forest land in the study area. To encourage a high response rate, implementation of the mail survey followed the principles of the Tailored Design Method (Dillman 2000). The mailings consisted of (1) a notice card, introducing the landowner to the study; (2) the questionnaire accompanied by a cover letter and a packet of eastern redbud (*Cercis canadensis L.*) seeds as an incentive; (3) a thank you/reminder postcard; (4) a second copy of the questionnaire, accompanied by a cover letter, to all nonrespondents; and (5) a third copy of the questionnaire, accompanied by a cover letter, sent by priority U.S. mail to all nonrespondents. The 12-page questionnaire consisted primarily of close-ended questions. After adjusting for undeliverable questionnaires and ineligible responses, the response rate was 54.7 percent.

Typology Creation

A typology of the family forest owners was created based on four sets of attitudes: reasons for owning land, landownership values, attitudes relating to collaborative stewardship, and community values. Each of these was addressed by a set of questionnaire items. Ordination was first used to uncover the latent attitudinal variables of interest. To determine the dimensionality of each attitude, Principal Components Analysis (PCA) was used. In this sense, ordination is a useful precursor to cluster analysis as it reduces the dimensionality of a large, complex data set and creates a smaller set of new, uncorrelated variables (the principal components) (McGarigal et al. 2000). Factors with eigenvalues greater than one were selected by using a maximum of 25 iterations.[3] For all scales yielding more than one component, Varimax rotation with Kaiser normalization was used to rotate the matrix orthogonally with the maximum number of iterations for convergence set to 25. Reliability analyses were performed on all scales by using Cronbach's alpha as a measure of internal consistency.

Weighted factor scales were constructed to score each individual on the new variables created above (principal components). In this method, the selected items for each factor are weighted by the rotated factor loadings for that item (de Vaus 2002). To adjust for missing values and avoid the loss of too many cases, the mean of each set of weighted items was used, i.e.:

Factor score = Mean of [(factor loading x item 1), (factor loading x item 2), …]

This produced a score for each respondent on each of the 12 new variables. These variables were then used to create the typology by using a TwoStep cluster analysis procedure with log-likelihood distancing. This

[3] An eigenvalue is a statistic that represents the amount of variance that is accounted for by a given component. Because each observed variable contributes one unit of variance to the total variance, components with eigenvalues greater than one account for more variance than that contributed by one variable.

resulted in two distinct attitudinal types of family forest owners. All statistical analyses were performed by using SPSS for Windows (version 12.0; SPSS, Chicago, IL).

Results

Family Forest Owners: An Attitudinal Typology

Two distinct attitudinal types of family forest owner were found, with 65.3 percent of respondents clustering together, and the remaining 34.7 percent forming the second cluster. The variable most significant in differentiating the clusters was the measure of the owners' legacy values (fig. 1). Members of the larger group tended to score significantly higher than average on the legacy index, and were therefore named the legacy owners. These owners also scored higher than average on enjoyment values, and on all of the ownership objectives: legacy and heritage, conservation, lifestyle, and utility. These owners are distinguishable by their relatively high emotional and family attachment to the land, and they are more likely to indicate that they own their land to pass on to their heirs or because it is part of their family heritage. In direct contrast to the legacy owners, the smaller group is most readily distinguished by smaller than average scores on the legacy values index. This group also scores significantly below average on all of the ownership objectives, as well as on enjoyment values and communication with other landowners. This other owner is defined by a relative lack of emotional and family attachment to the land, and family legacy is a relatively less important reason why they own the land. This group was therefore named the detached owners.

A comparison of the two attitudinal types based on demographic and land ownership characteristics revealed that there were many similarities between the groups. Family forest owners in the two groups did not differ significantly with respect to land holdings, gender, degree of absenteeism, or the proportions with urban/suburban/rural backgrounds (table 1). There was a significant difference in the proportion of farmers in the two groups, with legacy owners much more likely to describe themselves as farmers than detached owners.

Despite the demographic similarities, the two attitudinal types differed with respect to management behavior. Legacy owners were significantly more likely to have harvested trees, conducted timber stand improvement (TSI), and planted trees on their property than detached owners. They were also much more likely to describe themselves as managers. However, there was no significant difference between the groups with respect to the proportion of owners in each group who had a written management plan for their land.

Information Behavior by Attitudinal Type

Results show that family forest owners who identify strongly with their land also tend to draw on a greater variety of information sources to learn about their forest (fig. 2). Legacy owners use significantly more sources of information to learn about their land than do detached owners (two-sample Z test, $p = 0.000$). The top three sources of information for both groups were books or magazines; the Missouri Department of Conservation; and friends, relatives, or neighbors. Eight sources of information were used by significantly more legacy owners than detached owners (Fisher's exact test, two-tailed, $p < 0.5$): books or magazines; friends, relatives, or neighbors; Soil and Water Conservation Districts; logging contractors; TV, radio, or newspapers; Internet Web sites; farm suppliers or tree nurseries; and county extension educators. In addition, legacy owners are significantly more influenced by other people when making decisions about their woodland (two-sample Z test, $p = 0.000$; fig. 3). The most influential people for both types of owners were their spouses and their children; however, even these immediate relatives exerted only little to moderate influence on the primary decisionmaker.

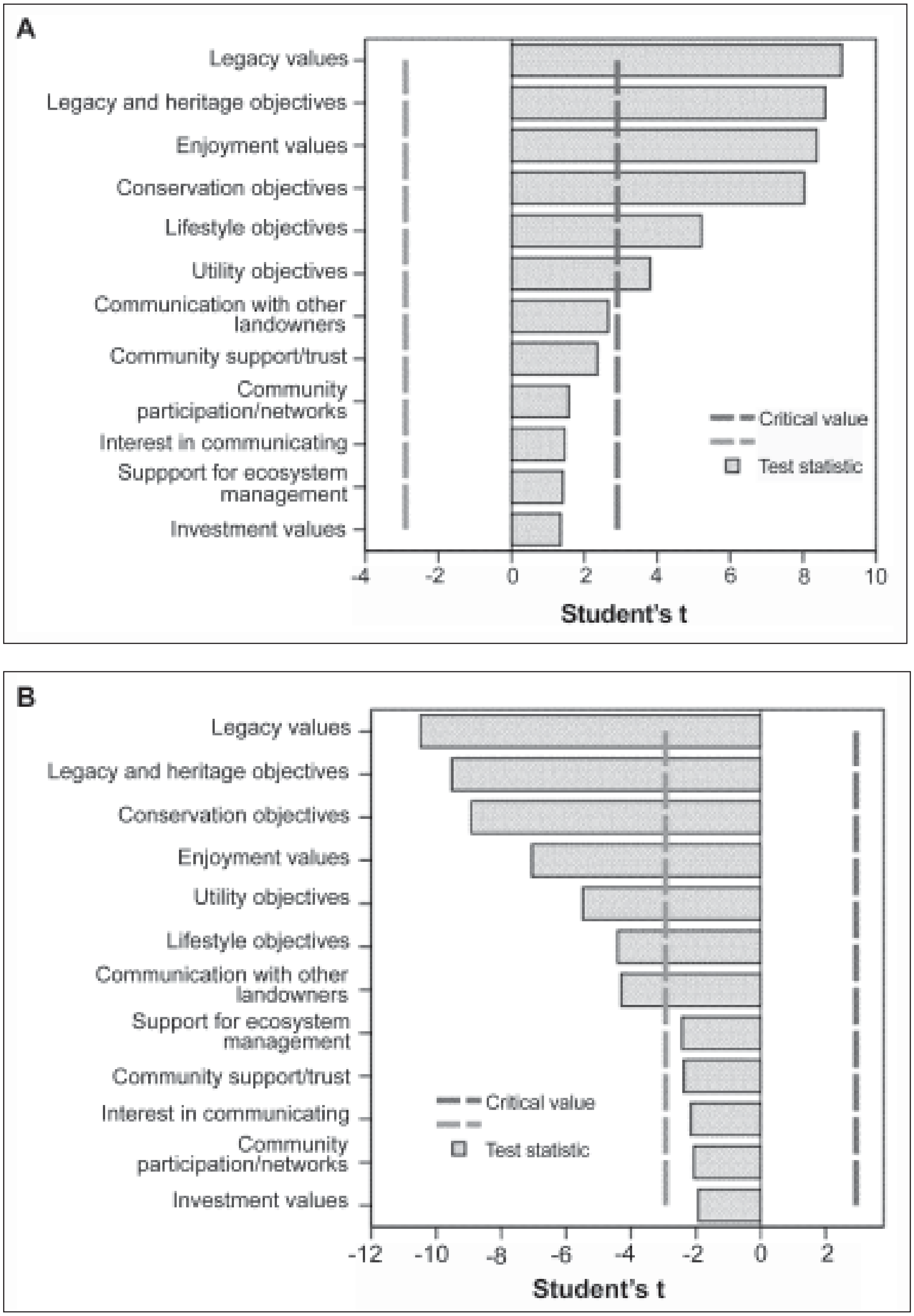

Figure 1—Students-t values for variables by cluster: (A) the legacy owner, (B) the detached owner.

Table 1—Demographic, land ownership, and management characteristics by attitudinal type

	P-value	Total	Legacy owners	Detached owners
Number		285	186 (65.3%)	99 (34.7%)
				Mean hectares
Land holdings (mean ha)	0.734[a]	75.08	72.83	79.39
				Percent
Absentee owners	0.796[b]	38.2	37.5	39.6
Past harvesting experience	0.003[b]	48.9	55.7	36.4
Past TSI experience	0.000[b]	22.3	28.8	10.2
Past tree-planting experience	0.003[b]	40.0	46.4	28.3
Self-perceived managers				
Yes	0.000[b]	65.5	75.8	45.9
No	0.170[b]	21.8	14.0	36.7
Don't know	0.157[b]	12.7	10.2	17.3
Have a written management plan	0.054[c]	3.2	4.3	1.0
Gender (percent male)		73.4	76.2	68.0
Background				
Urban		9.9	8.1	13.3
Suburban		34.6	31.4	40.8
Rural		55.5	60.5	45.9
Farmers	0.003[b]	19.9	25.0	10.2

[a] *P*-value is for two-sample Z test.

[b] *P*-value is for Fisher's Exact Test (two-sided).

[c] *P*-value is for Pearson Chi-Square (two-sided).

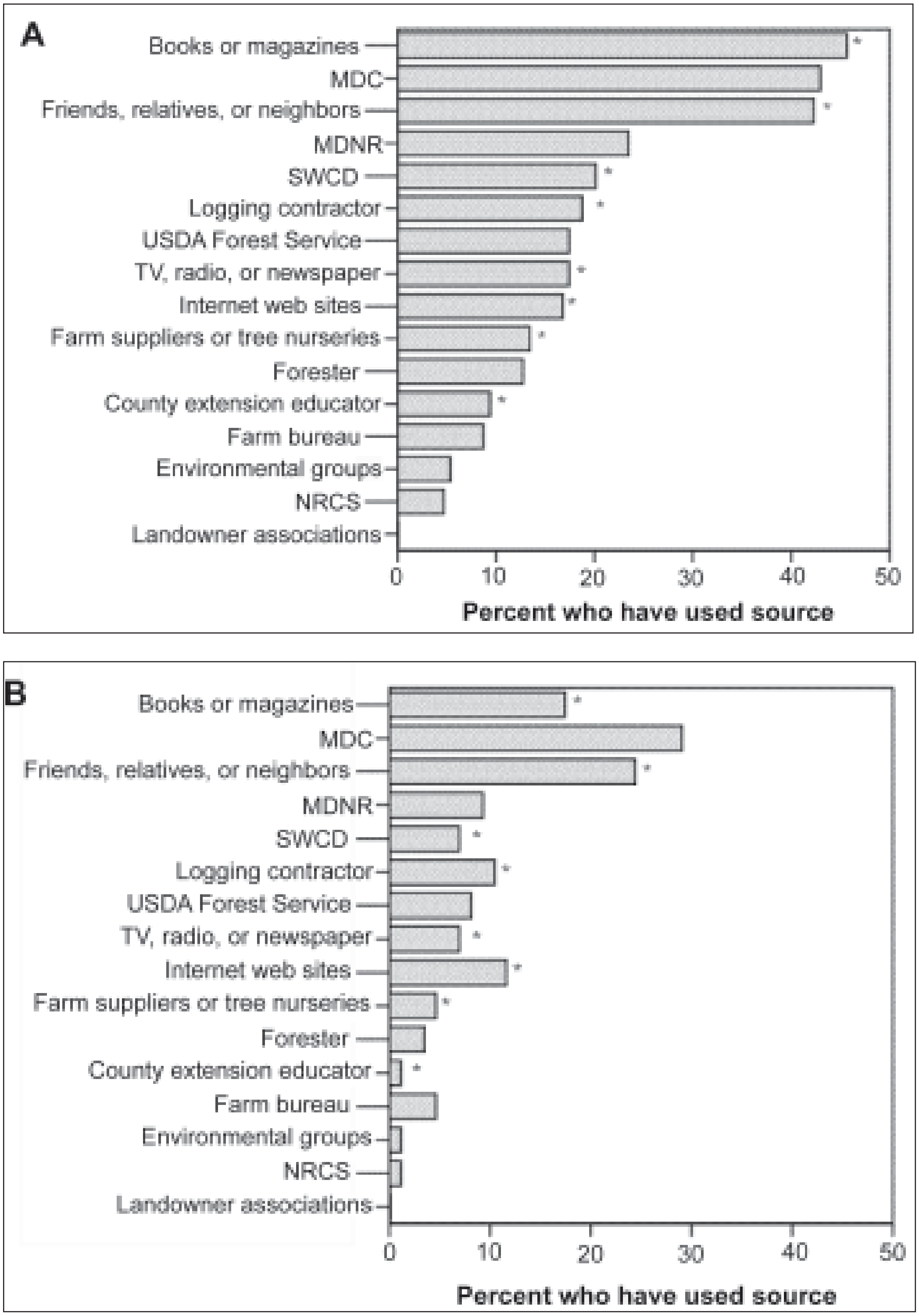

Figure 2—Sources of information used by family forest owner, by cluster: (A) the legacy owner, (B) the detached owner. Sources that are used significantly more by one type (Fisher's exact test, two-tailed, $p < 0.5$) are indicated with a *. MDC = Missouri Department of Conservation, MDNR = Missouri Department of Natural Resources, SWCD = Soil and Water Conservation District, NRCS = Natural Resources Conservation Service.

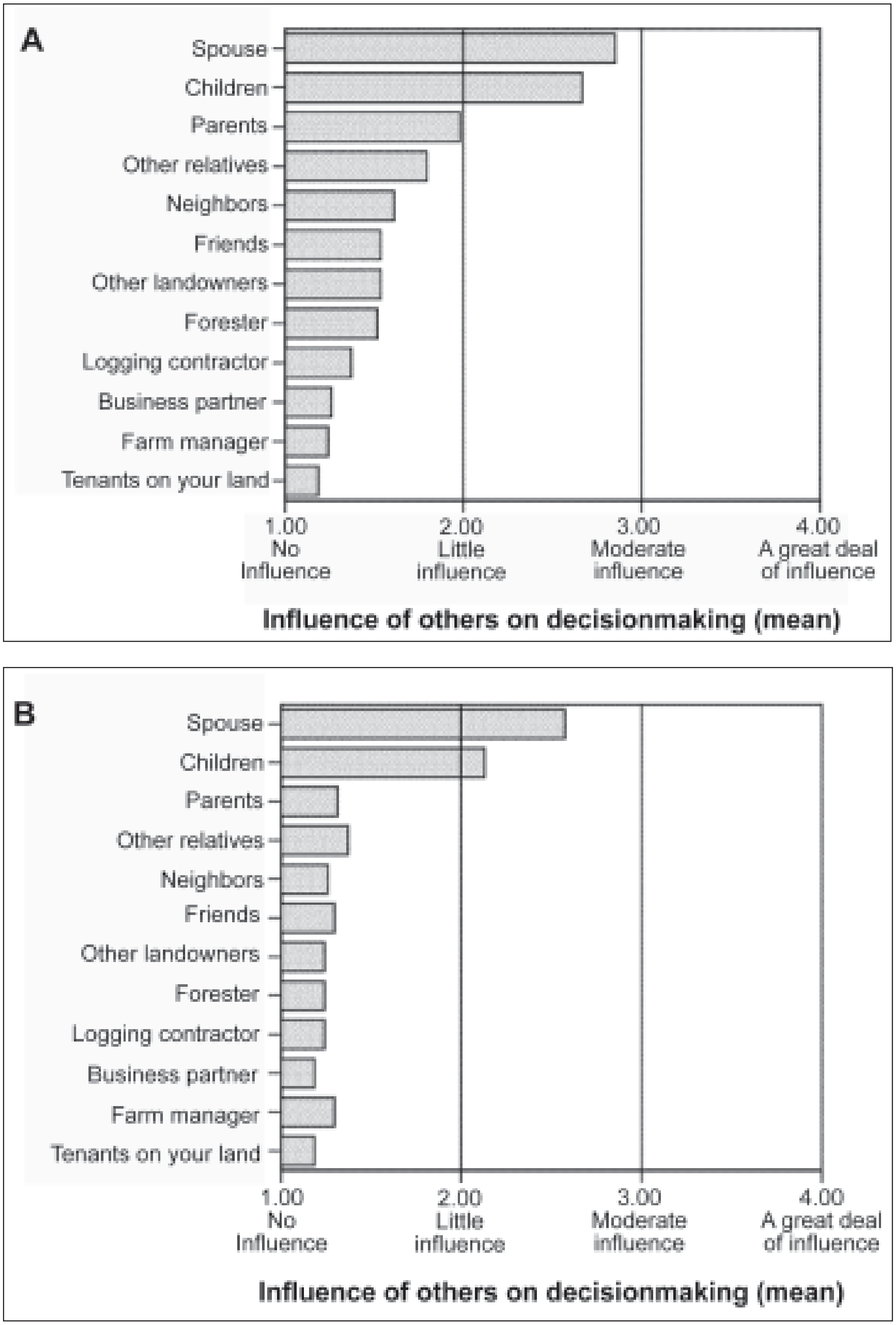

Figure 3—Degree of influence other people have on a family forest owner's management decisions, by cluster: (A) the legacy owner, (B) the detached owner.

Summary

Family forest owners in the Missouri Ozarks clustered into two distinct groups based on their ownership objectives, landownership values, attitudes toward collaborative management and community values. Legacy values and objectives were the most important factors in delineating the two groups. A large majority (65 percent) of the owners fell into the group with higher than average legacy values and were called legacy owners. The remaining 35 percent of owners had lower than average legacy values and were called detached owners. Legacy owners had significantly more harvesting, TSI, and tree-planting experience than did detached owners, and the former were more likely to see themselves as managers. However, there was no significant difference in the number of owners who had a written management plan. The two groups did not differ significantly with respect to land holdings, absentee ownership, gender, or urbanism. However, legacy owners were more likely to be farmers than were detached owners. Legacy owners did use significantly more sources of information to learn about their land than did detached owners. Legacy owners were also significantly more influenced by other people when making decisions about their woodland. Spouses and children were the most influential people for both groups.

Conclusions

Legacy values were the key dimension in separating attitudinal types of family forest owners. Family forest owners' attitudes should not be inferred based upon the size of their land holdings or their residency status (absentee vs. resident). Family forest owners who value their land for legacy and heritage reasons are more likely to be active managers. However, they are no more likely to have a written management plan. The overall use of information by forest owners is relatively low. However, legacy owners do make use of more information sources than do detached owners. The most likely way of reaching this group is books and magazines, the Missouri Department of Conservation, or the owner's friends, relatives, and neighbors. Although these results are not directly applicable to family forest owners in other geographic areas, it is believed that an increased awareness of the different styles of information behavior and their connection with an owner's attitudes can lead to improved outreach and assistance for family forest owners.

Acknowledgments

The authors gratefully acknowledge contributions from the following individuals: Amy Ross-Davis, Sean Huss, Sandy Rikoon, Mark Yates, and Jennifer Fleming. This project was supported by Initiative for Future Agriculture and Food Systems Grant no. 00-52103-9643 from the USDA Cooperative State Research, Education, and Extension Service.

English Equivalents

1 hectare (ha) = 2.47 acres

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Evaluating Technology Transfer in the Logging Industry: A Case Study With Portable Timber Bridges

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Abstract

A study was undertaken to investigate the market for new portable timber bridges, the barriers to technology transfer, and effective communication channels. The first part of the study used the "mall intercept" method to interview over 150 loggers. The second part of the research used a mail survey to over 600 technology transfer intermediaries (preidentified by loggers) in the logging industry. These intermediaries included state agencies (foresters), industry foresters, marketing professionals in private companies, officers in trade associations, and extension personnel. The third part of the study included over 20 portable timber bridge technology developers. Important sources used technology developers for disseminating technology information were identified. Also this research evaluated methods from a developers' point of view, for effectiveness in disseminating new technology information, identified factors influencing their decisions to provide new technology to the logging industry, and identified preferred intermediaries (channels) for transferring this new technology to the industry. Therefore, this research identified preferred channels of communication for transferring portable timber bridge technology in the logging industry and then identified technology transfer participant differences that hinder the transfer process.

Keywords: Technology transfer, communication channels, timber bridges, and marketing.

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Introduction

A fundamental problem in transferring technology is one of differences; differences between cultures, organizations, and individuals. It has been suggested that better methods (strategies) to overcome this problem are to reduce the degree of differences and to shorten the perceptual gaps in communication among transfer groups (Dearing 1993). Although technology developers, transfer intermediaries, and technology end-users may have different views and concerns about innovation, strategies to bridge the differences between these groups are essential to the success of any technology transfer effort. The transfer process has not always been smooth. Many technology transfer efforts between public and private sectors have been disappointing (Piper and Naghshpour 1996, Spann et al. 1995). In the past, technology transfer was viewed as a unilateral flow process (i.e., good technologies sell themselves). For example, the adoption-diffusion models developed in the 1950s (Rogers 1983). However, these models did not provide much guidance for improving or speeding up technology transfer efforts and processes (Baldwin and Haymond 1994). More recently, the subject has been heavily emphasized for marketing considerations. Yet, technology transfer processes and efforts are far more complex than most research recognizes (Baldwin and Haymond 1994). To succeed in technology transfer, it is necessary to overcome communication difficulties among groups (Irwin and Moore 1991).

Technology transfer from outside sources has been demonstrated recently in the timber bridge market. The U.S. Congress funded the Wood in Transportation (WIT) program (formally known as the National Timber Bridge

Initiative), which is administrated by the USDA Forest Service (beginning in fiscal year 1989) to help rebuild local infrastructures and increase the use of underutilized or low-value timber species for bridge construction. Since its beginning, over $20 million has been authorized for research, construction, and technology transfer of information regarding the use of timber for modern bridges (USDA FS 1995).

Objectives

- Identify transfer participants' methods of receiving and disseminating information.
- Determine the best channels of technology transfer for the diffusion of portable timber bridge technology to loggers.

Methodology

Sample Frame

To study how loggers receive new technology information, the sample frame consisted of loggers located within the eastern half of the United States. To determine if differences existed between demographic areas, four distinct demographic regions were identified. They included the East, South, Mid-Atlantic, and Midwest portions of the United States. These four regions accounted for a major portion of timber bridges that were funded by the WIT program.[3] Data from sample frame 1 (loggers) were collected by using the "mall intercept" interview method. Four logging industry trade shows were attended during May 1998 to September 1998, three in the Mid-Atlantic States and one in the Midwest. During the same period, questionnaires were also sent to several forestry-related trade associations in the Southern States and selected Cooperative Extension personnel in the New England states. These organizations agreed to request participation from loggers at logger training/education classes. These organizations returned completed questionnaires to the researchers.

A total of 158 useable questionnaires were returned and used for data analysis. Furthermore, respondents were segmented by different demographic regions and data collection locations. Eighty-nine respondents were from the Mid-Atlantic, 30 from the Midwest, 23 from the South, and 15 were from the Eastern United States. Trade shows resulted in 131 useable questionnaires, and 27 useable questionnaires were returned from different logger education or training classes. To test for non-response bias, data obtained from nonrespondents (via phone calls) were compared to data obtained from the original survey using student t-tests. No significant differences ($\alpha = 0.05$ level) were found between the two data sets, which indicated that nonresponse bias did not appear to be a problem in this case.

Important technology transfer intermediaries were identified from sample frame 1, loggers; sample frame 2 of 628 included state agencies (foresters), industry foresters, officers in forestry-related trade associations, extension personnel, and marketing managers in private companies. The list of 628 individuals (intermediaries) to be surveyed was developed from the following sources: (1) The 1997-98 North American Fact book (1997), (2) Cooperative Extension Service Personnel in Forest Management and Wood Products (Cooperative Extension Service 1995), (3) Membership Directory of the Society of American Foresters (Society of American Foresters 1997), (4) Directory of the National Association of State Foresters (National Association of State Foresters 1997), and (5) Registration List of Expo Richmond '98 Participants.[4] A mail survey was used to collect primary data from this population. Three hundred and eighty-six

[3] Cesa, E. 1997. Program manager, Wood in Transportation Program, U.S. Department of Agriculture, Forest Service. Morgantown. Personal Interview. November.

[4] Registration List. 1998. Richmond '98 Expo. Richmond, VA.

questionnaires were returned. There were 11 incorrect addresses and 6 respondents indicated that they did not interact with loggers; this resulted in 369 useable questionnaires. Respondents were segmented by different profession groups. One hundred and ninety two respondents were state agencies (foresters), 66 industry foresters, 20 trade association officers, 28 extension personnel, 42 marketing or management professionals, and 21 were other type of professionals (e.g., log buyers or land managers). The adjusted response rate was 58 percent. To test for nonresponse bias in this study, data obtained from nonrespondents (via phone calls) were compared to data obtained from the original survey using student t-tests. No significant differences (at the $\alpha = 0.05$ level) were found between the two sets of data, which indicated that nonresponse bias was not a problem in this part of the study.

The third part of the study included those individuals who have been involved in the design of portable timber bridge(s) for the WIT program (sample frame 3). A list was provided by the WIT program, which contained 20 developers. This research also added another five developers whose names were obtained from recently published reference and trade journals. Data from these individuals were collected by using a mail survey. Two respondents indicated that they were not involved in designing portable timber bridges, and four organizations indicated that the person (who we contacted) was either no longer with the organization or there was no such person in the organization (confirmed via phone calls). This resulted in 15 useable questionnaires returned (out of 19 portable timber bridge developers). Furthermore, respondents were segmented by different profession groups. Respondents were four employees of state or local government, seven university professors, two officers of trade associations, and two employees of the federal government. To test for nonresponse bias, data obtained from early respondents (returned after first mailing) were compared to data obtained from late respondents (returned after second mailing) by using the nonparametric Mann-Whitney "U" test. No significant differences (at the 0.05 level) were found between the two sets of data, which indicated that nonresponse bias did not appear to be a problem in this case.

Data Analysis

To discern for differences and problems associated with technology transfer participants in the communication flow diagram, several questions contained in each of these questionnaires were analyzed. These questions were (1) important sources in receiving (loggers), learning about (intermediaries), and disseminating (technology developers) new technology information; and (2) important factors in the decision to use (loggers), promote (intermediaries), and design (technology developers) portable timber bridge technology. These questions were all asked on a Likert-type rating scale from 1 (low) to 7 (high). Also, several open-ended questions (in each survey) were used to identify the methods needed to increase the adoption of portable timber bridge technology.

Analysis of differences and problems associated with technology transfer participants used both multivariate analysis of variance (MANOVA) and nonparametric (Kruskal-Wallis) tests to test for significant differences between technology transfer groups. Because the sample size of technology developers was relatively small, nonparametric tests are known as distribution-free tests were used because they make no assumptions about the underlying distribution of the data. The Kruskal-Wallis test was used to further analyze data under nonparametric statistic assumptions. The Kruskal-Wallis test is a nonparametric analogue to one-way analysis of variance (ANOVA). A significance level of 0.05 was used throughout the study.

Results and Discussion

For important sources in receiving (loggers, sample frame 1), learning (intermediaries, sample frame 2), and disseminating (technology developers, sample frame 3) new technology information, respondents were asked to rate which sources of communication [on the scale of 1 (below average importance) to 7 (above average importance)] were important. However, in this question, certain variables may conflict with intermediaries' role in the technology process, only loggers and technology developers were asked to rate identical variables contained in each questionnaire.

For loggers, the number one source of communication was personal contact with other loggers, followed by personal contact with industry foresters, logger education or training programs, trade shows, and trade magazine articles (table 1). For intermediaries, the most highly rated sources of communication were seminars or meetings, followed by trade shows, trade magazine articles, technical or peer-reviewed journal articles, advertisements in magazines, and personal calls from technology developers. For important sources in disseminating new technology innovation to the logging industry, technology developers rated personal calls to loggers as the number one source for disseminating new technology innovation; followed by personal calls to industry foresters, logger's education programs, trade magazine articles, and companies producing new technology (table 1).

The results indicate that end-users and developers (in the logging industry) preferred personal contact as the source for transferring technology information. However, intermediaries preferred seminars or meetings, trade shows, and trade magazine articles for learning about new technology information. Although personal contact with others is considered the best source for transferring technology information, it is expensive and time consuming. Using other sources for transferring new technology information could be more feasible than personal contact. The results also indicate that other more economical methods (sources) could be useful in the transfer of new technology information to the logging industry. They were trade shows, trade magazine articles, and advertisements in magazines. These variables were rated highly in each survey; therefore, they can be utilized to determine if differences exist between technology transfer participants.

To determine if differences existed between technology transfer participant groups, a Kruskal-Wallis test was performed. The null hypothesis tested was "There are no differences between technology transfer participant groups in terms of important sources for receiving, learning, or disseminating new technology information." This analysis resulted in at least one variable's p-value (asymptotic) being less than 0.05 (table 2). Therefore, we reject the null hypothesis and conclude that there were significant differences between technology transfer participant groups (in terms of important sources for receiving, learning, or disseminating new technology information). Followup statistical analysis was used to look for specific group differences (e.g., technology developer vs. loggers, technology developers vs. intermediaries, and intermediaries vs. loggers).

A Kruskal-Wallis test was performed to test for differences between technology developers and loggers. The null hypothesis tested was "There are no differences between loggers and technology developers in terms of important sources for receiving or disseminating new technology information." No significant differences were found between loggers and technology developers (no variable's p-value was less than 0.05) (table 2). This indicates that there were no gaps between loggers and technology developers in the important sources for receiving or disseminating new technology information. This analysis was then performed to test for the differences between technology developers and intermediaries. The null hypothesis tested was "There are no differences between technology developers and intermediaries in terms of important sources for learning or disseminating new technology information." This

Table 1—Importance of sources in receiving/learning/disseminating new technology information

Sources	Loggers (n = 158)	Technology developers (n = 15)	Intermediaries (n = 369)
Personal contact with other loggers or personal calls to loggers	5.8	6.4	
Personal contact with industry foresters	5.4	5.8	
Logger education or training programs	5.3	5.2	
Trade shows/conventions	5.1	4.6	4.8
Trade magazine articles	5.1	5.1	4.7
Sales people from companies producing and promoting new technology	4.9	5.0	
Advertisements in trade magazines or direct mail advertisements	4.8	3.9	4.0
Extension publications or newsletters	4.7	4.3	
Extension personnel	4.4		
State or regional foresters	4.3	4.1	
USDA, Wood in Transportation Program	3.8	4.2	3.1
Seminars or meetings			4.9
Reviewed journal articles			4.3
Personal calls from technology developers			3.8
Unsolicited literature			3.1

Scale: 1 (low) to 7 (high).

n = sample size.

Table 2—Communication preferences for receiving/learning/disseminating new technology information

Sources	Loggers (n = 158)[a]	Developers (n = 15)	Intermediaries (n = 369)	P-values[b]: All groups	Developers vs. loggers	Developers vs. intermediaries	Loggers vs. intermediaries
	– – – – – – – *Rating mean*	– – – – – – –					
Trade shows	5.1	4.6	4.8	0.06	0.19	0.59	< 0.01
Trade magazine articles	5.1	5.1	4.7	< 0.01	0.92	0.26	< 0.01
Advertisements in magazines	4.8	3.9	4.0	< 0.01	0.09	0.91	< 0.01
WIT program[c]	3.8	4.2	3.1	< 0.01	0.42	0.01	< 0.01

Note - Rating means (scale range 1 to 7) and n = sample size

[a] Nonparametric, Kruskal-Wallis test. Significant at $p < 0.05$.

[b] p-value multivariate T-Test (Hotelling's T2). Significant at $p < 0.05$.

[c] WIT = wood in transportation

analysis resulted in significant differences between technology developers and intermediaries (table 2). One variable, the WIT program, appears to result in group differences. Rating means for the WIT program by group were technology developers (4.2) and intermediaries (3.1). This indicates that the awareness level of the WIT program was relatively low among transfer intermediaries and intermediaries were not preferred for learning about new technology information from the WIT program.

MANOVA analysis was performed to test for differences between loggers and intermediaries. The null hypothesis tested was "There are no differences between loggers and intermediaries in terms of important sources for receiving or learning about new technology information." This analysis resulted in significant differences between loggers and intermediaries (Hotellings T^2-test = 0.12, $F_{5, 479}$ = 12.23; p-value = < 0.01). All variables are involved in group separation (table 2). This indicates that, in terms of important sources for receiving or learning about new technology information, loggers and intermediaries have quite differing views from each other. Rating means for advertisements in magazines by each group were loggers (4.8) and intermediaries (4.0). This indicates that loggers preferred receiving or learning about new technology information by reading advertisements in magazines, but this source was not preferred by intermediaries. Rating means for trade shows by each group were loggers (5.1) and intermediaries (4.8). This indicates that trade shows could be a preferred source for loggers in receiving or learning about new technology information. Rating means for trade magazine articles by each group were loggers (5.1) and intermediaries (4.7). This indicates that trade magazine articles could be a good channel for transferring new technology information to loggers. Rating means for the WIT program by group were loggers (3.8) and intermediaries (3.1). This could indicate that in terms of the awareness level of the WIT program, loggers rated the WIT program slightly higher than intermediaries. Although these variables indicate significant differences between the two groups, trade shows and trade magazine articles were ranked highly as important sources for receiving or learning about new technology information by both groups (table 2).

In summary, in terms of important sources for transferring technology to the logging industry, most differences occurred at the intermediary level, especially between loggers and intermediaries. There were no significant differences between loggers and technology developers. The awareness level of the WIT program was relatively low among transfer intermediaries, and intermediaries did not prefer advertisements in magazines as an important source for learning about new technology information. Therefore, to use the communication diagram of transferring technology to the logging industry, technology developers should notice the differences at the intermediary level.

When respondents were asked what the important factors were in the choice to use (loggers), promote (intermediaries), and design (technology developers) portable timber bridge technology, the factors (variables) in this question were environmental consideration, ease of operation, availability of design information, low cost, and regulations (table 3). Loggers indicated that the most important factor in the decision to a use portable timber bridge was ease of operation, which was followed by environmental considerations. The most important factor for intermediaries to promote portable timber bridge technology was regulations, followed by environmental considerations and ease of operation. Technology developers indicated that ease of operation was the most important factor in the design of portable timber bridges, followed by low cost (table 3).

To determine if differences existed between technology transfer participant groups, a Kruskal-Wallis test was employed. The null hypothesis tested was "There are no differences between technology transfer participant groups in terms of important factors in the choice to use, promote, or design portable timber bridge technology." This analysis resulted in at least one variable's p-value

Table 3—Communication preference in decision to use/design/promote portable timber bridge technology

Factors	Loggers (n = 158)[a]	Developers (n = 15)	Intermediaries (n = 369)	P-values[b c] All groups	Loggers vs. developers	Intermediaries vs. developers	Intermediaries vs. loggers
	– – – – – – – *Rating mean* – – – – – – –						
Ease of operation	5.9	6.7	6.0	0.03	0.26	< 0.01	0.82
Environmental considerations	5.8	5.0	6.1	0.02	0.03	< 0.01	0.21
Regulations	5.5	4.4	6.1	< 0.01	< 0.01	< 0.01	0.02
Low cost	5.4	6.3	5.7	0.13	0.71	0.09	0.12
Availability of product information	4.8	4.7	4.6	0.91	0.79	0.77	0.97

[a] Rating means (scale range 1 to 7) and n = sample size.
[b] Nonparametric, Kruskal-Wallis Test. A significance level at $p < 0.05$.
[c] p-value multivariate T-Test (Hotelling's T^2). A significance level at $p < 0.05$.

(asymptotic) being less than 0.05 (table 3). Therefore, we reject the null hypothesis and conclude that there were significant differences between technology transfer participant groups (in terms of important factors in the choice to use, promote, or design portable timber bridge technology).

Followup statistical analysis was used to look for specific group differences (e.g., technology developer vs. loggers, technology developers vs. intermediaries, and intermediaries vs. loggers). A Kruskal-Wallis test was performed to test for differences between technology developers and loggers. The null hypothesis tested was "There are no differences between loggers and technology developers in terms of important factors in the choice to use or design portable timber bridge technology." This analysis resulted in significant differences between technology developers and loggers. Three variables maximized group separation: environmental considerations, ease of operation, and regulations (table 3). Rating means for environmental considerations by group were technology developers (5.0) and loggers (5.8). Rating means for ease of operation by group were technology developers (6.7) and loggers (5.9). Rating means for regulations by group were technology developers (4.4) and loggers (5.5). This indicates that technology developers focused on low cost and ease of operation when designing portable timber bridges. End-users focused on ease of operation and environmental consideration when making the decision to adopt portable timber bridge technology.

A Kruskal-Wallis test was performed to test for the differences between technology developers and intermediaries. The null hypothesis tested was "There are no differences between transfer intermediaries and technology developers in terms of important factors in the promotion or design of portable timber bridge technology." This analysis resulted in significant differences between technology developers and intermediaries (table 3). Three variables maximized group separation: environmental considerations, ease of operation, and regulations. These results were identical to the differences between loggers and technology developers. Rating means for environmental considerations by group were technology developers (5.0) and intermediaries (6.1). Rating means for ease of operation by group were technology developers (6.7) and intermediaries (6.0).

Rating means for regulations by group were technology developers (4.4) and intermediaries (6.1). This indicates that technology developers focused more on design, but intermediaries focused more on environmental and regulation issues when making their decisions to promote portable timber bridge technology.

Conclusion

This research identified that there were significant differences between transfer participant groups in terms of important factors in the choice to use, promote, or design portable timber bridge technology. Loggers and transfer intermediaries reported that environmental considerations and ease of use (and regulations for intermediaries) were the most important factors in the choice to use and promote portable timber technology. However, technology developers focused on low-cost design and easy-to-use products for the industry. Portable timber bridge promoters should consider using both of them as promotional tactics (environmentally-sound and user-friendly product) to increase the utilization of promote portable timber bridges. For important sources in the transfer of technology information in the logging industry, this study indicates that personal contact is the most preferred source among transfer participants, followed by logger education or training programs, trade shows, and trade magazine articles. However, there were significant differences between transfer participant groups, and most differences occurred at the intermediary level, especially between loggers and intermediaries. There were no significant differences between loggers and technology developers.

In summary, the results of this study indicate that differences at the intermediary level (e.g., between intermediaries and loggers, intermediaries and technology developers) may be the major transfer obstacles in the communication diagram. And the differences found in this study may be one reason that the adoption process of portable timber bridge technology has been slow. A model (fig. 1) was developed to indicate the preferred

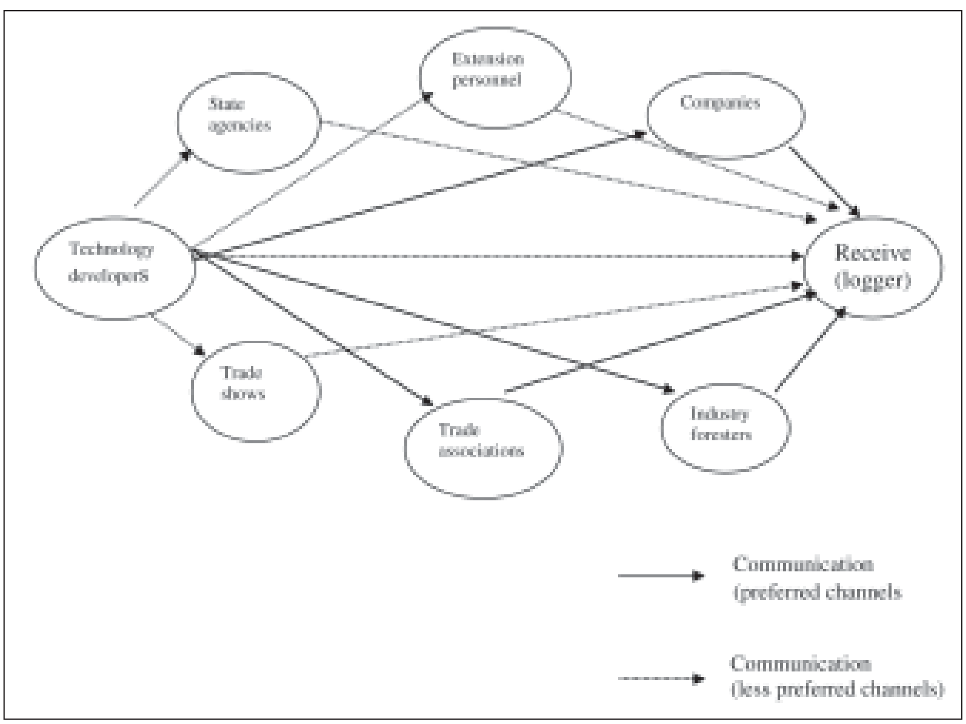

Figure 1—Preferred communication flow for technology transfer in the logging industry.

paths for technology transfer to the logging industry. It illustrates that direct contact with company foresters, industrial forester, and trade associations were the most effective methods of reaching loggers with new portable timber bridge technology.

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SILVAH-OAK: Ensuring Adoption by Engaging Users in the Full Cycle of Forest Research

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Abstract

Recent Forest Service Research and Development (FS R&D) logic modeling efforts focused on program delivery stated that an important precondition for effective science delivery was the engagement of users and partners throughout the full research and development cycle. The ongoing partnership among the Pennsylvania Department of Conservation and Natural Resources Bureau of Forestry, FS R&D, and Pennsylvania State University, focused on oak (*Quercus* spp.) regeneration, provides a case study of this engagement and associated successful science program delivery. This paper describes the engagement, diffusion, adoption, and expanded adoption phases of the partnership, which has changed both practice and research.

Keywords: Forest research, oak regeneration, program delivery, knowledge diffusion, knowledge adoption.

Introduction

The USDA Forest Service seeks to improve delivery of high-quality, relevant, research information and services to policymakers, managers, and other stakeholders in useful ways. From June through December 2004, representatives from five research stations, the Forest Service Research and Development (FS R&D) Washington office, Northeastern Area State and Private Forestry, and the National Forest System met to develop a logic model that would help provide a framework and strategy for improving program delivery. The logic model provides a logical chain that links desired outcomes to performance measures.

Working over a 6-month period under the guidance of a consultant, the team identified results (end outcomes, intermediate outcomes, activities, and measures) to guide successful program delivery of research products and tools. Feedback on the draft logic model was gathered during a 1-day meeting with external stakeholders. The final draft Logic Model[5] identifies the desired end outcome for Forest Service program delivery efforts as, "FS R&D results are adopted to improve sustainable management and use of natural resources." One strategy (or intermediate outcome) essential to achievement of this result is,

"Users, partners and interested people are engaged throughout the entire research and development cycle in:

- identifying information, research and delivery needs;
- setting research and delivery priorities;
- planning program delivery;

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[5] U.S. Department of Agriculture, Forest Service. 2004. Forest Service R&D Program Delivery Logic Model as of 21 Dec 2004. Unpublished document. On file with: North Central Research Station Headquarters, St. Paul, MN 55108.

- disseminating and supporting the use of FS R&D products."

The case study reported here demonstrates how engaging users in the full cycle of research enhances the likelihood that FS R&D results will be accepted and implemented by practitioners in the field to enhance sustainable management and use of natural resources.

Background

For several decades, regeneration of oak in mesic forests has been a principal challenge for managers interested in sustainable forestry (Crow 1988, Gottschalk 1983, Lorimer 1993, Miller and Kochenderfer 1998). In Pennsylvania, these concerns have been exacerbated by heavy deer (*Cervidae* L.) browsing in some parts of the forest (Hough 1965, Leopold 1943). About half of Pennsylvania's 16 million acres of forest land is occupied by mixed-oak (*Quercus* spp.) forest types (Alerich 1993) that depend on the presence of seedlings that are well-established in advance of harvest for successful regeneration. Data collected in conjunction with the 1989 inventory of Pennsylvania forests suggested that regeneration of desirable oak species was severely limited. Fewer than 10 percent of the sampled oak/hickory (*Carya* spp.) stands had sufficient advance regeneration of desirable species, including oaks, to ensure perpetuation of these species after a disturbance at high deer density, and only 27 percent met the criteria at low deer density (McWilliams et al. 1995).

Faced with these challenges, the Pennsylvania Department of Conservation and Natural Resources Bureau of Forestry (PA BoF) approached the USDA Forest Service Northeastern Research Station (NERS) to develop adaptive decision tools for improving representation of oaks in regenerating mixed-oak forests. About 15 years earlier, NERS produced the SILVAH computerized decision-support tools (Marquis and Ernst 1992) and training sessions (Marquis et al. 1984, 1992), which the PA BoF found useful for sustainable management of northern hardwood forests. In 2000, PA BoF sought cooperation to strengthen the applicability of SILVAH to mixed-oak forests. They provided funding to support these efforts. The joint NERS–PA BoF work on oak regeneration is a good example of how engaging users in the full cycle of the research process can facilitate adoption of research products.

Initial Steps

Designing a Collaborative Workshop

Discussions between the PA BoF and NERS resulted in a decision to begin strengthening SILVAH's approach to mixed-oak forests with a collaborative workshop for scientists and forest managers in January 2000. The PA BoF selected several of its managers, some partners in the private sector, and several scientists at Pennsylvania State University (Penn State) who were working on a related project. Scientists from two research work units in NERS also invited managers from the Allegheny National Forest.

The dates for the workshop were selected collaboratively, to maximize participation by the intended "experts." The PA BoF arranged for a meeting room and supported the travel of all its personnel and some members from the private sector; participants from NERS, the Allegheny National Forest, and Penn State were supported by their own institutions.

The goals of the workshop were to review the underlying structure of the SILVAH approach, to brainstorm ways to synthesize and integrate existing research into that framework, and to identify and prioritize research needs.

The Workshop

The agenda for the workshop emphasized participation and collaboration. One short presentation at the beginning of the first day described the SILVAH approach. The remainder of the agenda was organized around questions that needed to be answered to adapt the SILVAH approach to mixed-oak forest types. Participants received these questions in advance of the meeting. These included a series of questions to elicit a strategy for assessing regeneration assets and barriers in advance of harvest, another series of questions that would frame the types of goals for which prescriptions would be offered within the SILVAH-OAK system, and a third series of questions that linked specific silvicultural activities to goals and conditions.

The SILVAH program (Marquis and others 1992) functions as a stand-level decision and planning tool. It relies on data from systematic inventories of current overstory and understory conditions and user-defined constraints and objectives to suggest prescriptions designed to sustain existing tree composition, favor optimal tree growth, and promote successful natural regeneration. Use of a systematic, research-based decision-support tool like SILVAH ensures that managers' decisions are based on consistent and comprehensive inventory data and analysis principles. In our experience, this increases the confidence that managers, their agencies, and their "clients" have in the prescription outcomes.

Of principal interest in the SILVAH-OAK development work were understory inventory and analysis techniques and regeneration prescriptions. SILVAH relies on a "stocked plot" concept (Marquis and Bjorkbom 1982) for understory inventory.

Much of the existing oak regeneration research, on the other hand, relied on dominance or success probabilities. Landmark studies conducted by Sander (1971) and Loftis (1990) estimated the probability that seedlings and stump sprouts would successfully emerge as dominants or codominants many years after a regeneration harvest based on site quality and preharvest size. Brose and Van Lear (1999) documented substantial differences among different size classes of oak seedlings in terms of their response to the release treatment of prescribed fire.

The question-based agenda provided an excellent context for expert knowledge from both researchers and practitioners to add to results of existing research. For the question, "What is a countable seedling?" (i.e., one that has a positive probability of contributing to regeneration success), the answers included, "Nothing smaller than 6 inches tall makes it on my District," and "Loftis (1990) says that only seedlings with basal diameters greater than 0.5 inches have even a 10 percent chance of becoming dominant, and Sander (1971) says that seedlings smaller than that can't keep pace with the rest of the stand."

The group synthesized expert knowledge and research results into the SILVAH framework in two key steps. First, they recognized that dominance probabilities and stocking criteria are conceptually inverse. As seedling size and dominance probability increase, the threshold number of seedlings needed for probable success decreases. Second, they recognized that stocking criteria would need to be developed for different size classes of oak seedlings to allow users to easily recognize situations that call for treatments to enhance seedling competitiveness.

In addition to these adaptations of research conducted elsewhere, the experts developed a consensus on appropriate ways for SILVAH-OAK to address familiar Pennsylvania regeneration challenges: overabundant deer and interfering plants. Pennsylvania forests have suffered the impact of overabundant deer since the late 1920s (Hough 1965, Redding 1995), and NERS scientists have completed extensive research documenting deer impact on regeneration processes in Allegheny hardwood forests (deCalesta 1994, Horsley and others 2003, Marquis 1981, Marquis and Brenneman 1981, Tilghman 1989). SILVAH incorporates these research results in the form of a deer impact index, with values ranging from 1, for very low, to 5 for very high (Marquis et al. 1992). The experts gathered in January 2000 relied primarily on managers to define a key breakpoint for SILVAH-OAK; oak regeneration could not develop successfully or become competitive outside a deer-excluding fence at high (4) or very high (5) deer-impact index levels. The team also had to interpolate stocking criteria for different deer impact levels.

Although the probabilities of dominance research reflected the reality of competition among woody species, commercial and noncommercial, it did not reflect the mix of woody interfering plants found in Pennsylvania, nor did it reflect the importance of hay-scented ferns (*Dennstaedtia punctilobula* L.) and New York ferns (*Thelypteris noveboracensis* L.) (Horsley 1991). The importance of these ferns in interfering with the survival, establishment, and growth of desirable seedlings was known to be a secondary effect of deer overabundance (Horsley et al. 2003) and needed to be incorporated into the SILVAH-OAK framework.

At the insistence of managers attending the meetings, participants recognized explicitly the different levels of difficulty associated with regenerating oaks on xeric, relatively poorer sites versus more mesic and productive sites. Managers find it much easier to retain oak as a significant component of stand composition on xeric sites where few of oak's woody competitors are as successful as oak at withstanding severe site conditions. On more mesic sites, however, species such as red maple (*Acer rubrum* L.) or yellow-poplar (*Liriodendron tulipifera* L.), whose early aboveground growth greatly exceeds that of the oaks, can cast such dense shade that oak seedlings don't survive and grow.

The products of the workshop were a list of research needs, a chart reflecting the group's consensus on stocking criteria for different classes of oak seedlings (varying with deer impact index and site class), and a prescription framework for Pennsylvania mixed-oak stands.

Refinement, Diffusion, and Early Testing

In the subsequent months, NERS scientists, led by Patrick Brose, refined the approach outlined at the January 2000 meeting and translated the rough-cut workshop results into a preliminary set of inventory procedures and prescription charts. Brose developed tally sheets and inventory instruction sheets that would ensure that the data collected in understory inventories would match with the workshop's consensus stocking criteria. He translated the prescription framework ("Under what circumstances is prescribed fire appropriate? Under what circumstances is a deer-excluding fence needed?") into a family of decision charts driven by data collected in the inventory. He and other NERS scientists developed training materials related to the inventory and the decision charts. The NERS, PA BoF, and Penn State collaborated to design a 1-day workshop to share the inventory processes and decision charts with the PA BoF staff. Penn State provided a computer-equipped classroom in State College, and PA BoF managers, working with Brose, selected sites for practice inventory exercises.

In June 2000, more than 90 PA BoF foresters participated in the workshops, which successfully diffused these refinements of the January workshop throughout the PA BoF and to other land management organizations. The workshops launched a growing season "beta test" of SILVAH-OAK. The sessions included hands-on practice with the inventory procedures and the prescription keys in addition to presentations explaining the ecological principles and research results that formed the underpinnings of the new system. Other forest managers also participated in the sessions, as there was already widespread interest in adopting the system.

In the same way that users of new computer software are asked to "beta-test" the software by applying it to their work, managers who attended the workshops were asked to use the system in their inventory and prescription development work throughout the summer and to record what worked and what didn't. In particular, managers were skeptical of the suggestion that within each inventoried stand, they should check the relationship between root collar diameter and height for oak seedlings. Sometimes, especially in stands with high or variable deer impact in the recent past, shorter seedlings had developed strong root systems without gaining in height, as a result of deer browsing. These seedlings might have the appearance of belonging to one class of oak seedlings, but actually belong to another, researchers suggested (see Brose and Van Lear 1999). SILVAH-OAK developers asked managers to "beta-test" the inventory procedure that included checking this relationship and report back in the fall.

Further Refinements and Adoption

In late fall of 2000, representatives from each PA BoF District that had participated in the beta testing met with NERS and Penn State scientists to report results and further refine the SILVAH-OAK system. This workshop was planned collaboratively by PA BoF and NERS and organized and financed similarly to the January 2000 workshop. Most of the beta-testers were pleased with the new inventory system, and particularly agreed that investigating the stand-specific root collar diameter/seedling height relationship was worthwhile. They were more critical of the preliminary prescription charts. Specifically, some managers suggested that less complex prescriptions would result in successful oak representation in regeneration on the most xeric sites.

After the workshop and the feedback from the practical, field-based beta testing, substantial improvements were made to the prescription charts, but little change was made to the inventory system. The PA BoF adopted SILVAH-OAK as its standard operating procedure for prescription development in mixed-oak forests, and NERS scientists began to focus on integrating the new system into the SILVAH computerized decision-support tool and designing and installing the studies intended to close the knowledge gaps identified at the January 2000 meetings.

Related Research

Pennsylvania law allows the Bureau of Forestry to allocate up to 10 percent of the receipts from timber sales to activities designed to ensure successful regeneration of final-harvested sites on Pennsylvania state forest land (the 2.1 million acres of public lands administered by the PA BoF). A later law explicitly empowered the bureau to make investments in forestry research. The PA BoF has established a process to review regeneration projects and research proposals to determine needs and justify the allocation of funds. In the years since the January 2000 meeting identified knowledge gaps in our understanding of the oak regeneration process in Pennsylvania, studies have been initiated to close those gaps (table 1). Funding for many of these studies is provided by PA BoF Forest Regeneration Fund and Forestry Research Fund. Most of these studies are located across Pennsylvania's ecoregions on state forest land, and substantial in-kind support is provided by forest managers where the research studies are installed. Additional funding or in-kind support comes from the Allegheny National Forest, the Pennsylvania Game Commission, and the Connecticut Agricultural Experiment Station. For projects investigating the role of fire and fuel reduction activities in Pennsylvania forests, the Joint Fire Science Program is an important funding source.

The PA BoF also has funded a related suite of studies through Pennsylvania State University, based on data collected in operational regeneration treatments conducted on PA BoF stands. Kim Steiner, Jim Finley, Marc McDill, and their graduate students are principal investigators in these studies, focused primarily in the Ridge and Valley ecoregion. These studies have suggested that in some circumstances, survival and importance of small oak seedlings in Pennsylvania is better than suggested by research in other oak regions. Peter Gould, one of the graduate students on this team, developed a model that predicts third-decade oak stocking from understory data collected prior to a harvest treatment, and SILVAH-OAK incorporates this model to provide a tool for deciding whether to undertake actions to increase the proportion of oak in new stands.

Table 1—Studies initiated to close knowledge gaps identified by managers and researchers at the SILVAH-OAK workshop in January 2000

Study title	Principal investigator	Funding	Objective
Oak seedling and sprout dominance and survival probabilities as influenced by site factors and environmental classification	Gottschalk (USDA FS NERS[a])	PA BoF[b]	Develop Pennsylvania-specific probabilities to help validate the SILVAH-OAK stocking criteria.
Root development study	Brose (USDA FS NERS[a])	PA BoF[b]	Document the rate of root development in black, chestnut, northern red and white oak seedlings at light levels created in 3-step shelterwood harvest sequence.
Development of regeneration in two-age stands	Miller (USDA FS NERS[a])	PA BoF[b]	Determine the impact of a residual age class on the development of regeneration after 2-age harvests.
Mountain laurel study	Brose, Schuler (USDA FS NERS[a]), Ward (CT AES[d])	JFSP[c]	Determine the impact of silvicultural treatments on mountain laurel, considered a hazardous fuel by Joint Fire Science Program. Mountain laurel also interferes with the establishment and growth of oak regeneration.
Fire behavior/Fuel models study	Brose (USDA FS NERS[a])	JFSP[c]	Evaluate the effectiveness of standard hardwood fuel models for predicting fire behavior in mixed-oak forests and modify the models as necessary.
Administrative study of shelterwood-burn technique	Brose (USDA FS NERS[a])	ANF[e]	Test the local applicability of the shelterwood-burn technique developed in Virginia by Brose and Van Lear.
Northern red oak seedling response to forest liming	Brose, Long, and Horsley (USDA FS NERS[a])	PA BoF[b]	Determine the response of planted red oak acorns to 0, 2, 4, and 6 tons per acre of pelletized dolomitic limestone with and without deer exclusion.
Preharvest seedling development as influenced by light and competition	Gottschalk (USDA FS NERS[a])	PA BoF[b]	Determine what silvicultural are necessary to develop competitive advanced oak regeneration.

[a] USDA Forest Service Northeastern Research Station.
[b] Pennsylvania Department of Conservation and Natural Resources Bureau of Forestry.
[c] Joint Fire Sciences Program.
[d] Connecticut Agricultural Experiment Station.
[e] Allegheny National Forest.

Expanding Adoption

After a full year of operational use of SILVAH-OAK on state forest land, interest in adoption on other lands was increasing, as early adopters and developers shared news of the new program, primarily by word of mouth. In addition, use of the program increased interest in continuing education on oak ecology and silviculture, tied to the SILVAH-OAK system

Scientists and managers involved in development of SILVAH-OAK developed a week-long training session on the SILVAH-OAK approach and the underlying ecological principles with land and resource managers, modeled on the SILVAH training for Allegheny and northern hardwood forests offered by NERS scientists since 1978. The SILVAH-OAK course was first offered in autumn 2002. Attendees were hand-selected from a variety of management organizations to "beta-test" the training sessions. Detailed, day-by-day, lecture-by-lecture evaluations were solicited and received from participants, and the sessions were modified to reflect this input. Lecturers included scientists and managers. The sessions contained a combination of lectures, field tours, and exercises so that participants collect inventory data, practice using the decision charts, mark treatments in mixed-oak stands, and visit sites from several of the ongoing research studies. Since the "beta-test" training session, the session has been offered four additional times in Pennsylvania to about 120 participants from state and federal land management agencies, nongovernmental organizations, forest industry, and consultants. It has become a fixed feature of the Pennsylvania forestry calendar.

In 2004, organizers of the continuing education program for certified foresters in West Virginia approached the SILVAH-OAK team about offering the training there. At first, the West Virginia organizers were skeptical that people unfamiliar with extended silvicultural training would voluntarily participate in a week-long session, so the first year's training in West Virginia consisted of two 2-day sessions in 2004, attended by people from all organizations within the forestry profession in that state and several adjoining states. The sessions were very well received, and in 2005, the SILVAH-OAK team offered a 5-day session in West Virginia. Subsequently, a forester from The Nature Conservancy in Ohio who attended the first Pennsylvania training session approached the development team about expanding SILVAH-OAK to Ohio conditions. In 2005, the team held a meeting there to explore the potential for developing an invasive plants module within the SILVAH framework and to adapt SILVAH-OAK for use in Ohio.

Increasing demand for the SILVAH-OAK training is exceeding our capacity to conduct the training and continue to conduct research. Experience with the SILVAH training for northern and Allegheny hardwood forests, however, suggests some solutions. First, we have learned that if demand is high enough, people and agencies will find ways to address barriers such as out-of-state training bans. Already, most SILVAH-OAK training sessions have attendees from multiple states. Second, the training has rewards for the scientists who participate. As scientists spend a week together for the training sessions, they have numerous opportunities to review new and potentially contradictory results from each other's ongoing research, stimulating better collaboration and rapid integration of new results into the SILVAH framework. Equally important, the training sessions provide ongoing collaboration and feedback from users, who report emerging ecological issues as well as direct feedback on the SILVAH-OAK framework as a management tool.

In addition to the ongoing training, we have been integrating the SILVAH-OAK inventory, analysis, and decision-support tools within the SILVAH computer program. The SILVAH-OAK software will analyze inventory data, provide narrative and tabular reports of current conditions, provide a narrative description of the recommended prescription and marking guides for any partial cut, and provide a summary of the path through the decision charts dictated by the inventory data. Use of the computerized tool makes application of the SILVAH-OAK process easier. An interim computerized tool that analyzed SILVAH-OAK inventory data was released to PA BoF personnel in 2003, and software with complete SILVAH-OAK capabilities, including prescription generation, will be released soon. In addition, a Forest Service General Technical Report describing the SILVAH-OAK approach to inventory, analysis, and prescription and its ecological and research underpinnings is in preparation.

Our long-term goals include full integration of the research results from Penn State research projects with the SILVAH-OAK research into an integrated and fully field-tested approach to sustainable management of mixed-oak forests appropriate throughout the central Appalachian region. This framework is flexible enough to integrate new research results from the ongoing studies as they become available.

Lessons Learned

The SILVAH-OAK experience represents an excellent case study of user involvement in the full cycle of research and development (table 2), as suggested by the Forest Service logic model for program delivery. Beginning with a collaborative effort among managers and scientists to synthesize and adapt existing literature to a specific management challenge, this effort has led to collaborative identification of priorities for new research and for research to confirm results obtained elsewhere. It also has led to collaborative development of training and computerized program delivery tools. Equally important, it has led to changed practice in land management in mixed-oak forests, and all participants will watch future monitoring data and Forest Inventory and Analysis data to determine whether and to what extent these changed management practices result in improved outcomes on the ground.

Participants in this process agree that the collaborative nature of the effort increased the ease with which it was adopted by land managers. Successful collaboration between scientists and managers leads to improved appreciation of the different demands of the two groups' responsibilities. Land managers have to learn patience with the scientific process and the time it takes to complete a scientific investigation. We have found that it is particularly difficult for land managers, who must manage land in whatever condition they find it, to be patient with the process of selecting research sites that minimize sources of variability extraneous to the topic of the research. We also have found that scientists who collaborate with managers come to an increased appreciation of the pressures under which land managers work and of the benefits of even preliminary research results to land and resource managers.

This case study also shows that success breeds success. The NERS success with SILVAH for northern and Allegheny hardwoods made this a desirable framework for solving the oak regeneration challenge. The success of SILVAH-OAK in Pennsylvania makes it an attractive vehicle for work on similar problems in West Virginia, Ohio, and other regions of the mixed-oak forest.

This case study of ensuring adoption of research results by engaging users in the full cycle of research and development was started well before the Forest Service Research and Development Logic Model for Program Delivery. But the success of the SILVAH-OAK effort validates the Program Delivery Logic Model. We have learned that when managers and scientists collaborate with mutual respect, both research and management are improved. Specifically, an integrated framework for applying research results helps assure an internally consistent approach to land and resource management challenges, and collaboration with managers increases the likelihood that research studies will address priority management challenges and facilitates acceptance and implementation of results by practitioners in the field.

Table 2—One strategy for improving adoption of research results in the Forest Service Research and Development Program Delivery Logic Model is "Users, partners, and interested people are engaged throughout the entire research and development cycle…" This strategy lists four elements of research and development in which user involvement is suggested. This table shows those four elements and the ways in which PA BoF was involved with Forest Service R&D in each of those elements during the SILVAH-OAK research and development cycle.

Intermediate outcome (or strategy) 1:"Users, partners and interested people are engaged throughout the entire research and development cycle in:	
a: identifying information, research and delivery needs	PA BoF[b] asks NERS[a] to adapt SILVAH to help manage mixed-oak forests.
b. setting research and delivery priorities	PA BoF[b] and NERS[a] hold Jan. 2000 workshop to adapt existing research to SILVAH-OAK and identify knowledge gaps for research.
c. planning program delivery	PA BoF[b], NERS[a], and Penn State offer SILVAH-OAK training for field beta-testing, June 2000.
d. disseminating and supporting the use of Forest Service Research and Development products.	PA BoF[b] adopts SILVAH-OAK as its standard operating procedure for mixed oak forest management, cosponsors annual training sessions for forest managers.

[a] USDA Forest Service Northeastern Research Station
[b] Pennsylvania Department of Conservation and Natural Resources Bureau of Forestry

Metric Equivalents

1 acre = .405 hectares (ha)

1 ton per acre = 2.24 tonnes or megagrams per hectare

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Communication During the Research Process: Experiences Within Tropenbos International's Country Programs

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Abstract

That research could provide important information for forest management and governance is a statement that probably nobody would argue. The concept is good: use the knowledge, methods, and techniques that scientists develop to solve problems that people in society encounter. Then, why is it that we still see a gap between the research community and those who need the information? This case study demonstrates different approaches as used in the different Tropenbos International (TBI) country programs to promote uptake and application of research results.

To facilitate the identification of problems, TBI starts a country program with an elaborate program development process. This process is to ensure research that addresses the information needs of policymakers, forest managers, and users. The TBI-Ghana brings stakeholders together in focus group discussions. These meetings provide a forum where researchers can present research results and identify forest-related information needs.

The TBI has also undertaken many activities to facilitate information dissemination. Info sheets, a multimedia campaign in Indonesia, videos in Ghana, and an exhibition in Colombia were good ways to reach a broad audience.

An important conclusion that can be drawn from TBI's experiences is that communication does not only come in at the end of a research project, but it is important throughout the whole research process. Different activities were undertaken to facilitate this process. Developing a blueprint appeared not to be possible, but this article may be a source of inspiration for effective means to break the research-policy barrier.

Keywords: Communication, information dissenination focuses group discussion.

Introduction

Tropenbos International (TBI) is an international non-government organization (NGO) that aims to improve tropical forest management for the benefit of people, conservation, and sustainable development. It holds a vision in which knowledge and skills play a central role in improving forest governance and management. Four critical elements jointly constitute the strategy that TBI uses to achieve its mission (Tropenbos International 2005).

- Adequate, relevant knowledge and information needed to make better decisions on forests are available (by means of research).
- National human capacity is available to generate knowledge and to use it (by means of training and skills building).
- National forest sector organizations are able to manage and apply information (by means of institutional development).
- National mechanisms are operational for the exchange of information (by means of fostering multistakeholder knowledge dialogue).

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Only a limited amount of information and knowledge generated through research is translated into better forest policies and management. The TBI's experience is that promoting uptake and application of research results goes beyond information dissemination. The results of irrelevant research will not be applied even if the results are communicated well. Communication between the researchers and the problem owners like policymakers and forest managers is crucial throughout the whole research process. Communication is important at the initial stage to identify the problems, during the research process to keep stakeholders involved, and at the final stage to disseminate research findings (fig. 1).

Communication plays an important role in improving the interaction between researchers and stakeholders in all stages of the research process and improved interaction is crucial to uptake and application of research results. This case study demonstrates the different approaches, as used in the different TBI country programs, to achieve the same goal of realizing better forest governance and management based on knowledge and skills.

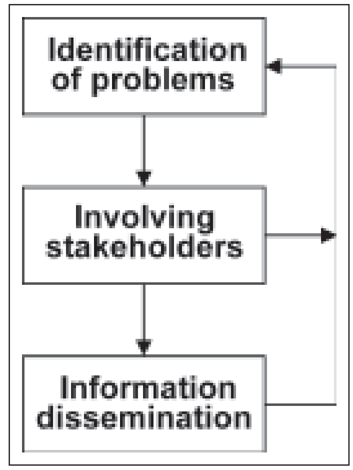

Figure 1—The role communication plays in all stages of the research process.

Identification of Problems

Realizing improved forest governance and management based on knowledge and skills starts at the beginning of the research process. The TBI's philosophy is that research, capacity, and information can work for good policy and management, if the research, in its conception and implementation, pays due respect to the needs and aspirations of forest users, managers, and policymakers.

Program Development Process

Country programs are TBI's prime means of achieving the TBI mission. Each country program starts with a thorough program development process. The aim of this process is to shape a program based on information and capacity needs of a country.

This approach has gradually evolved from TBI program development experiences in the past and is currently being applied in the Suriname Program. The principal elements of the program development strategy are outlined below (Tropenbos International 2004).

Draft an issues paper—
An "Issues Paper" outlines issues and challenges facing the forest sector and identifies their information component and their relevance for TBI's strategy. The most efficient approach is to base the issues paper on existing documentation (such as forest policies, national forest programs, etc.) that has been produced by using consultative processes and to verify and validate that information by means of stakeholder consultation. The information component and its translation into possible research questions are validated by the research community.

Map the structure of the forestry sector—
An institutional scan gives an inventory of the structure of the forest sector and identifies who is responsible for the generation and application of information. Capacity needs are identified. The institutional scan can be incorporated into the issues paper.

Form Bi-National Committee (BNC)—
Key decisions on scope and priorities of the program are made by the BNC. The BNC must take account of stakeholder views and the issues paper.

Organize stakeholder consultations—
Appropriate stakeholder consultation ensures that program objectives match the priorities of forest users and policymakers. "Appropriate" implies that the timing and scale of consultation is planned to achieve optimum benefits of consultation and avoid the pitfalls of raising unachievable expectations and obtaining unfocused short-term wish lists. Inputs (issues identification) by forest managers and policymakers are separated from inputs (research responses) by the scientific community. This is to avoid science-driven research agendas as TBI aims applied and demand-driven research.

Send out a call for proposals—
The research community is invited to submit research projects that match issues prioritized by the BNC by means of a "restricted call" for proposals. The rationale is to balance the needs of attracting innovative research with those of creating firm partnerships, achieving capacity building and institutional development goals within the limitations of restricted budgets and time-consuming application procedures.

Draft a multiannual plan—
The multiannual plan must be seen as a component of a country strategy, i.e., the view by TBI and its partners on the state of information in the forest sector, with priorities and strategies to address the main issues. More than a description of the content of the program, the multiannual plan provides context, focus, and direction for further development of the country program.

Focus Group Discussion

The TBI-Ghana brings stakeholders together in focus group discussions. The aim of the focus group discussion is to facilitate two-way communication. The TBI-Ghana identifies a topical forest-related issue, invites experts or stakeholder representatives for a presentation followed by a discussion. These meetings not only provide a forum where researchers can present research results and identify forest-related information needs, they also enable stakeholders to understand each other's points of view.

Based on the experience of TBI-Ghana gathered in the four meetings so far, TBI-Ghana drafted guidelines for successful focus group discussions (Nketiah et al. 2004).

Identify key societal forestry issues—
These may be issues on which different opinions, especially those held by different interest groups, are paraded as facts or issues that are considered delicate and are therefore not openly discussed. They could also be contentious issues that need to be subjected to critical analysis or debate. For each issue, the objective of the discussion should be very clear and shared by the participants from the start.

Select a facilitator or moderator—
A good facilitator or moderator should be independent and perceived as neutral. The person should also be able to focus the discussion to achieve the set objectives.

Identify resource people to prepare discussion papers—
Such papers provide factual information from credible or authentic sources, but could also present the view of a stakeholder group (i.e., position papers).

Ensure quality papers and presentations—
A resource person is selected for his/her expert knowledge on the topic and therefore a high-quality paper can be expected. It is important to brief the presenter about the kind of forum and the kind of participants that are expected. This is to ensure the relevance of the paper and the presentation for this specific forum and, in case the presenter is a scientist, to avoid a purely scientific presentation. Presentation guidelines sent in advance will contribute to the relevance of the paper.

Select a representative group of participants—
The participants must represent the different stakeholders involved and the representation must be balanced. These

may include opinion leaders and key actors. If one group dominates, the outcome of the discussion could give a wrong impression.

Ensure an effective followup—
Followup activities are essential if the effort is not to remain a "talk shop": just an exchange of opinions. At TBI-Ghana, the focus group discussion is followed by proceedings, and at least one info sheet on the topic and possibly a research project if the participants indicate that further research is necessary. The proceedings of the discussions should be prepared promptly and, where necessary, relevant extracts prepared as tailor-made information for important target groups. To this end, a team of rapporteurs may be appointed to cover the discussions.

The focus group discussions have proven to be a good activity to facilitate communication among many stakeholders. The fact that several organizations are involved and the combination of different tools—the discussion, publication of the proceedings, and info sheets—make this activity very helpful in establishing the links between researchers and stakeholders. Researchers have presented (intermediate) results to a relevant and interested audience, and the discussions served as input for some research projects.

Involving Stakeholders

An interactive process of problem identification that has resulted in relevant research projects is not a guarantee for application and uptake of research results. During the research project, it is important to involve partners who may eventually use the generated information. Involve partners in such a way that they feel it is their project. One of the constraints identified is that researchers do not always see the importance of sharing information or sometimes they lack communication skills. The participatory research approach that characterizes TBI-Colombia and communication trainings as given in Vietnam and Ghana illustrates efforts to improve integration of research and communication.

Participatory Approach

The Colombian dialogue of knowledge—
From academic research toward a knowledge dialogue with local indigenous people in the Colombian Amazon-

At TBI-Colombia, research is not only a matter of students and researchers, but also of indigenous people and nature conservers like national parks. Everybody needs to participate actively in the project, and therefore needs to agree on the objectives. The TBI-Colombia's participatory approach aims to involve all relevant stakeholders in the research process. Interaction between the academic and the indigenous approach is what TBI-Colombia calls the "Dialogue of Knowledge," based on respect and thoughtful listening.

Lessons Learned

Make the different interests explicit—
The interests of all partners should be clear in the project proposal, so that people participate in a project that they feel is theirs. Local initiatives, ideas from the field, and a bottom-up approach are most effective and should be listened to.

Work with local people as coinvestigators—
In many cases, it is possible to work with local people as coinvestigators. This enhances the integration and creates a relationship of trust. The local people often have their own way of investigating, and this certainly is another important source of knowledge, complementary to the academic way of doing research.

Set up an investigation working group—
To organize participatory research it is recommended to form a committee or working group with representatives of all stakeholders: e.g., the state forest or nature conservation unit, the local people, and, eventually, other groups. This working group can deal with research questions, set priorities, and look for funding possibilities. It also enhances the communication between the different participants and forms a bridge through which research is facilitated.

Define research lines—
To link the different research projects, the definition of research lines can be helpful. Research lines define a framework, in which future projects can follow former ones and form a first criterion for the acceptance of project proposals. This could be done by the committee or working group.

Communication—
During the whole process, communication plays an important role. The inter-institutional working group or research committee provides a platform where ideas on research can be exchanged and where questions and answers are formulated. During the research project, there is generous contact between the researchers, local people, and stakeholders, because this will be necessary for the final stage of the project, when the results have to be implemented. Frequent workshops, even when the final results are not yet ready, help to formulate adequate answers that serve the local society and the nature conservation organizations. Communication is the basis for a flexible approach: each time the researcher gets in contact with a stakeholder, he gets input to adapt his approach to society's questions.

Communication Training

During a TBI-Vietnam workshop in Hue in central Vietnam in October 2002, the head of the national Forestry Science Institute of Vietnam roughly estimated that currently only around 5 percent of the forestry research results are applied in practice. The main communication problems were perceived to be limited information dissemination capacities and the limited awareness of the importance of information sharing. TBI-Vietnam therefore provided communication trainings for forestry-related organizations.

The aim of the communication training was to strengthen the capacity of key forestry organizations in the field of information dissemination, developing communication tools and presentation skills, and to raise their awareness about the importance of sharing information. The target groups were local stakeholders in Hue (governmental and NGOs in the agricultural and forestry sector) and the Vietnamese TBI-Vietnam research partners.

Based on the experiences and lessons learned from the communication courses given in Vietnam and Ghana, a set of guidelines is given below.

Overcome language barriers—
A challenge in giving communication trainings in Vietnam was to overcome the language barrier. The communication officer worked closely together with a Vietnamese translator and together they developed the English and Vietnamese training materials for 3 modules and provided 11 training courses. The participants gave their presentations in Vietnamese so it was difficult for the Dutch communication officer to assess the content of the presentation. Therefore, she first trained the participants in evaluating each other's presentations, with a special focus on structure and content. The communication officer mainly concentrated on evaluating the body language and the general impression. The participants had the chance to practice their own presentation skills, but also learned how to evaluate each other and give constructive feedback.

Include interactive exercises—
It is essential to offer practical exercises and interactive modules during the training. Listening to a trainer may be interesting, but experiencing the effect of a practical example is a much more powerful tool to convince trainees. They will remember these practical or visual experiences, sometimes even years after the training. Practicing with case studies, especially those brought in by the participants themselves, gives the trainees the opportunity to immediately apply the theory and models in their work. They learn how to use what they just learned, and if they face any problems, these can be discussed and solved with the support of the trainer.

Create clear links—
Communication training becomes livelier if cases and examples are used that participants can identify with. It is therefore recommended to start with a discussion in which participants tell what kind of communication problems they experience during their daily work. Any problems or challenges they mention can be referred back to during the training. Communication with minorities who speak their own local languages was, for example, an issue for some participants. The multilingual training courses made clear, that with improvisation and good communication tools, clear communication is possible also in situations in which people do not speak the same language.

Use a multimedia mix—
A mix of media such as PowerPoint slides, handouts, background reading materials, and group exercises with case studies were used during the courses. The different means supported each other in getting the message across. It's also useful to bring extra literature or (visual) examples to the training, in case the participants are interested in learning more about the topic.

Ensure followup—
Apart from the paper and training materials handed out to the participants, it's useful to provide a CD with all materials in order to facilitate the participants or the hosting organizations to continue the communication training activities with their own local trainers who have attended the communication course.

Information Dissemination

Even if problem identification and the research process has been an interactive process, efforts need to be made to translate research results into improved forest management and policy. Once relevant information has been generated, it is still an art to create tailor-made information and get it to the right people or to reach a broad and relevant audience.

One can imagine that a policymaker or forest manager may not have the time to read a voluminous research report, the language might be too technical, or they may not immediately see the use of the information. Some extra effort may be needed to get the information accepted by the people who could use the information. Info sheets, exhibitions, videos, and a multimedia campaign illustrate the different approaches as used in the different country programs. A description of each approach and the lessons learned are described below.

Multimedia Campaign "ULIN"

"Ulin," named after the local timber ironwood, is initiated by several organizations from the environmental sector in East Kalimantan, Indonesia, to increase awareness and to improve the understanding of the current status and use of East Kalimantan's environment. The specific objectives are to:

- Inform and increase awareness of decisionmakers and major players about the current status and use of the environment and the environmental consequences of decisions taken by them.
- Increase knowledge of environmental issues within educational institutes.
- Increase awareness and knowledge of environmental issues of the general public.

The target group of the campaign consists of decisionmakers in the government (provincial, district, and city), the private sector, education institutes, NGOs, and the general public of East Kalimantan. Since the start of this campaign, eight themes have been covered; forestry, social forestry, watershed management, coastal resource management, conservation (twice), rehabilitation, and illegal logging.

Several tools are used in this media campaign such as fact sheets, roundtable discussions, radio programs, TV talk shows, and the newspaper. Every month an environmental theme is selected and highlighted for the month by using several media. This theme is selected by an editorial board on the advice of a group of experts/ stakeholders. The editing board consists of 14 people from NGOs and media.

After selecting the theme, a roundtable discussion with stakeholders and experts for that specific issue takes place. The roundtable is a high-profile discussion to search for more indepth information and explore the different opinions and views on the issues. The participants are representatives from government, private companies, NGOs, universities, and the press. On average, between 20 and 30 people attend a roundtable discussion. A special fact sheet is distributed in advance to the participants and the press, who also attend the roundtable. This fact sheet serves as kickoff to discuss the theme, and several have already been published by local newspapers in East Kalimantan.

Outcomes of the roundtable discussions have been discussed during radio broadcasts, and after each roundtable, several radio programs related to the theme are broadcast via the local radio. Once per month an "Ulin" talk show is broadcast on local television. For these talk shows, experts and stakeholders are invited to have a live discussion on television. During each talk show, the audience and people watching at home can ask questions.

Each month is concluded with a special four-page "Ulin" section in the local newspaper (the Kaltim Post) providing news, background information, opinions, and interviews on the theme. The section consists of articles, news items, interviews, and book reviews covering a wide range of aspects of the theme. On the back page, contact details are mentioned where people can give their feedback.

Video

In Ghana, videos are used to inform the target audience about a project, about project results, and the whole TBI country program in Ghana. The combination of moving images, sounds, and text makes the tool very appropriate for this goal. Videos are used in three ways within the TBI-Ghana country program. One project video has been created about the interdisciplinary and intercultural student project. It is shown to students to raise their interest to participate in the project, and to possible project partners. Videos have also been used to facilitate the bottom-up information flow from forest-fringe communities to forest managers and policymakers and to show during meetings to identify areas for collaboration.

Combination with other activities—
If the target audience is expected to undertake steps after seeing the video, it is better to show the video in combination with a meeting or workshop.

Write a script—
It is important to get the aim of the video straight, what the desired impact is, and who the target group is. The best way to integrate this information into the video is to write a script and define which excerpts should support the core message.

Choose the appropriate length of the video—
The most effective duration of the video depends on how it is used. In the case of the TBI-Ghana where the videos are used in meetings or dissemination workshops, the ideal duration seems to be not more than 10 minutes.

Maximize impact—
The combination of moving images, sound, and text increases the impact of a message significantly.

Info Sheet

The aim of an info sheet is to present tailor-made information in an attractive and easy-to-read format to promote uptake and application of research results. Especially its high adaptability, and therefore the suitability to make the info sheet tailor-made for defined target groups, is seen as an important factor for its success. Within TBI, info sheets are often used in combination with other activities such as focus group discussions or radio and TV programs like in the multimedia campaign. They are produced in different languages, depending on the country and event in which they are going to be used. For that reason, the possible cultural or language barriers are minimized. Info sheets are created on request (i.e., for a specific meeting) but also to proactively provide information to partners or interested parties.

Ensure appropriate content—
In terms of content, the info sheet must:

- Contain information based on high-quality and sound research results, stakeholders' consultations, processes, or any other reliable source.
- Be relevant for decisionmaking in terms of forest policy and sustainable forest management.
- Be in line with TBI's mission and vision.
- Give information tailored to address real, local, or international information needs.

Use an attractive format—
Regarding the format, the info sheet should:

- Be easy to read and understand for relevant target groups and stakeholders different from scientists and researchers (nonscientific language).
- Have an attractive format for the reader.
- Be easy to circulate as hard and soft copy.
- Have high adaptability to different target groups.

Interaction researcher-communication officer—
A constraint in the production of info sheets is that researchers sometimes find it difficult to write easy-to-read text for stakeholders outside the scientific world. The communication units play an important role to support, and sometimes to write, the text for the info sheets.

Use its high adaptability—
The advantage of an info sheet is that it can be easily produced and therefore is suitable to be tailor-made for defined target groups and to address many topics.

Exhibition

TBI-Colombia has developed a set of communication tools to facilitate a dialogue between academic and traditional knowledge and to promote the uptake and use of information and knowledge by policymakers and forest managers, including indigenous communities and the National Park Service of Colombia. The tool described below is an exhibition about feathers and crowns.

The aim of the exhibition was to raise awareness among the general public about indigenous people: the way they live and the challenges they meet. The exhibition would further help to establish a dialogue of knowledge between indigenous and nonindigenous people in Colombia.

In the last few years, indigenous communities have prepared a wealth of drawings and written documents illustrating their knowledge and beliefs just waiting to be shown to a bigger audience. Based on the experience of TBI-Colombia, some guidelines can be given for a successful exhibition.

Choose the right theme—
An important factor for success is picking the right theme. It should be a theme that has been worked on (by indigenous researchers) for a long time, which is thoroughly known and has "traditional values," which touches the people. The relation between the theme and natural resource management is important, and the theme should have a high aesthetic value. One of the exhibitions by TBI-Colombia was on feathers and crowns. The traditional crowns have been used for ages. The crowns have a symbolic value and are a reflection of their society. The link with forest management is clear: the crowns are made of feathers of parrots and other colorful birds; therefore, you have to know where to find these and how to collect them without damaging the birds. The theme pointed out the relation between indigenous people and their role in sustainable forest management.

Find the right occasion—
Another success factor is finding an occasion where the target group likely visits the exhibition. The feathers and crowns exhibition was presented at a fair in Bogota, which is held every 2 years and receives a lot of visitors. Having an exhibition in the capital, where most people live, is an advantage. The fair has its own publicity and public relation channels that work well, so there was no need to worry about logistics, about where people could park their car or who would be at the entrance to sell the tickets. The public has a broad interest in research-related themes.

Give background information—
Another factor of success might be that the senders of the information, the indigenous people, played an active role in the elaboration of materials and the presentation during the exhibition. This strengthened the message that was sent. However, the distance between the indigenous culture and the more "western" culture of Colombians necessitates a translator. Sometimes contextual or historical topics are so logical and clear to the indigenous people that they forget that without this context, other people don't get the message. A cultural translator has to paint a décor, a context.

Conclusion

The TBI has shared an example of different tools that have been developed in four continents to bridge the gap between the research community and problem owners such as policymakers and forest managers. Each communication activity contributed in one way or the other to this objective. There is no blueprint for transferring scientific information to different stakeholders and vice versa. Based on the experiences gained in the different communication activities, three conclusions can be drawn:

- In each communication activity, a combination of tools seems to be most effective. The examples of the multimedia campaign in Indonesia and the focus group discussions in Ghana combined with info sheets and proceedings seem to have a high impact through the combination of tools and the involvement of several organizations.
- To ensure that the researchers' priority receives the attention it deserves, a full-time staff position for communication in organizations aiming to link research to policy processes is highly recommended.
- The most important conclusion of all is that the research process and research organization needs to be reorganized in order to improve uptake and application of research results. Communication must be integrated to all phases of the research process. From proposal to the use of research results, communication plays an important role. Also during the research project, there should be generous contact between the researchers, local people, and stakeholders, because this will be necessary for the final stage of the project, when the results have to be implemented. Communication is the basis for a flexible approach: at each phase, the researcher gets input to adapt his approach to society's questions.

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Public Ideas and Local Policy in Urban Forestry: Reflections on a Program of Portable Science

Kathleen L. Wolf[1]

Abstract

The status of urban forestry is still at the "public idea" level in many communities, evolving to become policy in some municipalities. Planning for trees in the midst of high-density human settlements entails a complex mosaic of land use conditions, diverse stakeholders, and institutional practices. Many research outreach efforts address practical urban tree management practices. Policy-oriented technology transfer is also needed, as local decisionmakers may not be adequately informed of the benefits and functions of trees in cities. Policy outreach focuses on "why" rather than "how" concerning trees in cities. This paper features reflections-in-action about a policy-oriented technology transfer program. Key approaches are described such as (1) audience identification and access, (2) character and content of informational tools, (3) information dissemination practices, and (4) the role of "problem pioneers" and "champions." These efforts would benefit from formal appraisal and assessment, helping to refocus the program and provide insights for other similar programs. Specific evaluations might include (1) development of performance guidelines for print materials, (2) methodologies for tracing and tracking diffusion pathways, (3) monitoring the performance of technology transfer efforts in terms of innovation adoption, (4) focused assessment of "problem pioneer" and "champion" activities and influences, and (5) opportunities for integrating this outreach program with other similar efforts considering potential efficiencies and synergies.

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Keywords: Urban forestry, policy, public ideas, technology transfer, innovation diffusion.

Introduction

Urban forests are "green infrastructure" systems that provide many public goods, and may include patches of native forests, street trees, park groves, and any other trees growing on public or private property. Extensive research has demonstrated environmental, community economics, and psychosocial benefits (Dwyer and Schroeder 1994, Kuo 2003, Wolf 2005). Such benefits are best achieved through comprehensive planning and management of urban trees and forests. Yet many U.S. communities conduct urban forestry work on an ad hoc basis in reaction to citizen complaints or emergencies, rather than in a proactive, systematic way.

Policy guidance is needed to address the complexity of urban forest conditions and implement best practices in a systematic way. Policy development and adoption can be difficult. Urban forestry touches the lives of many community groups. Planting and managing trees in the midst of high-density human settlements entails acknowledgment and involvement of diverse stakeholders.

Technology transfer is essentially a communication process through which the results of scientific research are put into use (Eveland 1987). Urban forestry research has addressed "how" to sustain trees in cities (such as planting and pruning practices) and the reasons "why" communities should invest in an urban forestry program (such as benefit/costs analysis).

This paper presents the products of a social science research program that has focused on "why" local governments should consider and adopt urban forestry policy. The research has addressed the values and interests of urban stakeholder groups that may not be fully aware of the benefits and functions of trees in cities. Such groups may have significant influence with local decisionmakers.

Urban forestry policy outcomes are the result of interactions of community values, stakeholder perceptions, and political solutions. This paper first provides background on public ideas and the role of science, then describes outcomes of an extended urban forestry technology transfer program, and ends with recommendations for future research.

Public Ideas and Policy

Forestry has a long tradition of technology transfer, often associated with extension systems of universities and research stations. Technology transfer serves as a mechanism for dispersing new ideas, and subsequent adoption is dependent on complex cultural and interpersonal processes (Rogers 2003).

Many technology transfer efforts are aimed at economic optimization by landowners or industries through production enhancement, efficiency gains, and costs management. Urban forestry, on the other hand, is rarely a revenue-generating enterprise. It is a "public idea" that can potentially guide public action for the purposes of improved community health and welfare (Moore 1988).

The ideas that matter to communities and organizations are those that first conceptualize or frame a problem, then articulate solutions, often focusing on a subset of all possible strategies. Public ideas can give coherence and meaning to organizations (including local government), and guide investments for the future (Moore 1988). With regard to science, public ideas often set out the questions for which evidence is necessary.

There are many examples of well-established policy concerning systems or institutions that generate public goods but started as innovative public ideas: lighthouse installations, seatbelt laws, pollution abatement, and emergency response systems. Public ideas span various geographic scales and locations. They also differ in the degree to which they involve capital investment or individual behavior change. Some policies that originated as public ideas maintain their relevance as time passes; others are replaced by emergent innovations.

Change agents may be able to move public ideas to broader acceptance through careful analysis and strategic action (Moore 1988). Important steps include (1) diagnosis of what is already in place and its precedents, (2) respect for existing ideas and policies and the circumstances of their earlier adoption, (3) being able to clarify how existing or old ideas are limited, (4) communicate new ideas (though complex) in a straightforward and practical way; and (5) careful judgment of the capacity of the new idea to significantly improve existing systems.

In many locales, urban forestry is a public idea, with varying degrees of transition to policy. Most research on the study of innovation diffusion has focused on adoption of tangible products or processes, often focusing on the individual consumer as the unit of analysis (Owen et al. 2002). In contrast, a significant amount of urban forestry technology transfer efforts are aimed at addressing the large-scale needs of environmental and social systems of communities.

There has been little research to understand how effective such R&D efforts have been and their causal relationship to adoption of urban forestry innovations. Social systems complicate the science-to-policy process, but attention to this dimension is essential for effective information transfer (Spilsbury and Nasi 2006). Particular challenges include (1) diversity of change agents and adopters, (2) political jurisdiction types and geographic scale, (3) varied governance and decisionmaking mechanisms, and (4) diversity of professional disciplines within local government and their associated networks of technology dispersal (planners versus engineers, for instance).

Science Contributions

There is a strong, though often indirect, relationship between science and public ideas. Public ideas entail public deliberation and, if adopted, then action. Science is often the source of innovative ideas and practices. Science can inform public debate, providing models of how a community should deal with an issue or delineating a range of practical actions to fulfill public choices of desired outcomes.

Scientists and technology managers often underestimate the difficulty of the technology transfer process. Technologists may think of the technology transfer process as a one-way movement of a technology from a research and development source to a receptor system of key individuals. When technology transfer occurs too slowly, it is thought to be the fault of the receptors.

Public ideas rarely become powerful based on empirical evidence and science communications alone (Moore 1988). Clear reasoning or carefully developed and interpreted facts are important, yet rarely make ideas convincing to the general populace. Rather, ideas become anchored in people's minds through illustrative anecdotes, simple diagrams and pictures, or connections with broad generalities about human nature and social responsibilities. Fact and logic can reinforce and strengthen the hold of idea but will rarely replace simpler public perceptions.

The process of sharing research results might more accurately be thought of as a communication process. Such an interactive process is two-way, with messages flowing in both directions. Individuals in a receptor organization may actively seek information about possible answers to self-perceived problems. Or they may be directed to information by issue advocates. Thus, the science transfer process is a transaction in which questions, answers, clarifications, and other information flow in both directions.

Urban Forestry Science

Forests, trees, and canopy cover are being reduced at alarming rates as urbanization continues in the United States. Actual and projected decline in extent and condition of the urban forest has been documented in many U.S. communities (American Forests 2006, Nowak and Walton 2005). Forest loss increasingly affects human health and welfare, as nearly 80 percent of the U.S. population resides in urbanized areas.

Much of the recent research in urban forestry articulates various urban environmental problems, and then illustrates how the presence of urban forests diminishes or mitigates impacts. The psychosocial significance of trees in cities has become another substantial scientific contribution. Experiences of nature are profoundly important to individuals, small groups, and entire communities (Kuo 2003).

In addition, social research has assessed the assumptions of stakeholders who are not resource managers, but whose practices impact forest resources. For instance, law enforcement officers may encourage vegetation removal within high-density residential areas to eliminate the supposed hiding places of criminals, yet analysis does not support an association of landscape planting and crime (Kuo and Sullivan 2001)

Scientific efforts will continue to address situations of perceived conflicts concerning trees in cities. The resulting knowledge can be applied to counter both public underestimations of benefits and overstatement of risks of urban trees. Yet integration of science with policy will never be as straightforward as scientists may hope for. Moore (1998) noted that, "instead of thinking of [public] ideas as scientific conclusions, we must recognize them as society's effort, groping in the dark, to help itself deal with intractable problems" (p. 83).

A Program of Portable Science

I have conducted a research program on the human dimensions of urban forestry for about 10 years during my affiliation with the College of Forest Resources at the University of Washington. Much of the science has addressed public perceptions with regard to trees in particular urban land use contexts, such as central business districts and transportation systems.

An associated policy-oriented technology transfer program has been developed. Outreach materials have been derived from my own and other sources of social science research. These portable science products are a condensed packaging of scientific results and are readily accessible by nonacademics. They are targeted to decisionmakers and key stakeholders within municipal governments and organizations.

The materials of this research program differ little from the standard practices of most technology transfer programs. The key elements are research summaries presented as fact sheets, a Web site portal that provides access to print materials, research outcomes summarized as PowerPoint presentations, and submittal of research outcomes to professional publications. Materials can be accessed at www.cfr.washington.edu/research.envmind.

Construction and distribution of the materials has been based both on theory and user feedback. Some elements and content of the technology transfer efforts were intentional and have been sustained throughout the program. Others were adaptive in that there were changes prompted by anecdotal feedback on product effects and consequences.

Schön (1983) described the knowledge-building potential of the "reflective practitioner." Knowing-in-practice can be achieved if a person makes intentional effort to reflect on what was done and learned within professional activity. Using "reflection-in-action" a self-evaluator enters an "experiment" by weighing the problem situation and the solution response. One initiates an interaction within a situation of uncertainty with repeated efforts, and with each attempt attains a greater degree of insight and understanding. This process includes an appreciation for the unintended and secondary effects of action.

Through successive actions and practices the reflective practitioner generates a capacity to understand broader actions and implications. In a "conversation" with a situation, the practitioner strives to generate ideas or artifacts that are coherent and understandable. Although the content of the outreach materials has been derived from rigorous science, I have used reflection-in-action to develop and expand the technology transfer program.

Products, Processes, and Reflections

Print products have been constructed based on theoretical principles about how people process information. Early work in cognitive psychology suggests that people actively retain five plus-or-minus two information bits. Although readers and viewers can certainly understand greater content complexity, chunking the content into a small number of categories enables both comprehension and memorableness. Thus, all fact sheets are organized by about five ideas (using headings and subheadings), and primary messages are graphically highlighted. Web site content is likewise "chunked" into topics that are readily distinguished. This telegraphs major content to viewers and conveys an informational structure that may be retained.

My social science research typically involves extensive collaborations with urban stakeholder organizations and key informants, such as nonprofit directors, urban planners, and community development specialists. These relationships provide insights for technology transfer. The language and presentation of outreach materials is crafted to coalesce with the communications norms of professional cultures (such as business people or transportation officials). Thus the outreach materials depart from the standard scientific article format. Results and conclusions often precede a brief overview of methods. Statistical outcomes are used to highlight key findings. Practical applications are featured. All material is presented in a graphic format that is visually appealing and readily understood. A balance of scientific tone and readability is pursued in order to project scientific credibility yet acknowledge the needs of various reader audiences.

The Web site serves multiple functions. The main page displays a comprehensive outline of my entire research program. Each research subarea has been prepared as a separate page so that public requests for information can be referred to a distinct Web portal. Print materials—fact sheets, higher quality professional publications and scientific articles—are downloadable as PDF files. Associated Web sites and information sources are linked, enhancing both the substantive content of the messages and the credibility of a small-scale research program.

I strategically share outreach products to enhance their position in policy situations. Strategies have included (1) announcements in professional list serves and organization membership lists, (2) submittal of research notes to professional publications, (3) requests for placement of my Web links on related Web sites, (4) mailing or e-mailing new publications to people or organizations known for their high level of networking activity, and (5) inclusion of Web access information in all my presentations or meeting announcements.

The emergence of transfer pathways beyond my primary efforts has been quite interesting. Fact sheet and PowerPoint content has been adapted to secondary publications by professional and advocacy groups. Maintaining the fidelity of the scientific information can be a challenge as newsletter and trade publications editors may not understand the scientific derivation of fact bits. Some authors or editors will corroborate with the source, others rely on the clarity of the source materials for accuracy. Of particular concern are the tertiary publications, as second-generation interpretations seem prone to inaccuracy or overstatement.

It's been said that technology transfer is a body contact sport. Technologies are transferred through interpersonal networks (Valente 1994), and the nature of these networks, in large part, contributes to effectiveness of technology transfer.

Rogers (2003) articulated phases of the innovation adoption process. Agenda setting is the first formal stage and is the process whereby organizations seek innovations to cope with a problem. Agenda setting is typically followed by matching, redefining/restructuring, clarifying, and routinizing processes. Public ideas may precede agenda setting as communities take some time to recognize and frame incipient problems, such as those associated with trees and forests in cities. If a public idea concerning urban forestry matures into a policy response within local government, then other science-based sources provide implementation guidelines.

My research appears to be used to promote the public idea of urban forestry, and for local agenda setting. My initial efforts in technology transfer involved creating products. As products moved into use, my outreach activity expanded to include stakeholder interactions.

"Problem pioneers" are individuals that perceive a problem that is not only new, but is destined to be important to an entire field or the community at some time in the future. They are often ahead of their time, and feel compelled to address a problem before others either detect it or recognize its significance (Patton 2002). Local problem pioneers are often the initiators of uptake of my research outreach, and later either become champions or recruit others to endorse urban forestry.

"Champions" are influential agents in the science-to-policy transfer. Rogers (2003) defined a champion as a charismatic individual who provides enthusiastic support for an innovation, thus overcoming indifference or resistance. Champions may occupy key positions or have other means of influence. They are often respected as opinion leaders both within their organizations and in their extended professional networks. They typically demonstrate well-honed interpersonal and negotiating skills in working with other people.

Problem pioneers and champions throughout North America have accessed print materials or sponsored travel for public presentations in order to initiate public dialog about urban forestry in their communities. I have made presentations to city councils, planning commissions, municipal agency staff, community service groups (such as Kiwanis), and business organizations (such as Chambers of Commerce). These personalized presentations appear to magnify the influence of the scientific data, owing to interpretations that connect to local conditions and social circumstances.

Proposed Research

My formal research program has addressed issues associated with the social and institutional contexts of urban forestry. This series of national-level studies has focused on questions of "why" trees belong in cities, rather than providing technologies about "how" to best plant and manage urban forests. Communities can use this knowledge to build public ideas about urban forestry that may evolve into policy.

My reflection-in-action has generated knowledge that is different from, but can become the basis of scholarly investigation. A formal appraisal and assessment would help to refine the technology transfer program and provide insights for other similar programs.

Evaluation should include feedback loops so that end-users can provide information about their experiences with products and perceived effectiveness. Such feedback would provide guidance on the format and presentation of information tools such that they more rapidly enter the policy process and better inform decisionmaking. Scientists typically avoid becoming advocates for policy, so soliciting information from informed and effective policy participants could enhance production and delivery of research outcomes.

Second, identification of key audiences within policy development settings is essential but not readily done. The full range of potential receivers and their policy inclinations has not been analyzed. Once receivers are identified, the character and the content of the informational tools could be crafted to better meet their informational needs.

Research opportunities are endless; here are possibilities:

- Develop evaluative performance guidelines for print materials.
- Develop methods for tracing and tracking materials diffusion pathways.
- Monitor the performance of technology transfer efforts, in terms of innovation adoption, from outreach to action.
- Conduct focused assessment of "problem pioneer" and "champion" activities and influences.
- Discover sociopolitical dynamics that may encourage a decisionmaker to be more receptive to urban forestry policy development (such as Tree City USA awards or community sense of place).
- Present opportunities for integrating this outreach program with other similar programs, considering potential efficiencies and synergies.

Rogers (2002) noted that, given the tremendous public investment in research and development, it is surprising that more research attention has not been given to investigating technology transfer. The scholarly study of this process is underfunded and dissipated among a variety of disciplines. Better theoretical conceptualization and more effective methodological approaches are needed to illuminate the nature of the technology transfer process. These limitations have been observed concerning tangible products but apply to policy-oriented technology transfer as well. Improved science-based policy interventions could encourage greater quantity and quality of urban forests, improving quality of life for millions of people.

Acknowledgments

Grant support for the research and technology transfer products reported here was provided by the USDA Forest Service on recommendation of the National Urban and Community Forestry Advisory Council.

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