WILDLIFE HABITAT ASSOCIATIONS IN SILVAH AND NED

Scott Thomasma and Helene Cleveland[1]

Insights for Managers

- **For several states in the northeastern and north-central United States, habitat assessment models have been developed that link wildlife species to the structural and compositional features of forests as determined in forest inventories.**
- **Four of these are included in the NED decision support system and in a stand-alone program called WHAM (Wildlife Habitat Assessment Matrices).**
- **Users of SILVAH and NED can access the models in NED and produce lists of species whose habitat needs are met based on the data collected.**
- **The Pennsylvania habitat assessment model originated in the 1990s and has been recently updated through cooperation with a committee of wildlife scientists and several of the Commonwealth's Biological Survey technical committees.**

INTRODUCTION

Foresters and wildlife managers have long known that forest management activities have impacts on wildlife communities (see Smith 1962). Research has also shown that private landowners often cite provision of wildlife habitat as one of their main reasons for owning forest land (Hodge 1996, Jones et al. 1995, Kluender et al. 1999). Direct census of wildlife populations is challenging and expensive, and until the late 1980s, publications developed to provide information on how forest management activities can benefit wildlife tended to focus on single species, especially game species, and how to manage their habitats, such as deer wintering areas in northern regions (see Berner and Gysel 1969, Boer 1978, Larson et al. 1978).

In 1969 a breakthrough occurred as a result of an effort led by Jack Ward Thomas, who was a USDA Forest Service wildlife biologist and later Chief of the Forest Service. The breakthrough was the first report that listed wildlife habitat associations for hundreds of species in a specific region: the Blue Mountains of Oregon and Washington. The report contained various matrices that showed what each species' habitat needs were, such as bogs, snags, or standing water. The authors believed that "Habitat, therefore, is the key to organizing knowledge about wildlife so it can be used in forest management" (Thomas 1979).

[1] Computer Programmer (ST) and Forester (retired) (HC), USDA Forest Service in Michigan and Washington, DC, respectively. ST is corresponding author: to contact, call 906-361-1716 or email scott.thomasma@usda.gov.

Table 1.—Vegetative and physical structural features

Layer	Feature
Ground (0–2 feet)	Amount of dead and downed logs
	Percent cover of rocks, forest litter, and vegetation
Shrub (2–10 feet)	Percent cover of vegetation
	Type of shrub (deciduous, coniferous, ericaceous)
Midstory (10–30 feet)	Percent cover and type (deciduous and coniferous)
	Snags (dead trees)
	Trees with cavities (live or dead)
Overstory (>30 feet)	Same as midstory
Within-stand	High exposed perches—live or dead overstory trees that clearly tower above the main canopy
	Low exposed perches—those in the shrub layer such as fences, downed tops, or snags shorter than 10 feet
	Water sources—vernal ponds, permanent ponds, seeps, and perennial streams
	Subterranean habitat—friable soil (soil that can be burrowed into), rock piles, rock crevices leading below the frost line, and caves
	Mast species—soft or hard mast producers

DEVELOPMENT OF HABITAT ASSESSMENT MODELS FOR EASTERN FORESTS INCLUDING PENNSYLVANIA

For northeastern foresters, Richard DeGraaf and his colleagues began work to produce a similar tool (DeGraaf et al. 1992, DeGraaf and Rudis 1986). DeGraaf et al. (1992) compiled habitat information for more than 300 species of amphibians, reptiles, birds, and mammals. The report contained matrices that showed the forest type, size-class, and the horizontal and vertical structural features (Table 1), such as cavities or ground cover, required by each species.

DeGraaf et al. (1992) inspired much additional work. Some of that is described in Twery (2019) as early products of the NED development team (Thomasma et al. 1998, Twery et al. 2012). Northrop (2009) followed this model in Maryland, and Thomasma et al. (2007) followed it in Michigan. In Pennsylvania in the early 1990s, Jim Finley of Pennsylvania State University and student Helene Cleveland carried these ideas one step further. Their work was intended to modify a traditional silvicultural inventory to also acquire data on structural features important to wildlife and use data from such an inventory to determine which wildlife species had potential habitat in a stand. Their work involved three steps:

1. Review and adapt or acquire habitat data for Pennsylvania.

   Because the DeGraaf et al. (1992) publication was for New England, we needed to review that information to determine which species inhabited Pennsylvania and whether their habitat needs were different. To acquire habitat data, we sent a series of questionnaires to the Pennsylvania Biological Survey technical committee members, to biologists in the Pennsylvania Game Commission, and to experts in the mid-Atlantic region asking for their help in reviewing and revising the New England habitat data and acquiring data on species inhabiting Pennsylvania but not New England. The result was habitat data for 227 Pennsylvania species.

2. Determine how to measure habitat structural features quickly and accurately in a way that would complement a silvicultural inventory.

   To modify a silvicultural inventory to measure habitat structural features, we researched various methods to determine percent cover, dead and downed woody debris, cavities, etc. After reviewing texts of sampling methods (Brower and Zar 1977, Brown 1954, Schreuder et al. 1993) and conducting inventories at the Penn State Stewardship Forest (Harvey 1994), it became apparent that some structural features would be expensive to measure accurately. These features appear in such small quantities or are so scattered in the stand that they would require an excessive number of plots to be statistically accurate. However, these features are important habitat components. The compromise, in most situations, is to note their presence if they occur within a stand. These within-stand features (Table 1) include water sources (vernal or permanent ponds, perennial streams, or seeps); subterranean habitats (friable soil, rock piles, rock crevices, or caves); and soft or hard mast-producing species. For the other features we investigated various percent cover measurements, line transects for dead and downed logs, relative density, and basal area measurements.

3. Develop an easy way to use the computer capabilities of the early 1990s to manage the data to provide a list of species that potentially had habitat without going line by line through the matrices for hundreds of species.

The result was the Habitat Assessment Model or HAM (Cleveland and Finley 1998, Harvey 1994), which contained an inventory process to produce stand-level data that could be used in a manual format (using groups of species) or a computer format to determine a list of potential species' habitats. Foresters could also predict the changes an activity would make to the stand, for example, changes caused by a thinning or shelterwood. Foresters could run the predicted post-treatment data again and get a list of species' habitats that would be in the postactivity stand. The second list would provide an idea of which species' habitat would be lost, added, or unchanged to aid in decisionmaking.

For the original computer format and for HAM's inclusion in the NED program, every species in HAM has a rule that is compared to inventory data. An example using the winter wren (Table 2) shows it uses only three forest types and only the large sawtimber size-class. It also needs dead and downed wood, either deciduous or coniferous shrubs, and live or dead cavity trees. So if a stand with these features is entered in NED, the program will list winter wren as having potential habitat in the stand.

As with any program or model, habitat assessment models have important limitations:

- Information about structural features for some species is limited, and assessment outcomes should be treated as hypotheses.
- Inventory data are averages and do not reflect patchiness that a species may be using.
- The inventory is for a single stand—it does not consider nearby landscape variables that may influence site use by some species.
- Forest types were based on DeGraaf et al. (1992) and needed to be expanded to fit Pennsylvania conditions.

Table 2.—Computer rule showing habitat requirements for winter wren

WHITE PINE or EASTERN HEMLOCK or WHITE PINE/RED OAK/RED MAPLE
And LARGE SAWTIMBER
And 50 cu ft DEAD & DOWN
And DECIDUOUS SHRUBS (> 20%) 'or ' CONIFEROUS SHRUBS (> 20%)
And DEAD CAVITY TREES or LIVE CAVITY TREES

RECENT UPDATES AND IMPROVEMENTS

As more wildlife managers became aware of the SILVAH-Oak guidelines for sustaining oak in oak forests and participated in the associated training sessions (see Brose 2019), interest in strengthening the wildlife relevance of SILVAH grew. In September 2012 the SILVAH team held a workshop for interested wildlife managers. The goal was to brainstorm ways to strengthen the wildlife aspects of SILVAH and to introduce Pennsylvania wildlife managers to NED and its capabilities. The result of the meeting was a sustained effort that included three main thrusts:

1. Update the Pennsylvania habitat assessment data.
2. Develop a stand-alone tool that is based on all the models currently in NED to explore wildlife habitat relationships in forest.
3. Strengthen the links between SILVAH and NED so SILVAH users would be able to use the same data to access recommendations for regenerating and managing oak forests and the wildlife habitat assessment capabilities of NED.

UPDATING PENNSYLVANIA WILDLIFE HABITAT RELATIONSHIPS

To minimize the limitations and take advantage of habitat research since 1994, the original HAM data (Harvey 1994) were compared with habitat data from the 2005 and 2015 Pennsylvania Wildlife Action Plan and habitat data on other refereed websites (such as Birds of North America at Cornell University). Members of the Pennsylvania Biological Survey technical committees and other experts are reviewing and revising the resulting data. Their revisions will be incorporated into NED. At the same time, a built-in update process has been added to the software to allow experts to provide suggested changes at any time. The SILVAH/NED wildlife team will then review and incorporate these suggestions.

The Pennsylvania Game Commission has provided up-to-date species ranges by county (the original model had ranges by physiographic provinces) and other State of Pennsylvania databases.

The updated Pennsylvania habitat assessment model was also compared to MDWILD (Northrop 2009), to habitat associations in the 2015 Pennsylvania Wildlife Action Plan, and to U.S. Forest Service Forest Inventory and Analysis forest types to expand HAM forest types to include oak-hickory, oak-pine, and hard pine (pitch pine, Virginia pine, etc.). Release of the newest updates is awaiting final review by the Forest Service biologists.

Acquiring data on species' habitat structural features is difficult and complicated. However, as stated in the 2005 Pennsylvania Comprehensive Wildlife Conservation Strategy (which became the Wildlife Action Plan):

> "Clearly defining species-habitat associations is somewhat complicated … Though complicated and incomplete, it is nevertheless vitally important to attempt to associate species with their key habitats to begin formulating conservation goals and objectives" (PGC-PFBC 2005).

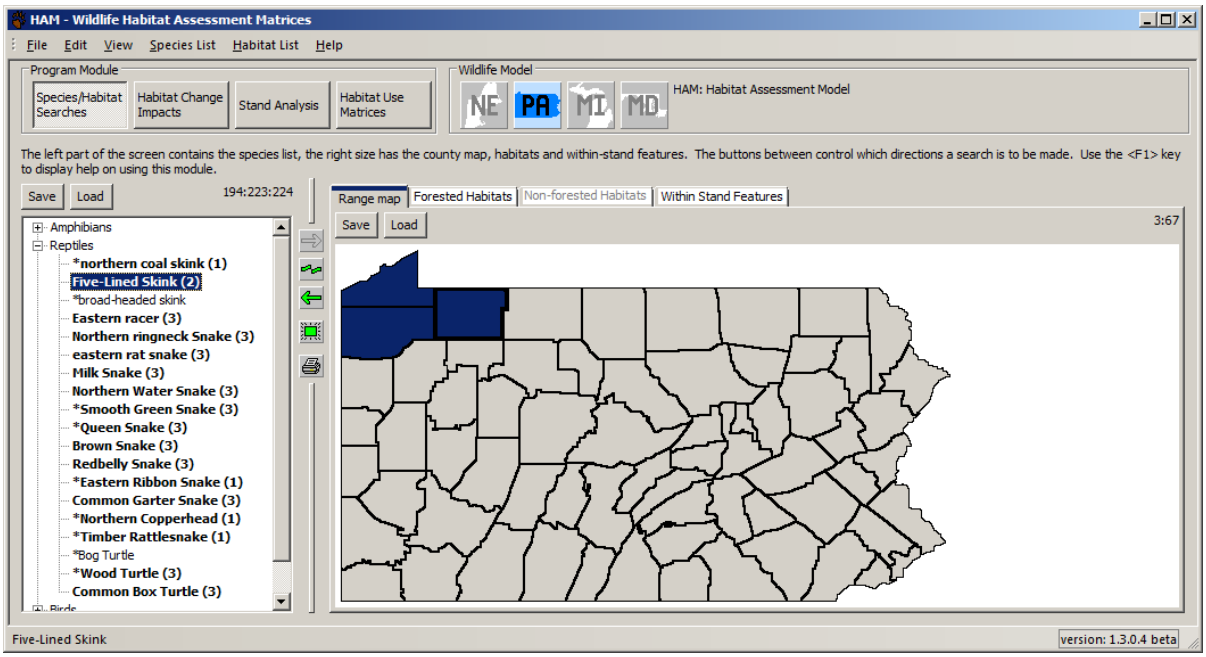


Figure 1.—Species list (species in bold) for three northwestern Pennsylvania counties.

DEVELOPMENT OF WHAM

The updated models for Pennsylvania, as well as those for Michigan (MIWILD; Thomasma et al. 2007), Maryland (MDWILD; Northrop 2009), and the model based on the DeGraaf et al. (1992) data (NEWILD; Thomasma et al. 1998), are included in a new computer program called the Wildlife Habitat Assessment Matrices (WHAM, a stand-alone program that contains all the data from the four habitat models, including species ranges, forest types, size-classes, structural features, and, for some models, nonforest structural features such as agricultural land. It relies on specific but qualitative or presence/absence information about habitat attributes rather than inventory data and can provide information at several scales of space and time.

WHAM can provide species lists by county or several counties. Figure 1 shows which species inhabit three counties in northwestern Pennsylvania. The numbers after the species names indicate the number of counties of the three in which it was found. A search can also be done in reverse; that is, by clicking on one or several species the user can find which county or counties they inhabit. Similar searches can be done for forest types, size-classes, and within-stand features and any other data in the matrices.

WHAM can also help you understand habitat change. Figure 2 shows the results of a stand growing into the next size-class. The "pre" condition acreage was northern hardwoods 20 acres, red maple (*Acer rubrum*) 30 acres, and balsam fir (*Abies balsamea*) 50 acres, all in the seedling size-class. The "post" conditions are the same acreages for the same forest types, but at the sapling-pole size-class because of growth. The species list on the right shows habitat gains and losses. The red cells are losses, the green are gains. The Blackburnian warbler (*Setophaga fusca*) gains 50 acres, and the chestnut-sided warbler (*Setophaga pensylvanica*) loses 50 acres. The values in the "pre" and "post" conditions could also represent changes caused by forest management actions; the results would show the difference in wildlife habitat. This type of lookup has also been used to evaluate land swaps where an agency was contemplating exchanging ownership of one area for another.

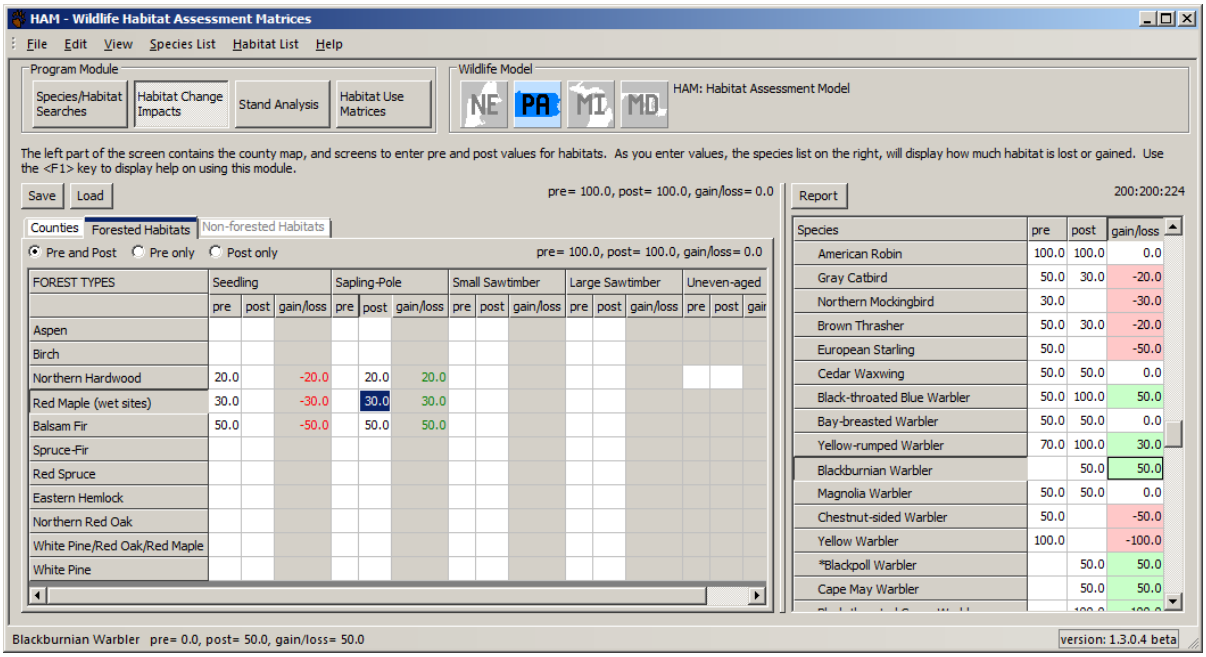


Figure 2.—Habitat change caused by trees growing into next size-class.

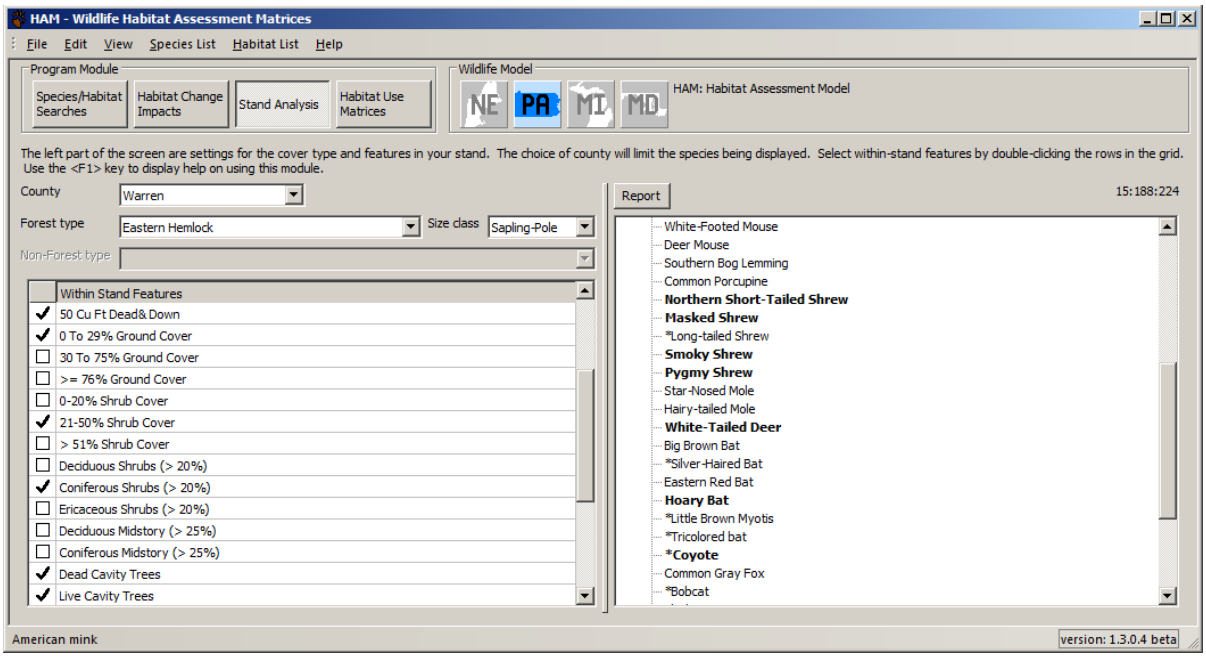
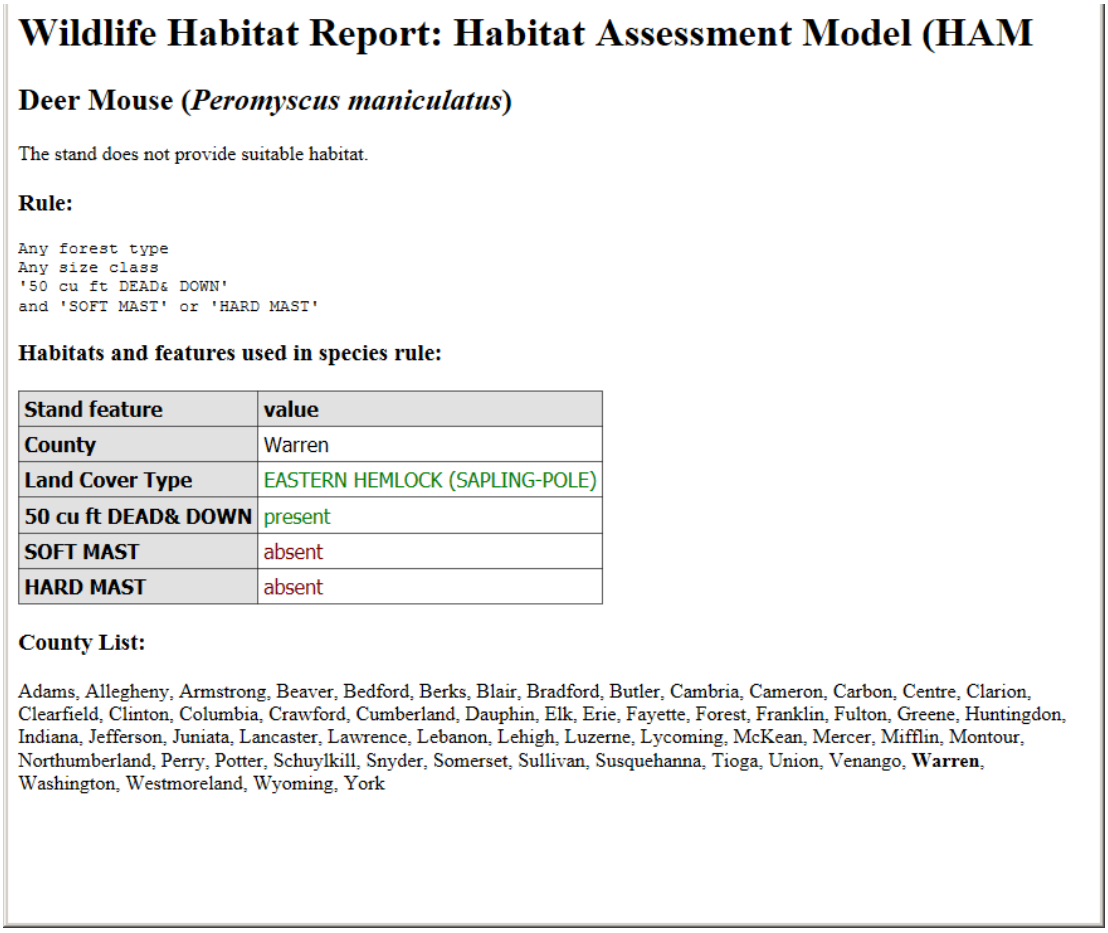


Figure 3.—Species list for an eastern hemlock sapling-pole stand in Warren County, PA.

Figure 3 shows the results of a single stand evaluation. In this example, the stand is located in Warren County (which limits the species list to the right on the figure). It's an eastern hemlock (*Tsuga canadensis*) sapling/pole stand, and a few within-stand attributes have been selected including dead/downed and forest litter. The species list on the right has the wildlife species (in bold) for which the stand meets the rules. The evaluation is conducted using the species rules and finding species whose habitat attributes are found in the stand. For example, the masked shrew (*Sorex cinereus*) is boldface on that list. The deer mouse (*Peromyscus* spp.) and other species are not included, because some feature they need does not exist on the stand.



Wildlife Habitat Report: Habitat Assessment Model (HAM

Deer Mouse (*Peromyscus maniculatus*)

The stand does not provide suitable habitat.

Rule:

```
Any forest type
Any size class
'50 cu ft DEAD& DOWN'
and 'SOFT MAST' or 'HARD MAST'
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Habitats and features used in species rule:

Stand feature	value
County	Warren
Land Cover Type	EASTERN HEMLOCK (SAPLING-POLE)
50 cu ft DEAD& DOWN	present
SOFT MAST	absent
HARD MAST	absent

County List:

Adams, Allegheny, Armstrong, Beaver, Bedford, Berks, Blair, Bradford, Butler, Cambria, Cameron, Carbon, Centre, Clarion, Clearfield, Clinton, Columbia, Crawford, Cumberland, Dauphin, Elk, Erie, Fayette, Forest, Franklin, Fulton, Greene, Huntingdon, Indiana, Jefferson, Juniata, Lancaster, Lawrence, Lebanon, Lehigh, Luzerne, Lycoming, McKean, Mercer, Mifflin, Montour, Northumberland, Perry, Potter, Schuylkill, Snyder, Somerset, Sullivan, Susquehanna, Tioga, Union, Venango, **Warren**, Washington, Westmoreland, Wyoming, York

Figure 4.—Habitat report showing the features needed by the deer mouse.

The user can click on "deer mouse" to see a wildlife report (Fig. 4) that shows the features needed by the deer mouse and comparing them with the attributes of the stand data that were input. For the deer mouse, neither soft nor hard mast was listed as a stand attribute. The program shows how the species list changes when within-stand attributes are added to or removed from the stand. In this example, if the user goes back and checks off one of the mast types (hard or soft), the deer mouse will be included.

Strengthening the SILVAH/NED Connection

We use the same wildlife rules in habitat evaluation in NED (Twery et al. 2011, 2012). NED is a forest ecosystem management decision support system (https://www.nrs.fs.fed.us/tools/ned/products/ned3/). It contains a family of software products that are intended to help resource managers develop goals, assess current and future conditions, and produce sustainable management plans for forest properties. There is an easy way to import SILVAH (https://www.nrs.fs.fed.us/tools/silvah/) data into NED, and it was decided not to duplicate the same wildlife analysis in both programs. NEWILD, MIWILD, HAM, or MDWILD are used for wildlife analysis. NED has the advantage of being able to input or import inventory data (e.g., SILVAH data) from several stands and evaluate how the stands meet species' needs using the same rules as WHAM.

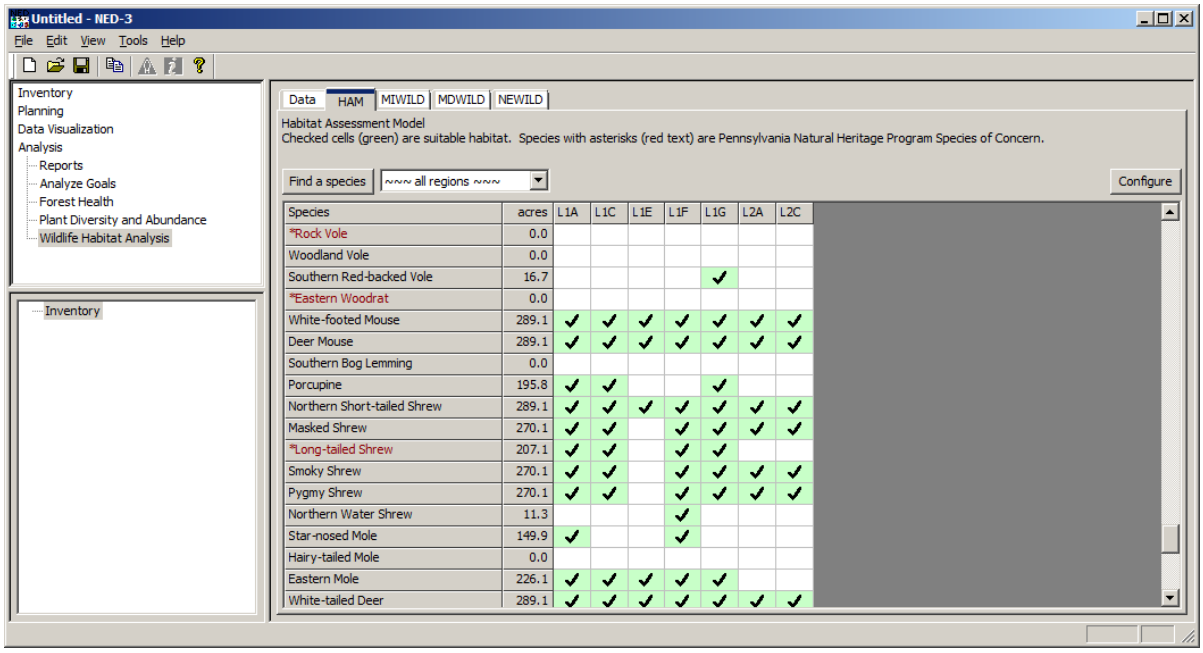

Figure 5.—Wildlife list for multiple stands in NED.

Figure 5 shows the species that find habitat in various stands in a single property (highlighted with a green arrow). A click on any green arrow (or empty cell) brings up a short description of the habitat requirements that were evaluated so the user can understand the model. A user can run this model on stand conditions before and after a silvicultural treatment to understand possible habitat changes.

Clicking on the block for the southern red-backed vole in stand L1G brings up the report in Figure 6. The report shows how the stand attributes meet the species rule. To understand why the southern red-backed vole (*Myodes gapperi*) does not have habitat in stand L1F, the user must view the report by clicking on the box and the data from the inventory. The report shows that the stand lacks sufficient shrub cover (Fig. 7). The stand contains only 3.8 percent shrub cover, when it needs a minimum of 21 percent shrub cover. Therefore, stand L1F does not provide all the necessary habitat structural features for the vole.

The NED and WHAM programs quickly allow users to determine which species potentially have habitat in the stand or stands. By evaluating which structural feature may be limiting, the manager can plan to add or create the feature in the stand; for example, piling rocks for basking sites along skid roads, leaving cavity trees, or creating vernal ponds. Paraphrasing one of the HAM reviewers, "no one is going to manage for shrews or voles, but they are extremely important to higher predators and it's good to show managers what structural features are important to them so they can plan accordingly."

Wildlife Habitat Report: Habitat Assessment Model (HAM)

Stand: L1G

Southern Red-backed Vole (*Myodes gapperi*)

The stand is suitable habitat, the following conditions are met: Any forest type Any size class '50 cu ft DEAD& DOWN' and '21-50% SHRUB COVER' and '30% FOREST LITTER'

Species Rule:

```
Any forest type
Any size class
'50 cu ft DEAD& DOWN'
and '21-50% SHRUB COVER' or '> 51% SHRUB COVER'
and '30% FOREST LITTER'
```

Habitats and features used in species rule:

HAM feature	NED variable	value
Habitat Type	HAM Forest Type NED Forest Type	WHITE PINE oak southern pine
Size Class	Size class	large sawtimber
50 cu ft DEAD& DOWN	Coarse Woody Debris	178.3 (cu.ft./ac.)
21-50% SHRUB COVER	Shrub layer cover	28.3 (% cover)
30% FOREST LITTER	Leaf litter cover	80.0 (% cover)
> 51% SHRUB COVER	Shrub layer cover	28.3 (% cover)

Figure 6.—Report showing how stand L1G attributes meet the habitat rule for the southern red-backed vole.

Wildlife Habitat Report: Habitat Assessment Model (HAM)

Stand: L1F

Southern Red-backed Vole (*Myodes gapperi*)

The stand does not provide suitable habitat.

Species Rule:

```
Any forest type
Any size class
'50 cu ft DEAD& DOWN'
and '21-50% SHRUB COVER' or '> 51% SHRUB COVER'
and '30% FOREST LITTER'
```

Habitats and features used in species rule:

HAM feature	NED variable	value
Habitat Type	HAM Forest Type NED Forest Type	NORTHERN HARDWOOD Appalachian hardwoods
Size Class	Size class	small sawtimber
50 cu ft DEAD& DOWN	Coarse Woody Debris	90.8 (cu.ft./ac.)
21-50% SHRUB COVER	Shrub layer cover	3.8 (% cover)
30% FOREST LITTER	Leaf litter cover	60.0 (% cover)
> 51% SHRUB COVER	Shrub layer cover	3.8 (% cover)

Figure 7.—Report showing how stand L1F attributes do not meet the habitat rule for the southern red-backed vole.

CONCLUSION

Since the early 1990s, developments in the NED family of decision support tools included increasingly powerful ways to understand the relationships between forest attributes, forest management, and the known habitat needs of hundreds of wildlife species. The result is a family of computer programs, including NED, WHAM, and, indirectly, SILVAH, which provide powerful support for managers who want to consider wildlife habitat needs and consequences of management actions.

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