SILVAH: MANAGERS AND SCIENTISTS WORK TOGETHER TO IMPROVE RESEARCH AND MANAGEMENT

Susan L. Stout and Patrick H. Brose[1]

Abstract—SILVAH is a systematic approach to silvicultural prescription development based on inventory and analysis of stand data for Allegheny hardwood, northern hardwood, and mixed oak forests. SILVAH includes annual training sessions and decision support software, and it ensures a consistent, complete, and objective approach to prescriptions. SILVAH has created a community of practice with common vocabulary and framework for assessing forest stands. Lessons learned from thirty years of research-manager cooperation may be relevant to the work of the Consortium of Appalachian Fire Managers and Scientists. Managers benefit in at least three ways from participation in the SILVAH community of practice: their prescriptions are demonstrably based on data and science and are internally consistent; relationships with scientists help attract research attention to emerging problems; and they have access to lessons learned by other managers using SILVAH. Scientists also benefit: they have confidence that their work is on problems of high priority to managers; their impact is increased by early adoption of research by managers; the scale and scope of forest observation is increased by the community of observers sharing a common framework and vocabulary; and managers are often able and willing to help locate appropriate study sites and provide in-kind services, such as treatment applications.

INTRODUCTION

SILVAH, originally an acronym for Silviculture of Allegheny Hardwoods, is a systematic approach to silvicultural prescription development based on inventory and analysis of stand data for Allegheny hardwood, northern hardwood, and mixed oak forests of Pennsylvania and adjoining States. It is relevant to the Consortium of Appalachian Fire Managers and Scientists because of its success in creating a community of practice in which scientists and managers work together through the full cycle of research, from problem selection and hypothesis formation through study implementation, data collection, analysis, delivery of results, and organization of those results into guidelines useable by managers. Such a community increases the probability that problems of high priority to managers will receive appropriate research attention and that research results will actually influence practice. In this paper, we give a brief history of the development of SILVAH and the lessons learned about building a community of practice that improves research and management.

ORIGINS

In 1967, managers in northwestern Pennsylvania organized a Society of American Foresters (SAF) meeting around regeneration failures that were, in their opinion, too common in the local maturing second-growth Allegheny and northern hardwood forests, consisting of black cherry (*Prunus serotina),* red and sugar maple (*Acer rubrum* and *saccharum),* American beech *(Fagus grandifolia)*, black and yellow birch (*Betula lenta* and *allegheniensis*), and other species. They invited Ben Roach (fig. 1), a research assistant director of the U.S. Department of Agriculture, Forest Service Northeastern Forest Experiment Station, headquartered near Philadelphia. Managers wondered about the relative importance of everything from seed production, soil and site factors, interplant competition and interference, to browsing by white-tailed deer (*Odocoileus virginianus*) and snowshoe hare (*Lepus americanus*) as possible reasons for the observed failures.

Roach assigned a protégée, David Marquis (fig. 1), to the Warren, PA, Forest Service Research Lab in northwestern Pennsylvania and helped him recruit scientists from around the region whose skills represented the possible explanations of regeneration failures. Ted Grisez (fig. 1), already in place, had a near-encyclopedic knowledge of local forest ecology and some familiarity with both natural and artificial regeneration methods (Grisez and Huntzinger 1965, Grisez and Peace 1973). John Bjorkbom (fig. 1) came from New England, where he had studied regeneration of the highly desirable birch species (*Betula* spp.) of those northern hardwood forests (Bjorkbom 1979, Bjorkbom and others 1979). Lew Auchmoody

[1]Susan L. Stout, Research Forester and Project Leader, USDA Forest Service, Northern Research Station, Irvine, PA 16365
Patrick H. Brose, Research Forester, USDA Forest Service, Northern Research Station, Irvine, PA 16329

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(fig. 1) came from West Virginia, where his research focused on soil nutrition and individual species responses to changes in nutrition (Auchmoody 1973, 1978). Steve Horsley (fig. 1) came from New Jersey, and his knowledge of ecophysiology was soon applied to understanding interference with regeneration from other native plants like ferns (Horsley 1977a, 1977b). Eventually, Roach himself became a scientist at the Warren Lab, where he focused on studies related to his long established expertise in quantifying relative density and growth responses to intermediate cuttings (Roach and Gingrich 1968, Roach 1977). Marquis himself took on additional studies on regeneration and the role of white-tailed deer browsing in regeneration failures (Marquis 1974, 1975).

As the scientists arrived in Warren, they prepared problem analyses and a plan of work focused on the regeneration problems. Figure 2 is from a flow chart in the problem analysis that organized the early research. First, the scientists adopted a definition of successful regeneration from earlier work that Roach and colleagues had conducted (Roach and Gingrich 1968). A stand was considered to have regenerated successfully if 70 percent of sample plots in the harvest area were stocked with desirable or commercial seedlings or saplings, with stocking criteria represented as numbers of seedlings taller than a certain height (Marquis and Bjorkbom 1982). The scientists thought about what decisions, data, and knowledge were essential to managers for making a successful regeneration prescription, and they organized their studies to provide the data and knowledge needed to make better decisions and achieve better outcomes. For example, they asked, "What constitutes adequate advance regeneration? Does abundant advance regeneration ensure success without fencing? What soil-site-stand factors are correlated with regeneration success?" And for each of these questions (and many more), they designed a study. The flow chart even prioritized the studies. Although we do not know this for certain, we suspect that in addition to the traditional scientific approach to choosing research questions, this flow chart was influenced by the ideas that had been expressed by managers at that 1967 SAF meeting, and by ideas that Marquis was hearing as he built relationships with managers of public and private forests across the region.

As the research began, collaboration between management and research deepened, as many of the new studies were done in partnership with management agencies. For example, Allegheny National Forest managers cooperated when researchers sought to erect fences within a subset of the harvest areas in which regeneration had failed to develop. Even though the fences were erected after the harvest had been declared a regeneration failure, full stocking of desirable seedlings developed inside fences on 87 percent of the study areas (fig. 3). This result indicated that deer were a critically important barrier to regeneration success (Marquis 1974).

Another study on lands of the Allegheny National Forest showed that the presence of abundant advance regeneration was the most effective predictor of which final harvests would regenerate to desirable species composition and stocking (Grisez and Peace 1973, Marquis and Bjorkbom 1982). The news that advance regeneration mattered was delivered with recommendations for how to collect inventory data that would help managers recognize which stands met the advance regeneration requirements, and which would need some kind of silvicultural intervention to increase advance regeneration before a final harvest would lead to successful stand regeneration. Although understory inventory may seem obvious for hardwood silviculturists from a vantage point 40 years in the future, implementing such an inventory program demanded significant changes in forest management practice. Selecting appropriate stands to harvest had been something silviculturists could do based on overstory inventory data collected at any time of year. Now, they needed inventory data that were twice as expensive to gather, because both overstory and understory data were needed, and the effective season for such inventory was shortened to a few months in the growing season. Because the payoff was so high, and the guidelines for implementation were sensitive to managers' constraints, most agencies and industries on the Allegheny Plateau implemented the new inventory procedures. Managers implemented the inventory practices, but more important, they began to plan harvests in stands where advance regeneration was adequate. When those stands regenerated successfully, managers had real-world confirmation that the pre-harvest analysis was a sound basis for management.

BEGINNING A COMMUNITY OF PRACTICE

Another reason for widespread adoption of these early guidelines was the Allegheny Hardwood Silviculture training sessions (fig. 4). By 1976, research results had accumulated to the point that Roach and Marquis thought they were ready to give silviculturists something to aid with management decisions and improve outcomes from both regeneration harvests and intermediate treatments. Two people worked with the research staff to ensure that the content was useful and accessible to managers. One was the Penn State Extension forester of that era, Sandy Cochran, a partner from the very beginning. He had a special gift for asking the question everyone else was thinking, and he institutionalized post-session reviews of participant evaluations that led to progressive improvements in later sessions. The second person was Jim Redding (fig. 1), a forester from the Allegheny National Forest who joined the research staff and gave presentations at training sessions about how to use the SILVAH approach to inventory and marking and how the approach improved his practice. Cochran's role was later taken up by Dr. Tim Pierson.

In many ways, the training sessions shared the ideals of today's fire consortia: creating a forum for structured conversations about research needs, research results, and their application to management problems. The fundamental idea of the training sessions has not changed since the beginning; gathering high quality data about current conditions and analyzing those data using consistent and rigorous procedures gives professional resource managers an objective, research-based starting point in planning silvicultural prescriptions. This idea is the essence of what is now known as the SILVAH system. SILVAH guidelines were never intended as a substitute for professional judgment, but rather as a starting point, ensuring objective, consistent, and complete review of key factors.

When the first training sessions were given, the staff believed that in a few years they would have reached all the foresters on the Allegheny Plateau and the sessions would end. Very quickly, both managers and scientists realized that there were unforeseen benefits from annual training sessions. Organizers encouraged a diversity of participants, limiting any single agency or company to no more than 20 percent of the seats in any given class. They also encouraged full participation by the research staff, not "drop in, give a lecture, and depart." Marquis and his colleagues published a handbook of guidelines and a synthesis of their research basis, as well as the lectures from the training session (Marquis 1994; Marquis and others 1984, 1992). Organizers realized that the training sessions were creating relationships and a common vocabulary and framework for discussing emerging problems. In addition, as scientists regularly spent a week together listening to each other weave new research results into the SILVAH framework, they learned to resolve potential conflicts between results from different studies. Equally important, as agency heads and field foresters alike saw that research results could really help them do their jobs, the willingness—even eagerness—of management agencies to host research studies increased. Thus the cycle of research-management collaboration began to be self-perpetuating.

COMPUTERIZED DECISION SUPPORT

Even though the SILVAH approach to inventory, analysis, and prescription was always quantitative, it did not start out as a computer program. There were pages and pages of calculations, and in the early days, those were done with pen and pencil or a simple handheld calculator. Rich Ernst (fig. 1), a scientist at the Lab, began to program his handheld HP calculator to do the SILVAH calculations just to stay ahead of his crews in the training sessions. Over time, the software graduated to a Data General mainframe, then to early PCs, and continues to be updated as new scientific results are translated to management guidelines (Marquis and Ernst 1992; Knopp and Stout, in press). This happened just as PCs were beginning to be widely available, so we started to think that people might benefit from software to process their inventory data, producing both comprehensive analysis and the SILVAH recommendations. An early adopter was the Hammermill Paper Company, which used SILVAH to inventory all of its lands and develop a database of stand characteristics. In addition to helping with ownership-wide treatment plans —on how many acres will we plan to apply herbicide this year, and where are they?—the database also enabled them to have some market nimbleness: sugar maple (*Acer saccharum*) prices are up? We know exactly how to figure out which of our stands are stocked with a high proportion of sugar maple and which of those would benefit from a thinning.

EXPANDING SILVAH TO OTHER FOREST TYPES

When the Pennsylvania Bureau of Forestry sought third-party certification from the Forest Stewardship Council (FSC) in the 1990s, FSC commended the structured framework of SILVAH and recommended its expansion to mixed oak (*Quercus* spp.) forests. The Bureau of Forestry convened a committee of scientists and managers to address this recommendation. It included faculty from Penn State and Forest Service scientists from the Irvine, PA, (formerly Warren) Lab and from the Morgantown, WV, Lab. The process that emerged was quite remarkable. Participants worked to translate the important results from research elsewhere into the SILVAH framework. For example, using prescribed fire in combination with shelterwood harvests to regenerate oak forests in Pennsylvania was a novel approach, so research results from South Carolina (Barnes and Van Lear 1998) and Virginia (Brose and Van Lear 1998) were used to develop interim guidelines. Similarly, stump sprouting and dominance probabilities of oak reproduction in regenerating stands from Missouri (Sander and others 1976, 1984); and North Carolina (Loftis 1990) were used to develop interim criteria for inventorying oak seedlings. Equally important, the group identified research gaps and priorities to strengthen the recommended guidelines over time, and because the Bureau of Forestry has both regeneration and research funding available, they have been able to make a very substantial investment of dollars, lands, and in-kind support for silvicultural research to fill those gaps. The group also worked with field foresters to test the proposed new SILVAH procedures before full-scale adoption and to modify them as needed.

Once the SILVAH-Oak process had been validated and adapted to accommodate field forester observations and research studies had begun, Brose and others (2008) published a second SILVAH handbook for using SILVAH in mixed oak forests and launched a parallel series of training sessions focused on the SILVAH-Oak guidelines. The Bureau of Forestry is the primary partner in this effort. While there is considerable overlap of students within Pennsylvania for the SILVAH-Oak and Allegheny Hardwood Silviculture training sessions, the mixed oak sessions have also been in demand in several other States, and varying versions of the SILVAH-Oak training sessions have been offered in Indiana, Kentucky, Maryland, Ohio, and West Virginia.

MUTUAL BENEFITS ENSURE CONTINUED RESEARCH-MANAGEMENT COOPERATION

What has sustained SILVAH through 37 years since the first Allegheny Hardwood Silviculture training was offered in 1976? Why do foresters continue to use the software, attend the training sessions, and request specific research studies from the SILVAH team? Why do land management agencies, public and private, adopt SILVAH guidelines to support their silvicultural decision processes and provide sites and in-kind services for SILVAH-related studies? Why do scientists continue to work to ensure that research results are fit within the SILVAH system and reported at training sessions, and why do they continue to participate in the several weeks of preparation and participation that the training sessions demand each year? We believe that the success of the SILVAH system is due to the continued flow of benefits for both managers and scientists (table 1).

The benefits for managers include the obvious, consistent, and objective relationship between their decision-making criteria and scientific research. By using the SILVAH system, managers can show their stakeholders, from stockholders to members of the public, the link between research, the guidelines and data used for a specific decision, and the choices they make on the ground. For example, foresters in the Pennsylvania Bureau of Forestry must submit a SILVAH printout reporting both inventory results and SILVAH's recommended prescription when seeking approval of a timber sale. They are free to deviate from the SILVAH recommendation when working in a forest type SILVAH doesn't recognize, after mortality or wind events, in aesthetic road buffer zones, or on strip mine remediation. They are also encouraged to suggest deviations when local circumstances such as adjacency to a recently harvested stand, local evidence of a good seed crop of a seed-banking species, such as black cherry (*Prunus serotina*) or yellow-poplar (*Liriodendron tulipifera*), evidence of insect and disease impacts, or proximity to a stream suggest a modification, and they can use the SILVAH vocabulary and framework to explain their deviation.[2] Similarly, the Allegheny National Forest plan cites SILVAH in its *Silvicultural Guides for ANF Forest Types*.(USDA Forest Service 2007, appendix A, page A-5).

An additional benefit for managers is the opportunity to interact with scientists and managers from other agencies on a regular basis, using a common vocabulary and framework. Many agencies and organizations encourage or even require new employees to participate in a SILVAH training session early in their tenure, and they allow more experienced employees to participate again after intervals of 5 to 10 years. A week-long shared experience with ample field time and informal engagement during breaks builds comfortable relationships among all participants in the sessions, making it easier for either a manager to phone a scientist with an observation, question, or concern or for a scientist to contact a land manager to confirm the range of a particular problem or situation or to seek a study site. It also creates relationships among those who work for different agencies, so that as one agency or institution develops new ways to apply or even modify SILVAH guidelines, the innovation is diffused to other agencies and to the research community more rapidly than it would diffuse between agency heads.

The third benefit for managers is the ability to participate in the scientific process. The SILVAH community of practice makes this happen in several ways. First, concerns and observations voiced by managers at training sessions or in followup conversations influence the choice of problem selection for scientists. Second, managers become aware of studies early in their development and have opportunities to see treatments as applied and view preliminary results in the field. Finally, managers and scientists in the community may be able to see and hear preliminary research results as they make their way through the sometimes long and arduous process of publication. Although there is some risk that peer review may result in re-interpretation of results, scientists can communicate these changes easily to those who have requested early results, and to agencies through the regular training sessions. The manager-scientist relationship also allows for immediate discussion of seemingly new or unique problems as they arise, as well as timely site visits to improve the effectiveness of consultations.

The SILVAH community of practice helps both scientists and managers better understand the different cultures of science and management (USDA Forest Service 1997),

[2]Personal communication. 2014. Scott A. Miller. Chief, Silviculture Section, Pennsylvania Department of Conservation and Natural Resources, Bureau of Forestry, P.O. Box 8552, Harrisburg, PA 17105-8552.

which in turn helps scientists design studies in ways that increase the probability that lessons learned will be relevant to management decisions and will help managers, over time, ask questions in ways that lend themselves to testable hypotheses and formal research studies. Such open communications also allow for adjustments in recommendations as information in older published results is superseded by new, yet-to-be-published findings.

A second benefit for scientists is a wide network of thoughtful observers. Managers who are increasingly comfortable with the culture of science are often able to classify their field observations into useful classes. Two examples from the SILVAH history illustrate this advantage. As scientists and managers began to share concerns about sugar maple health in the Allegheny Plateau ecoregion, it was the observations of astute managers across the ecoregion that helped scientists design a study to test slope position and glacial history as potential causes of variation in sugar maple health, growth, and regeneration. The resulting gradient study relied on cooperation with managers to identify 19 different locations, some glaciated and some unglaciated, all with sugar maple in plateau-top and lower landscape positions, where the study took place, leading to real breakthroughs in understanding the effects of site quality on sugar maple health (Horsley and others 1999, Long and others 2009). The second is a current study of oak regeneration problems in south-central Pennsylvania that was designed to test differences in soils resulting from different geological formations as observed by the forester on site.

A third major benefit for scientists is access to both research sites and in-kind services, such as treatments. The sugar maple example, where managers helped scientists find 19 different topographic gradients with sugar maple growing along the gradient, is also illustrative of this example. A more recent case involves a current test of the hypothesis that the impact of white-tailed deer on vegetation is a joint function of the actual density of deer and the heterogeneity of vegetative communities, age classes, and forage production in the landscape surrounding the subject stand. To test this hypothesis, which itself was generated by shared observations of scientists and managers, scientists needed to find more than 20 locations in which harvests were planned in a given year, and in which the prior treatments were essentially the same. The cooperation of managers, the use of similar silvicultural practices, and lots of scientific legwork later, the study moved forward with 25 sites representing 7 different ownerships. One land manager even agreed to plan a harvest specifically to create sites for the study, if needed. An example of in-kind services provided by cooperating managers involves another study of changing deer impact on vegetation, where landowners cooperating in the Kinzua Quality Deer Cooperative have completed more than 1,300 miles of transects to detect deer pellets and browse damage on seedlings over the last 12 years (Royo and others 2010, Stout and others 2013).

SUMMARY AND CONCLUSIONS: LINK TO CONSORTIUM OF APPALACHIAN FIRE MANAGERS AND SCIENTISTS

There are many parallels between the SILVAH community of practice and the Consortium of Appalachian Fire Managers and Scientists. These parallels include regular interactions dedicated to understanding each other's knowledge and observations, along with emerging problems and emerging solutions. The SILVAH experience suggests that a well-defined framework that integrates management challenges with research-based solutions and highlights and prioritizes research gaps using common vocabulary will strengthen research-management collaboration in the long run. The SILVAH example also confirms that there are benefits to all participants, including early access to emerging solutions, increased access to careful observations of natural phenomena, and increased access to research sites and in-kind services. The community of practice or consortium model provides a basis for sustained relationships between managers and scientists that allows for the orientation of new participants, the maturation of existing participants, and retention of collective memory as older participants retire.

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Table 1—Attributes of the SILVAH system and the associated benefits to managers and scientists that have sustained the system through decades

Attribute of research/management cooperation	Benefit to managers	Benefit to scientists
SILVAH Decision Charts and Guidebooks provide objective, consistent, science-referenced basis for decisions	Demonstrably science-based decisions	Framework for resolving apparent conflicts as new research results emerge
Regular interactions provide scientists and managers with shared vocabulary and framework at training sessions	Access to emerging research results, relationships with scientists that provide timely consultations	Much wider network of systematic observations, relationships with managers that identify high-priority research needs
Managers are engaged in the full research cycle	Training sessions and resulting relationships allow users to participate in problem selection, research design, and science delivery	Scientists have increased confidence that research is relevant and that results will be adopted
Increased understanding of cultural differences between science & management	Managers develop increased understanding of scientific uncertainty	Scientists gain increased understanding of managers' timeframes and broader social context of decisions
Sharing of resources	Managers gain new tools for data collection, analysis, and interpretation	Scientists gain access to research sites and in-kind services.

Figure 1—Key members of the Forest Service team that launched the SILVAH system. Top row, left to right: Ben Roach, Dave Marquis, and Ted Grisez. Second row, left to right: John Bjorkbom, Lou Auchmoody, Steve Horsley, Rich Ernst, and Jim Redding.

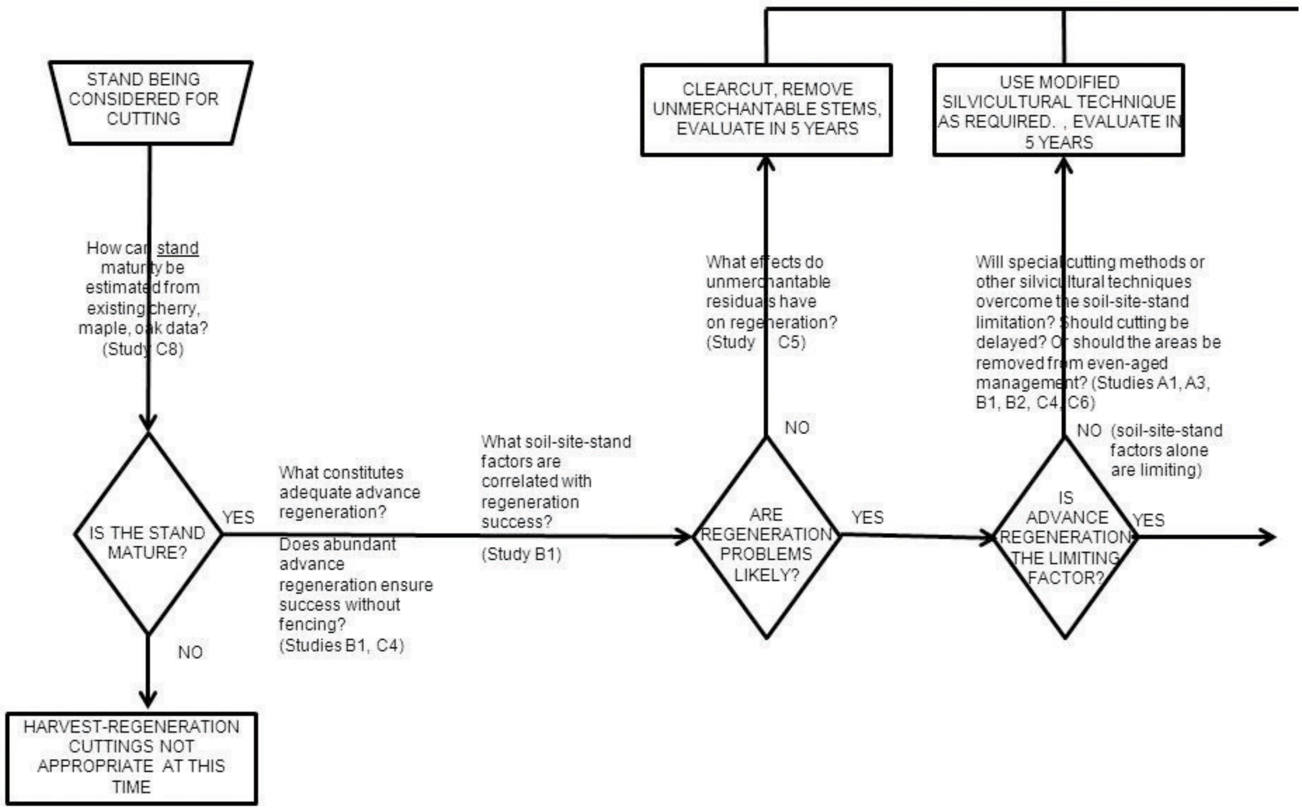

Figure 2—Excerpt from Research Problem Analysis, Research Work Unit NE-1108 (1971).

Figure 3—Regeneration on left is inside a deer-excluding fence and developed after the same harvest as the grasses on the right, which developed where deer eliminated seedling regeneration.

Figure 4—Participants in the first one-day SILVAH training session in 1976 and the most recent session in 2013.