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 eco-regions 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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