NED AND SILVAH: A HISTORY OF THE COALITION

Mark J. Twery[1]

Insights for Managers

- **When SILVAH data are read into NED-3, they can produce lists of wildlife species that are likely to find suitable habitat in the stand represented by those data.**
- **SILVAH data can be interpreted from a water quality, aesthetic, or forest health perspective.**
- **NED users can essentially run SILVAH on their data from within the NED framework to provide access to the expert prescriptions available from SILVAH when their stands are of the forest types well served by SILVAH.**

INTRODUCTION

Forest management decision support software has been used for several decades. Many people have tried a variety of approaches, with varying degrees of success, to provide information that helps forest managers make decisions. This chapter documents some of the successes and failures of NED and SILVAH.

In 1988 the U.S. Department of Agriculture, Forest Service Northeastern Forest Experiment Station used its Genesis program to stimulate innovation. Under the leadership of H. Clay Smith, it convened the Stand Regeneration working group and, under the leadership of David Marquis, created the Stand Growth working group. Before that time, silvicultural research across the station had been scattered; each local researcher worked independently, which resulted in a variety of growth models and approaches to silvicultural analysis and prescription. The Genesis working groups used the SILVAH system of inventory, analysis, and prescription as a model to consolidate much of the silvicultural research that had been produced by scientists across the station's territory (Benzie 1977a, 1977b; Dale and Hilt 1989; Frank and Bjorkbom 1973; Lancaster 1985; Lancaster and Leak 1978, Leak et al. 1969, 1987; Perala 1977; Philbrook et al. 1973; Roach 1977; Safford 1983; Stout and Nyland 1986; Stout et al. 1987). The idea was to develop a software package that would provide a universal framework for sharing silvicultural research results and proposing recommended actions. The first step was to develop a software package that consolidated several growth models that had been developed independently around the northeastern United States, including SILVAH (Marquis and Ernst 1992), NE-TWIGS (Teck and Hilt 1991), Fiber (Solomon et al. 1995), and Oaksim (Hilt 1985). This software package was called the Northeast Decision Model, or later NED.

The Northeast Decision Model began as an effort to help foresters manage their various forest types for timber production, but the developers recognized the growing concern among forest managers who needed to manage for additional benefits, including wildlife habitat, water production and protection, recreation, visual qualities, and forest health. This recognition induced the recruitment of experts in each specialty the model needed to address.

[1] Research Forester (retired), USDA Forest Service, Northern Research Station, Burlington, VT 05428. To contact, call 802-862-4945 or email at mtwery@gmail.com.

The coalition of interested parties expanded NED through outreach to include resource specialists from the various state agencies in Pennsylvania, New York, New England, and the Lake States, among others. National forest managers in the region also volunteered to participate, as did private consulting foresters and researchers from a variety of universities.

In the summer of 1990 David Marquis and H. Clay Smith convened a large group of researchers and practitioners in the various fields for a field tour in Pennsylvania and West Virginia. The group originated with the Stand Culture and Stand Regeneration working groups and included silviculturists, wildlife biologists, landscape architects, social scientists, hydrologists, and ecologists. During this trip, participants discussed the conditions that were needed to provide wildlife habitat for species of interest, the aesthetic qualities of slash piles, the maintenance of water quality, and other topics.

The underlying assumption was that by manipulating vegetation through silvicultural activity, a forester could affect conditions in the forest. The right conditions could, in turn, increase or decrease the likelihood that a specific goal would be met, whether that goal was for timber, wildlife habitat, recreational aesthetics, or water production. The entire group recognized the need to find a common set of terms by which they could describe the conditions necessary to meet the goals of their specialties. Once defined in terms that could be evaluated from a forest inventory, the design was to create a computer program to help managers develop scenarios that would create the conditions that met their needs. It was readily apparent that a single committee could not efficiently accomplish the work related to so many disciplines, so the group subdivided into expert committees. At the same time, the need for a common framework and vocabulary necessitated a steering committee whose members would help each disciplinary committee use the common terms and concepts consistently.

At the end of 1991 David Marquis retired, and leadership of NED passed to Mark Twery, another USDA Forest Service Northeastern Research Station scientist.

NED is a set of decision support tools designed for the analysis of integrated prescriptions for managing forests for values up to a landscape scale. It is organized around four steps for creating management plans:

1. Define the goals for managing a property.
2. Collect data to determine current conditions on the property.
3. Analyze the data to compare current with desired conditions to develop prospective prescriptions to achieve the management goals.
4. Compare simulations of forest development under a variety of prescriptions to determine which scenario is most likely to achieve the identified goals.

From its beginnings in the late 1980s and early 1990s, NED differed from SILVAH in several ways:

- NED explicitly included multiple values and disciplines.
- NED allowed for inclusion of multiple stands and some consideration of spatial arrangement of those stands on and in a landscape.
- NED covered many more forest types than SILVAH.

SILVAH still offered explicit expert silvicultural prescriptions to optimize timber growth and ensure diverse regeneration for a narrower range of forest types.

EARLY DEVELOPMENT

The NED team created a program known as NED/SIPS, the Northeast Decision Model Stand Inventory Processor and Simulator (Simpson et al. 1995). This program ran in DOS and enabled consulting foresters to summarize inventories and analyze potential growth of timber for an individual stand. NED/SIPS borrowed heavily from SILVAH (Marquis and Ernst 1992) in philosophy and format, but it did not include the expert system function in which SILVAH advises the user on the right action for a particular stand (Marquis et al. 1992). Many consulting foresters in the Northeast adopted NED/SIPS; however, it was of limited utility to public land foresters and others who needed to evaluate management across resources and across a landscape because it did not address other resources.

In parallel with NED/SIPS, the team began to develop a program to incorporate the knowledge gleaned from the various disciplinary expert committees. This program became known as the Forest Stewardship Planning Guide (FSPG) (Alban et al. 1995). FSPG and all subsequent programs were developed in the Microsoft Windows® environment. The target users were consulting foresters and private landowners, who together could use the program to help clarify the landowner's goals and identify which resources could be managed at the same time on the same piece of land, and which needed to be separated in either time or space. However, FSPG was built simply to evaluate alternatives in principle without incorporating field data from a forest inventory. FSPG did find use among consulting foresters in the Northeast, and it became commonly used in introductory forestry programs at schools around the region.

An additional stand-alone program to evaluate wildlife habitat took form at this time. Known as NEWILD (Thomasma et al. 1998), the information previously published by DeGraaf et al. (1992) in book form was converted into rules that could be evaluated in the computer based on the forest inventories. The creation of new inventory guidelines that included characteristics not usually addressed by foresters but necessary or useful for evaluating habitat (shrub cover, litter cover, high perches, etc.) was another outcome of NED development during this period, based on work by Cleveland and Finley (1998). One key innovation of NEWILD was the presentation of lists of wildlife species with potential habitat in any stand based directly on foresters' inventories.

NED-Health was another program developed as a component of the NED project. It provides information on stress agents such as insects, fungi, weather, and people, that affect the health of the trees within a forest. The program analyzed the composition of a specific forest and identified potential causes of damage, methods to recognize specific agents, and possible actions to avoid or mitigate damage. It was built from a single screen much like that of NEWILD, but it added a screen to allow display of several information options. Although identified as potentially useful information, the resources available could not keep up with the changing world of pests and forest health issues, and the program never received wide distribution. Its resources continued to be available in other subsequently developed programs, however.

The next step in development, to incorporate field data from an inventory on a multiple-stand property and evaluate these data for multiple resources, occupied the late 1990s and resulted in the program known as NED-1 (Twery et al. 1998, 2000). NED-1 created the context in which to incorporate the rules developed by each disciplinary expert committee and evaluate them in the context of the other resources. See, for example, analysis of water goals in the context of forest management presented by Twery and Hornbeck (2001). The wildlife habitat analysis structure used in NEWILD was developed using Cleveland and Finley's (1998) rules

for Pennsylvania and incorporated into NED-1. Because the tasks of integrating multiple resources into a unified analysis across multiple forest stands were complex, we decided to delay incorporating growth simulation in the combined model. At this point development expanded to include researchers and practitioners from outside the northeastern United States, and the name of the effort changed from the Northeast Decision Model to NED.

CONTINUING DEVELOPMENT

Geographical expansion of NED centered around the southeastern United States; key players included Michael Rauscher of the Southern Research Station and Donald Nute and Walter Potter of the Artificial Intelligence Institute at the University of Georgia. Through this collaboration, we developed a structure to integrate the goals of forest inventories with a method by which we could analyze the degree to which goals were likely to be met under a variety of conditions (Nute et al. 2002, 2004; Rauscher et al. 2000, 2001). This work developed into the program NED-2 and used PROLOG as a basic framework for handling the artificial intelligence needed to manage the integration.

We determined that the best way to integrate treatments and growth simulation into the program would be to use a well-supported simulator, so we chose the Forest Vegetation Simulator (FVS) (Crookston and Dixon 2005). We could thus implement simulated treatments and use a variety of growth models to project development of the forest stands. The NED development team used FVS as the engine behind the scenes to create its own interface within the NED-2 system to design and schedule treatments and implement growth projections (Wang et al. 2002).

Other side projects that sprang from the NED development work included Stewplan, (Knopp and Twery 2003), which attempted to provide a template for consulting foresters to generate stewardship plans that conformed to standards that allowed private forest landholdings to participate in cost-share programs. Stewplan was successfully distributed to consulting foresters and state service foresters throughout the region, and some states adopted policies accepting a Stewplan report as a valid format for their stewardship plans.

Another related development effort was NED-Lite (Knopp and Twery 2006), which was developed as way to allow electronic data entry to be performed on handheld devices in the field. This saved time and eliminated transcription errors in the process of copying data from paper field sheets into the computer. NED-Lite was developed for the Palm operating system and achieved a favorable reception among consulting and service foresters, but the Palm system lost popularity, making it difficult to keep up with changing software requirements. NED-Lite was adapted at least partially to the Microsoft CE system for handheld devices and saw further use, but lack of adequate resources relegated this software to use by only a devoted few.

Wildlife habitat analysis continued, and the regions where it was applied continued as the principles and structure of NEWILD were adapted to Pennsylvania, Michigan, and Maryland (Thomasma and Cleveland, 2019).

Development of NED-2 (Twery et al. 2011, 2012) continued through the decade; it became useful in a variety of contexts. Numerous college and university programs around the Northeast adopted it to teach students forest inventory summarization techniques and to analyze alternative management strategies.

NED-2 allowed users to create scenarios of management activities across multiple stands in a management area through time and allowed analysis of conditions at any step. Analysis of a snapshot of conditions allowed evaluation of the degree to which stated goals were being met through comparison of actual or simulated conditions to those identified as desired conditions based on previously assembled expert knowledge and identified goals. One considerable limitation to these analyses was the constraint imposed by the lack of simulation models to project changing conditions other than the standing inventory of trees. For example, abundance and size in the understory of species other than trees are not modeled in existing systems, nor are the times needed for trees that die to progress from snags to down woody material to forest floor organic matter.

These experiences proved useful, both for actually managing forests and for showing the shortcomings of NED-2. One of the primary problems identified was the slow speed at which NED-2 ran simulations. Once this slowness was traced to the use of PROLOG as the controlling software, we determined to rewrite the software without PROLOG, using C++ for all major functions. This change resulted in development of NED-3, which is the current state of the NED software (https://www.nrs.fs.fed.us/tools/ned/). NED-3's improvements include a flexible data import facility, much faster simulation using all variants of FVS, which can be customized from the NED-3 interface, a wider variety of user-selected and user-defined treatments, and an improved report selection interface.

INTEGRATION BETWEEN NED AND SILVAH

Because NED-3 was being developed by the same people who were updating and expanding SILVAH, the development of the two programs could overlap again. The current version of NED-3 can run SILVAH (https://www.nrs.fs.fed.us/tools/silvah7/) directly to generate standard SILVAH output from inventories created using NED data inputs.

Shared resources and shared approaches to addressing multiple management objectives, integrated inventories, and comprehensive analyses allow NED and SILVAH to use each other's development products to good effect. For example, the NED wildlife habitat analyses were relatively easy to incorporate into SILVAH's later versions with minimal adjustment of inventory parameters. SILVAH's expert system advice on next steps in a management scenario has been incorporated into the NED interface directly, because SILVAH on NED inventories can be run within the NED program.

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