Knowledge transfer and extension in the Canadian Ecology Centre – Forestry Research Partnership: From awareness to uptake

by Guy K.M. Smith[1], John F. Pineau[2] and F. Wayne Bell[3]

ABSTRACT

Knowledge transfer, including awareness, transfer, extension, training, and education activities, was purposely incorporated into the Canadian Ecology Centre – Forestry Research Partnership (CEC-FRP) at an early stage as part of an adaptive management approach. Over the course of 7 years, the level of involvement from researchers, policy-makers, and forest resource managers in knowledge transfer activities progressed from passive to interactive participation, with each successive stage requiring greater attention to timing and the capacity of participants to take in new knowledge. An interactive approach, dubbed core teams, proved essential in overcoming barriers to the flow of knowledge into practice. Four case examples: (1) revising growth and yield predictions, (2) integrating spatial and nonspatial landscape analysis tools, (3) developing and applying advanced silvicultural decision-making, and (4) applying spray delivery systems, are used to convey the success of knowledge transfer and extension efforts in the CEC-FRP and the essential role of the core teams. Physical, human, and financial resources, coupled with strong involvement by partner organizations, were key factors in the success of knowledge transfer efforts.

Key words: active adaptive management, forest management

RÉSUMÉ

Le transfert des connaissances, incluant la sensibilisation, le transfert, les services d'information, la formation et les activités éducatives, a été sciemment inclus dans le partenariat du Centre écologique du Canada – Partenariat pour la recherche forestière (CEC-PRF) dès les premières étapes en tant qu'élément de l'approche d'aménagement adaptatif. Au cours des 7 années qui ont suivi, le niveau d'implication des chercheurs, des concepteurs de politiques et des aménagistes de la ressource forestière dans le transfert des connaissances est passé de celui de passif à celui d'interactif, impliquant à chaque étape successive une plus grande attention au moment et à la capacité des participants d'acquérir de nouvelles connaissances. Une approche interactive, doublée d'équipes centrales, s'est avérée être essentielle pour surmonter les obstacles empêchant l'écoulement des connaissances vers le champ de la pratique. Quatre exemples : (1) la révision des prédictions de croissance et de rendement, (2) l'intégration des outils d'analyse spatiale et non spatiale de l'écosystème, (3) le développement et l'application de nouveaux processus de prise de décision en sylviculture et, (4) l'utilisation de systèmes de diffusion étendue, sont utilisés pour démontrer le succès des efforts de transfert de connaissances et des services d'information enregistré par le CEC-PRF et le rôle essentiel des équipes centrales. Les ressources physiques, humaines et financières, ainsi que le haut niveau d'implication des organisations participantes, ont été les facteurs clés du succès des efforts de gestion des connaissances.

Mots clés : aménagement adaptatif actif, aménagement forestier

Introduction

Forming a partnership is a good starting point for identifying, developing, and implementing ecologically sustainable and scientifically defensible leading edge forestry practices (CEC-FRP 2000). A partnership alone, however, does not assure success; a clearly articulated goal upon which to focus efforts, define respective roles, and make commitments is critical (Rogers 1998). Yet without a plan and accompanying capacity to move knowledge into practice, a goal remains a distant target. The flow of knowledge into practice is a path fraught with potential barriers, such as knowledge experts not explaining well or not being understood (Fazey *et al.* 2005), philosophies and reward systems diverging between science-oriented and management-oriented institutions (Rogers 1998), and relationships among those involved weak or lacking in the trust necessary for the exchange of knowledge (DeYoe and Hollstedt 2004).

Over 7 years, the Canadian Ecology Centre – Forestry Research Partnership (CEC-FRP) has generated, shared, and moved knowledge into practice. The path has not been without obstacles but for the most part they have been overcome. This paper describes the CEC-FRP approach to facilitating the sharing and adoption of knowledge and technology from science to practice within an adaptive management framework. Four of many possible examples of successful transfer are offered with accompanying lessons learned.

[1]Natural Resources Canada, Canadian Wood Fibre Centre, 1219 Queen St. E., Sault Ste. Marie, Ontario. E-mail: gusmith@nrcan.gc.ca
[2]Canadian Institute of Forestry – Institut forestier du Canada, 6905 Hwy. 17 West Mattawa, Ontario. E-mail: jpineau@cif-ifc.org
[3]Ontario Forest Research Institute, Ontario Ministry of Natural Resources, 1235 Queen Street East, Sault Ste. Marie, ON P6A 2E5 E-mail: wayne.bell@ontario.ca

Definitions

During the course of implementing the CEC-FRP we did not need to define terms associated with our transfer efforts, but we have found it necessary in this paper. The majority of definitions were adapted from Perera *et al.* (2006).

Knowledge is generalized principles, concepts, and specific facts that provide the contextual basis for application. *Knowledge transfer* is the group of activities that increase the understanding of a topic with the goal of encouraging application of this knowledge. *Technology* is the mechanical means (e.g., geographical information systems, spatial models, spray technology) necessary for the application of knowledge. *Technology transfer* is the group of activities that increases a person's skills as needed to use a technology.

The related activities most commonly used by the CEC-FRP were awareness, transfer, extension, training and education. These are defined as follows: Awareness involves creating a learning environment in which one's vigilance in observing or alertness in drawing inferences from what is experienced is enhanced. *Transfer* is the act of conveying knowledge from one person to another; researchers can transfer their knowledge to policy-makers and forest resource managers through newsletters, conferences, or direct contact. *Extension* is the act of offering instruction to persons unable to attend transfer activities at the usual time or in the usual place; policy-makers or forest resource managers who become aware that new knowledge exists may choose to proactively contact the researcher for information rather than wait for a scheduled transfer activity. *Training* is the act of learning about a model or tool through classroom style instructions, followed by repetitive use of the tool or model. *Education* encompasses both the teaching and learning of knowledge, proper conduct, and technical competency. It thus focuses on the cultivation of skills, trades or professions, as well as mental, moral and aesthetic development.

The 4 broad groups of individuals directly involved in CEC-FRP knowledge transfer activities, categorized as defined by Buse and Perera (2006) include researchers, transfer specialists, forest resource managers, and policy-makers. Researchers are those devoted to conducting research, knowledge synthesis, experimentation, and/or monitoring (see Bell *et al.* 2008a, this issue, for definitions). Within the CEC-FRP, this group included the Ontario Ministry of Natural Resources (OMNR) and Natural Resources Canada (NRCan) researchers, OMNR regional specialists, consultants, university professors, and post-doctoral candidates. Transfer specialists focused on managing knowledge transfer activities. This was a small group of NRCan, Tembec, and OMNR staff often referred to as the *CEC-FRP extension team*. *Forest resource managers* are professionals who plan and/or implement forest management plans or operations. Within the CEC-FRP, this group included staff from each of the core sustainable forest license holders (McPherson *et al.* 2008, this issue) including Tembec and Nipissing Forest Resource Management staff and OMNR district staff. *Policy-makers* are those devoted to writing or approving provincial policies or guidelines. Policy-makers were exclusively OMNR staff. Ontario's researchers, forest resource managers, policy-makers, and transfer specialists have a diverse array of academic backgrounds including forestry, biology, and land-use planning.

Knowledge Transfer within the Forestry Research Partnership

A base to build on

It is not always the case that research partnerships explicitly commit resources to convey new knowledge. However, in the case of CEC-FRP, awareness, transfer, extension, training, and education activities were supported from the start with the commitment of physical, human, and financial resources by the partners (Pineau and Smith 2006).

Physically, the partnership was based at the Canadian Ecology Centre (CEC), a non-profit educational organization with accommodation, meeting, and office facilities in Samuel de Champlain Provincial Park in the Great Lakes–St. Lawrence Forest Region near Mattawa, Ontario (CEC 2008). The centre's interactive learning environment, which integrated technology and modern thinking into its structures, offered an innovative platform for a knowledge transfer program. With its state-of-the-art computer lab and proximity to research sites and facilities, the CEC was frequently used for transfer and training activities. Additional infrastructure was provided by NRCan, OMNR, and Tembec Inc. in the offices and facilities used to accommodate staff and provide venues for learning events.

Human resources included science and knowledge transfer professionals belonging to partner organizations who found in the CEC-FRP new opportunities to work jointly and pool resources and talents. A succession of youth interns—university and college graduates sponsored through NRCan's science and technology internship program—gained experience and contributed significantly to the partnership.

Financially, the collective activities involved in conveying knowledge became the largest single budget item of the partnership, with direct funding from each partner (but most significantly Tembec Inc.), and external funding from Government of Ontario programs including the Living Legacy Trust and Forestry Futures Trust. Additional capacity was built through working relationships with affiliate organizations, for which the CEC-FRP became a primary transfer vehicle.

Progression from passive to interactive participation

Between 2000 and 2008, the relationship between researchers, forest resource managers, and policy-makers evolved very rapidly from passive to functional to interactive participation as described by Pretty (1995; Table 1).

In 2000, when the partnership was first initiated, participation by researchers and forest resource managers in the *technology transfer program*, as it was first named, can best be described as passive. Although participation from policy-makers was considered, this group was not actively engaged at the outset. Aside from the small group of OMNR and NRCan scientists involved in designing the CEC-FRP research program, most researchers and forest resource managers were basically told what was going to happen or had already happened. The program functioned primarily to promote the CEC-FRP goal of increasing the supply of fibre to Tembec mills in northeastern Ontario by 10% in 10 years (Bruemmer 2008, this issue) amongst partners and to gather science outputs pertinent to that goal. Transfer activities included workshops, Web site development, newsletter production, CEC-FRP promotion, and support to funding proposals.

Table 1. A typology of participation (adapted from Pretty 1995)

Participation category	Description
1. Passive	Participants are told what is going to happen or has already happened.
2. Extractive	Participants answer questions posed by extractive researchers using questionnaire surveys or similar approaches.
3. Consultative	Participants are consulted and external agents listen to views.
4. Material incentive	Participants provide resources, for example labour, in return for food, cash or other material incentives.
5. Functional participative	Participants form groups to meet predetermined objectives related to the project, which can involve the development or promotion of externally initiated social organization.
6. Interactive	Participants engage in joint analysis, which leads to action plans and the formation of new local institutions or the strengthening of existing ones.
7. Self-mobilization	Participants initiate activities to change systems independent of external institutions.

Within 3 years of the initiation of the partnership, it became evident that the approach to transfer needed to evolve into a focused extension program with increased participation by partners. Extension activities emphasized helping participants learn to support improved decision-making, and could be classified as consultative or functional participation. Extension specialists helped to bridge the gaps between research and operations, enabling the transfer of knowledge and information as well as joining the working circles of researchers, policy-makers, and forest resource managers (DeYoe 1998, Smith and Johnson 2007). Thus, the program was renamed *FRP extension* to be more consistent with terminology in national and international working circles (Johnson 2006).

By 2005, the program evolved to the point where it could be described as interactive participation. Demand for direct training and education was increasing, not only for existing forest professional and technical workers, but also for recent and upcoming graduates of post-secondary forestry programs. Communicating via passive means did not assure the uptake or use of new knowledge or technology. Target audiences were generally too busy to take notice of, let alone learn to use and integrate, new science outputs and results of their own volition. Focused training courses that included how-to and hands-on instruction became more common. In addition, workshops, seminars, and tours changed to a decidedly application-oriented educational and instructional tone and approach.

The core team approach

At the heart of the CEC-FRP extension program was the development of strong connections among researchers, transfer specialists, and forest resource managers. In what was considered a pilot approach, the CEC-FRP established 3 transfer teams in May 2000, i.e., one team for each of the Romeo Malette, Gordon Cosens, and Nipissing forest management units (MacPherson *et al.* 2008, this issue). The *core teams*, as they soon became known, comprised transfer specialists and local and regional OMNR, Tembec, and Nipissing forest management and operations staff. Researchers were not members of the core teams but were invited to participate as needed.

The objectives of the core teams were to (a) facilitate direct extension/knowledge transfer between researcher and target audiences (field/operations, planning, managers); (b) promote rapid and efficient uptake of knowledge, information, and tools resulting from CEC-FRP-related projects; (c) interactively select research results for dissemination and implementation; (d) support operational implementation of improved practices towards a general goal of enhancing forest productivity; and (e) actively assist planning, silviculture, and operations staff with the implementation and use of new knowledge or technology.

The core teams received input and guidance from the CEC-FRP extension team. The latter provided a coordination and facilitation role, ensuring that the core teams developed and met scheduled milestones and had regular opportunities to meet with researchers. Facilitated meetings were held a minimum of 3 times per year (April, September, and January), with the onus on the CEC-FRP-appointed facilitator to organize. However, meetings occurred only when more than 60% of the designated members were available. Meeting themes and locations were generally determined collectively, prior to the end of the previous session. Documentation for each session included minutes that were circulated to core team and CEC-FRP secretariat members, and a brief annual report of activity and accomplishments submitted to the CEC-FRP general manager and circulated to core team and secretariat members (details of the overall CEC-FRP organizational structure are provided in Bruemmer 2008, this issue). All core team members participated in an annual joint working group meeting, held at the CEC in February, which included a member evaluation of core team effectiveness. This feedback was used to help set priorities for future knowledge transfer activities and project funding.

The core team concept soon became the primary method for engaging forest resource managers and was deemed fundamental to stimulating the uptake of new knowledge at the management unit level through direct transfer, extension, and training activities. The core teams will continue be the primary vehicle to communicate and transfer science and information relating to the partnership's pilot project *Implementation of Enhanced Fibre Production on the Romeo Malette Forest* for the duration of the forest management plan currently being produced (2009–2019).

Examples of the Core Team's Role in Knowledge Transfer

One criterion for success for the CEC-FRP can be summed up with the simple question, "Did the CEC-FRP make a difference?" The answer, from a number of perspectives—including those of forest resource managers and researchers—is a definite *yes*.

The following 4 case examples are outlined to provide evidence of that success: (1) revised growth and yield predictions, (2) integrated non-spatial and spatial and landscape analysis tools, (3) developed and applied advanced silvicultural decision-making framework, and (4) developed and implemented advanced navigation and spray optimization technology. Other examples could have been used, but these were selected because they also demonstrate timely links to an adaptive management cycle (Fig. 1) and, more importantly, to forest management plans in preparation during the period of core team transfer activities. These examples also demonstrate the diversity of methods used to convey knowledge. For each, we describe the need for and the activities used to accomplish transfer. In all examples, the core team approach was instrumental in helping to clear the barriers to the flow of knowledge and information.

Case No. 1 – Revising growth and yield predictions enables better silvicultural treatments and more reliable allowable harvest determination

Yield predictions are the basis for determining allowable harvest levels and forecasting changing forest condition, key requirements of forest management planning (Sharma *et al.* 2008, this issue). Additionally, Crown forest management in Ontario requires strategic silvicultural options treatment packages for selecting the best treatment options for a range of site conditions (OMNR 2004; Bell *et al.* 2008b this issue). The CEC-FRP was instrumental in the development of a comprehensive suite of yield curves based on a provincial growth and yield plot network. The new products replaced yield curves developed in the 1950s and incorporate data for a range of silvicultural intensities across a range of sites (Sharma *et al.* 2008, this issue).

Dr. Margaret Penner, a consultant specializing in stand growth and yield contracted by CEC-FRP, worked with an extensive data set from Ontario's growth and yield plot network and provincial growth and yield specialists to develop the curves. Curves were fitted using available data with coefficients and data sets subjected to peer review (Penner *et al.* 2008, this issue). Data were stratified by natural- and plantation-origin stands and related to a continuum of silvicultural treatment outcomes (described in Bell *et al.* 2008b, this issue), resulting in a comprehensive set of *empirical yield curves*. OMNR planning, information management, and science specialists cooperated in building coefficients from the new curves into data preparation tools for strategic forest modeling, developed software, and trained planning teams across northeastern Ontario in its use. Adoption of the new curves was supported by the compatibility of the new products with existing modelling and inventory support tools approved for use in forest management planning (Rouillard and Moore 2008, this issue).

The empirical yield curves were first implemented on a trial basis in Romeo Malette Forest plan, with the core team being the critical extension vehicle for adoption of the new technology. The CEC-FRP ensured that Dr. Penner met with the core team to support the trial use of the curves. The Romeo Malette pilot provided lessons and guidance for subsequent extension of empirical yield curves to other units in northeastern and northwestern Ontario. Each management unit requires a specific adaptation of the yield curves to account for different forest stand stratification and manage-

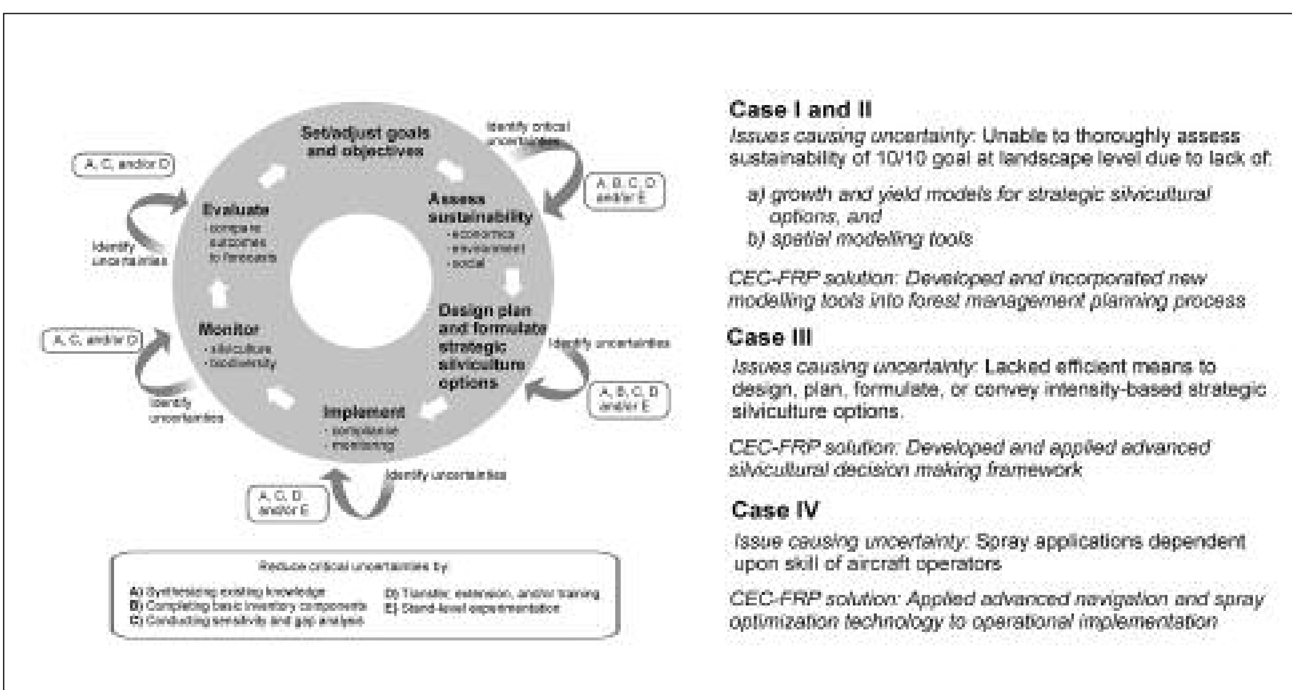

Fig. 1. An illustration of how the case studies discussed in this paper fit within the adaptive management cycle applied in the Forestry Research Partnership (adapted from Bell et al. 2008a, this issue).

ment unit-specific forest inventory. Refinement continues as additional data are acquired to further validate fitted curves and to develop curves for underrepresented stand conditions and treatments.

In this case example, a new product was developed for which there was an identified need and direct application, easing the acceptance and adoption into operations. The challenge was fine-tuning the curves for individual planning teams, which was possible through face-to-face core team meetings and relied on the mutual trust built through using local data and working together to develop the new curves. The larger challenge for the CEC-FRP was to get the new curves accepted in policy since managing a series of forest management unit-specific curves was more complex than having a uniform set for an entire region. This process may have been easier if policy-makers had been engaged in the core teams from the outset.

Case No. 2 – Integrating non-spatial with spatial modelling brings forest-level planning to a new level

Strategic analysis for forest-level planning is a requirement for Crown land forest management in Ontario. The requirements for forest management planning in Ontario present complexity that challenges the limits of a non-spatial, linear programming model. However, at the outset of the CEC-FRP in 2000, the Strategic Forest Management Model (SFMM), a nonspatial model, was the standard modelling tool used at the management unit level (Davis 1999; Rouillard and Moore 2008, this issue). A spatially explicit modelling approach would enable evaluation of various scenarios to optimize the specific location and timing of harvest treatments in relation to non-harvested areas over many years. Use of a spatial modelling tool or a combination of nonspatial and spatial tools could explicitly account for changing forest condition, habitat supply, and other values in relation to the specific distribution of stands over the management area (Rouillard and Moore 2008, this issue).

The CEC-FRP was instrumental in building the case and advocating for the approval by the OMNR of the Patchworks spatial model, developed by Tom Moore of Spatialworks Inc., as a strategic analysis tool (OMNR 2007). The core teams were critical in the trial and development of Patchworks to meet forest planning needs on the Romeo Malette and Nipissing Forest management units. The teams consisted of Tembec and OMNR forest modelling and planning specialists directly interested in the management unit plans. They worked closely with model developers and with OMNR planning and information management specialists to adjust and improve the software to ensure compatibility with SFMM and inventory support tools approved for use by OMNR. The core teams are credited with identifying early problems and challenges, finding ways to overcome them, and developing management unit-specific approaches to integrate SFMM and Patchworks (Rouillard and Moore 2008, this issue). Direct technical support and on-site training of users working with local empirical data were critical steps in achieving adoption and use of spatial modelling.As in the Case 1 example, the need for and advantages of this new tool were evident, easing its adoption. Having the developer work with planning and operations staff to find optimal solutions for their management units was key to transfer success, In this case, policy-makers and planners were involved from the outset, which eased policy adoption as well.

Case No. 3 – Developing and implementing an advanced silvicultural decision-making framework optimizes investments and results

Substantial synthesis and aggregation of knowledge during the life of CEC-FRP has advanced silvicultural decision-making. Bell *et al.* (2008b, this issue) describe in detail the development of the NEBIE framework for describing silvicultural intensities (the NEBIE acronym refers to varying levels of silvicultural intensities from natural disturbances to extensive, basic, intensive, and elite). Improved yield curves (see Case 1 discussion above) were tailored to match the NEBIE framework.

In this case, OMNR research scientist Wayne Bell saw the need for a common language for and knowledge about environmental effects of various silviculture intensities and proposed the NEBIE Plot Network. Forest resource managers Jeff Leach (Tembec Inc.), Don Bazeley (Tembec Inc.), Peter Street (Nipissing Forest Resource Management), and Steve D'Eon (Natural Resources Canada), were directly involved in planning and implementation of intensity-based, ecosite-specific, strategic silvicultural options for 4 of the 8 NEBIE installation sets.

Mr. Leach saw the immediate potential to incorporate the framework directly into the forest management planning process as a new approach to developing strategic silvicultural options. Benefits of this approach to Tembec include a common language for strategic silvicultural options across sustainable forest management units. Corporately, this translates into better decisions about where and how to spend dollars on silvicultural treatments (McPherson *et al.* 2008, this issue). With the framework embedded directly in the forest management plan, Tembec staff can make more consistent planning decisions about regeneration levels on specific areas, which in turn should lead to better operational decisions. A caution, however, is that the framework supports, but does not substitute for, decision-making by silviculturists with working knowledge and experience on the management unit (J. Leach[4], personal communication).

In this case, knowledge transfer did not require transfer specialists. The direct participation of forest resource managers in the design and implementation of the research gave them ownership of the project, framework, and direct access to the researchers involved. Transfer specialists, however, did contribute to broadening the awareness of the project across Canada and internationally by posting information on the CEC-FRP Web site, publishing newsletters, and hosting workshops. Transfer specialists also ensured that the framework was used in the development of the growth and yield (Case 1) and landscape modelling exercises (Case 2). Transfer specialists also ensured that the framework formed part of ongoing field tours and site visits by groups and delegations and was included in large-scale demonstration plots.

The operational application of science has become reality on 3 enhanced productivity demonstration areas, one on each of the CEC-FRP flagship forest management units: Gordon Cosens (Block 44), Romeo Malette (Block 18) and Nipissing (Block 108) (see McPherson *et al.* 2008, this issue for more information). With active involvement by core teams from the beginning, these areas have become focal points for putting the latest knowledge, technology, and tools to use. These areas are demonstrations and trials of enhanced inventory,

[4]Silvicultural Specialist – Boreal Ontario, Tembec Inc.

patchworks spatial modelling, empirical yield curves, genetically improved stock, mixed species plantings, optimized herbicide application, and commercial and precommercial thinning. The sites have brought together CEC-FRP partners with interests in science, operations, and policy, and demonstrated the benefits of treatments aimed at increased productivity.

In this case, the need for the knowledge product was less clear from the outset compared to the yield curves and spatial modelling examples. The sites were recognized as both transfer tools and products combined, offering actual visual demonstration of implemented enhanced forest productivity science. The direct involvement of resource managers in study design and implementation helped to foster ownership and convince them of the value and applicability of the concepts. Working together to plan, integrate, and implement enhanced forest productivity concepts into forest planning was key to success. Awareness building and transfer efforts, specifically multiple explanatory field tours, helped the integrated concepts to diffuse beyond the partnership.

Case No. 4 – Developing and applying advanced navigation and spray optimization technology reduces environmental impacts and operational costs

In 2003, Vic Wearn, a CEC-FRP transfer specialist working closely with Tembec staff on the Gordon Cosens Forest near Kapuskasing, suggested a project to apply the latest aerial application technology to Tembec's herbicide program. Mr. Wearn recognized the opportunity within the partnership to bring research and operations together to address a clear need. Motivations for forest resource managers in Tembec to take interest were to: (1) use best available science and technology to optimize aerial application, as per a requirement of forest certification, (2) increase operational efficiency, and (3) minimize environmental effects of treatments.

NRCan research scientist Dr. Dean Thompson brought scientific expertise in the use of advanced technology for aircraft guidance, remote sensing, data analysis, and airborne spray delivery. The technology was applied to the specific operational conditions on the Gordon Cosens Forest. This included use of fixed-wing aircraft rather than helicopter application, which was the norm in other settings where the new application technologies were commonly applied.

One of the immediate gains realized through the trial was the optimization of spray block aggregation. Geographic positioning system (GPS) navigation and on-target deposition enables the applicator to precisely target spray blocks, thereby reducing wasted or off-target spray. Tembec estimates that the optimization of block layout translates into a minimum 20% reduction in costs (J. Leach, Tembec, personal communication, 2008).

From a scientific standpoint, the CEC-FRP enabled an operational trial that attracted interest from other provinces and countries. Dr. Thompson has since collaborated with researchers from the United States and New Zealand on the validation and refinement of a decision support system for optimizing aerial spray application. In May 2008, the CEC-FRP hosted a workshop to provide training in the use of the decision support software to applications specialists from across Canada. From a policy perspective, the work on the Gordon Cosens forest provided valuable empirical data to validate models that help to determine buffer zone requirements. The models are used by the Pest Management Regulatory Agency in Canada to develop definitions and set regulations for the aerial application of forest herbicides.

In this case, operational application and advantages of the new technology were obvious and transfer consisted mainly of awareness building by way of demonstrating what the technology could do and training applicators in its use. The selling features for forest industry were certification advantages and cost savings. As well, the links to policy were clearly defined. Transfer efforts contributed to successful implementation but the challenges were much diminished compared to the previous examples.

Overcoming barriers – lessons learned

The transfer successes of the CEC-FRP had their beginnings in research and transfer efforts predating the partnership. Yet something about the partnership made the period from 2000 to 2008 a watershed of sorts for bringing new knowledge to improve management and operations. The question is: How were some of the common barriers to adoption of new knowledge, process, and tools overcome? We offer the following assessment relative to commonly cited barriers (c.f., Rogers 1998, DeYoe and Hollstedt 2004, Fazey *et al.* 2005).

Barrier: Inefficient knowledge transfer for individual projects

Prior to the formation of the CEC-FRP, knowledge transfer from researchers to forest resources managers in northeastern Ontario was ad hoc, typically by topic or specific project. The CEC-FRP provided a dedicated program of knowledge transfer, which proved more effective as the required capacity and funding were allocated to meet the needs of individual projects while specifically ensuring that transfer activities addressed partnership goals. Moreover, the approach offered efficiencies as the needs of multiple projects were often met through a single transfer event—such as a workshop or field visit—and allowed linkages among projects to be more clearly communicated and results integrated.

Barrier: Knowledge transfer for individual projects not synchronized with forest management planning process

Many researchers have expressed frustration following attempts to have their research incorporated in forest management plans. In Ontario, where the forest management planning process is cyclic (OMNR 2004), researchers need to be cognizant of the importance of the timing of transfer efforts. Even if their knowledge is relevant, adoption is not guaranteed if forest resource managers or policy-makers are engaged at the wrong point in the planning cycle.

Timing of tools used for strategic planning is more critical than the planning of specific knowledge about silvicultural practices or silvicultural technologies. Forest management plans are prepared on a 10-year cycle (OMNR 2004). The preparation of the plan occurs in 2 phases (1) long-term strategic planning and planning of the first 5 years of operations, and (2) planning of operations for the second 5-year term. Forest management planning essentially follows an adaptive management cycle from determining goals and objectives, to assessing sustainability, to determining best management practices, etc., which if tied to learning can be referred to as an adaptive management cycle (Fig. 1). Hence, knowledge or technologies that are relevant to strategic planning are best timed to coincide with the first part of the planning cycle. Annual operational plans offer opportunities to incorporate new knowledge about silvicultural practices or technologies at any point in the cycle.

We demonstrate how timing works using the Romeo-Malette Forest management plan and our 4 case examples. Given that the plan would be renewed in 2009, transfer specialists focused their initial efforts on ensuring that researchers transferred relevant products, such as the growth and yield models (Case 1) and the spatial analysis models (Case 2), early on. By 2007, forest resource managers were drafting best management practices and strategic silvicultural options. Through transfer and extension efforts, knowledge gained from work on NEBIE Plot Network and large plot demonstrations (Case 3) was immediately incorporated into the plan. For the advanced navigation and spray optimization technology results (Case 4), timing was not critical since plan implementation would not occur until 2009; however, transfer specialists ensured that forest resource managers were aware of the project by engaging them from the outset to ensure that the technology could be incorporated into operational plans as soon as it was available.

Barrier: Knowledge experts not communicating well or not well understood

Initial knowledge transfer efforts relied on traditional activities such as hosting conferences, seminars, workshops, publishing newsletters, and posting information on the web. The CEC-FRP approach ensured that these activities were executed consistently, in a timely manner, and focused on user-defined needs/topics. Wherever possible, direct face-to-face meetings were arranged, often at the Canadian Ecology Centre, in the field or at forest resource manager's offices. Extension specialists, employed by the partnership, encouraged and facilitated direct interaction between researchers and forest resource managers. Core teams identified specific needs and formulated questions for researchers, while extension specialists helped to develop an effective 2-way flow of information. Knowledge experts encompassed more than researchers; they included specialists in forest planning, analysis, and information management. The extension team worked to ensure that these experts communicated effectively and were well understood by their audience in order to best facilitate the adoption of new tools and knowledge. Specifically, this was accomplished by ensuring that core team facilitators were well-trained, natural communicators, knowledgeable about relevant science and research, its application, and forest planning and field operations. The unique talents of a core team facilitator were essential to catalyzing interchange among core team members; paraphrasing where appropriate, providing verbal examples and illustrations, and always emphasizing and encouraging the direct application and use of specific science and research outputs and results.

Barrier: Diverging philosophies and reward systems among institutions

It is not uncommon for science institutes to have diverging philosophies and/or reward systems (Rogers 1998). The challenge is to be aware of and overcome the differences. In the CEC-FRP experience, a complex set of institutions came together, comprising the domains of science, planning, policy, and operations in both government (provincial and federal) and industry organizations. Success in the above described case examples was achieved by finding common ground and common purpose among the various interests. In the case of empirical yield curves, for example, the CEC-FRP acted as a catalyst for the trial and adoption. The partnership exerted influence at the senior management level in OMNR to gain approval for the use of the new curves. At the level of the forest management plan, the CEC-FRP provided impetus for change via the core team, coupled with direct training and technical support, to encourage their trial and adoption. The CEC-FRP formed a critical connection among the partners during the development of the curves, helping to ensure a flow of data and information towards clear objectives, ultimately ensuring their acceptance and use by all partners in all levels of both government and industry; and also promoting an understanding that yield curves were not static, but could change and continuously improve as new data became available (Sharma *et al.* 2008, this issue).

Barrier: Relationships among participating organizations weak or lacking in the trust necessary for knowledge exchange

In many respects, the CEC-FRP success story is one of relationships built on many levels over more than 7 years. The extension program was instrumental in relationship-building via a selection of media—including face-to-face meetings, digital video "newscasts," Web site profiles, publications, and field visits—to consistently introduce the players as well as their contributions to partnership goals. Core teams became the focal point for building relationships and trust around the development of forest management plans. Furthermore, efforts were made to ensure an appropriate range of interests was represented on CEC-FRP committees, including the executive and advisory committees. As knowledge transfer increasingly focused on improved tools for forest planning (particularly spatial modelling and empirical yield curves), the importance of including OMNR planning and policy specialists on committees became increasingly clear. Inclusion and participation encouraged the sharing of issues and needs and built the trust necessary for the exchange of knowledge and its eventual adoption in policy, planning, and operations.

Barrier: Receiving organization lacking capacity to uptake knowledge

Because the role of CEC-FRP knowledge transfer encompassed awareness, transfer, extension, and training phases, knowledge recipients could work through the processes of trial, adaptation to specific needs, and adoption into practice. The extension and training functions were direct and highly specific to the management unit needs of Tembec Inc., the company responsible for producing the forest management plan. Core teams brought planners, modellers, and researchers together to address specific forest management plan requirements. This close interaction resulted in a capacity for the knowledge uptake that did not exist in Tembec alone. This model of specialist-practitioner interaction is similar to the "embeddedness" model used in the Millar Western Forest Products Ltd.'s detailed forest management plan (Van Damme *et al.* 2008).

Summary

Through the CEC-FRP, forest management plans were improved through the use of more reliable yield curves, more realistic allocations of harvest areas over time, more science-based decisions among silvicultural treatment options, and better practices. Although solid research was key to these advancements, the changes could not have been achieved without the dedication of the CEC-FRP extension program, the financial and in-kind contributions from the partners, and the core teams' efforts to overcome barriers to the flow of knowledge. The CEC-FRP extension program relied on a range of approaches to support and facilitate the adoption of knowledge and technology including awareness, transfer, extension, training, and education. The combination of activities and the consistent ongoing efforts were important to success. Central to the effort were the core teams, whose collective will to make new knowledge relevant and useful on forest management units was key. Facilitated by the extension team, the core teams forged constructive interaction among researchers, forest resource managers, and policy-makers. Through the CEC-FRP, the partners have learned a great deal about knowledge transfer and hope that the lessons learned here are of value to other organizations planning to implement transfer programs within an adaptive management framework.

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