Northeast Region SARE and ACE Programs
SECTION 1

General Information:

1. **Project Number:** LNE93-38
   Grant Number: 404 - 53 / 393E
   Funding Period: June 1, 1993 — May 31, 1996

2. **Project Title:** Biodiversity Education Through the PA Forest Stewardship Program

3. **Project Coordinator:** James C. Finley, Ph.D., Stephen B. Jones, Ph.D., & Robert P. Brooks, Ph.D.

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4. **Type of report:** Annual

5. **Date of report:** December 14, 1995

6. **Reporting period:** From October 1, 1995 to November 30, 1995

7. **Major Participants:** No new information

8. **Cooperators:** No new information

9. **Project status:** Continuation of a previously approved project, following revision and completed review

10. **Statement of Expenditures:** Follows this sheet

LNE 93-38 final report

Project Title: Biodiversity Education Through the Pennsylvania Forest Stewardship Program

SECTION II

1. Objectives

1. Develop procedures for assessing biodiversity on farm and private woodlots.
2. Establish a demonstration site for biodiversity management.
3. Expand the state's capacity to develop and deliver educational programs on biodiversity.

2. Abstract

Two main goals of this project are:

- to provide professional foresters with a methodology to rapidly assess the nature and quality of habitat components, and
- to provide private forest landowners—including farmers—with an understanding of biodiversity and the potential impacts their activities have on biodiversity.

Biodiversity if defined as the variety and variability among living organisms and the ecological complexes in which they occur. This was the starting point at which development began.

3. Specific Project Results

A. Findings and Accomplishments

Biodiversity Education workshops designed to introduce the assessment protocol and analysis program, now called HAM for Habitat Assessment Model, to private forest landowners were held on May 31-June 1, 1996 and September 20, 21, 1996. Participating in the workshops were several teachers and nearly 50 VIP/Coverts volunteers. VIP/Coverts volunteers are private forest landowners who after application to the Pennsylvania Forest Stewardship Program complete 40-hours of intensive training in forest resource issues and management. The training carries with it an obligation to provide 40-hours of service, including outreach to peers and support of the Forest Stewardship Program. Some VIP/Coverts volunteers choose to participate in additional training such as an introduction to the methodology developed in this grant.

March 13, 1996 an invited paper entitled "Assessing Wildlife Habitat: Working at the Stand Level: was given at Maintaining Biodiversity: The Essence of Intelligent Tinkering Conference held at Shippensburg State University. More than 70 attendees, principally teachers, attended the presentation and several subsequently enrolled in the aforementioned two-day workshops. Their hope was to use HAM in middle and senior high school science curriculums.

The US Forest Service Northeast Forest Experiment Station (NEFES) has completed a second season of field work validating HAM by comparing predicted species to census data on 18 study areas. Likewise the Procter and Gamble Corporation and Audubon partnership completed an additional 14 assessments this past season. Their hope is to use HAM to work with private landowners and timber harvesters, showing them the changes in habitat caused by their harvesting decisions. Their intent obviously is to support forest stewardship on private forest lands.

The NEFES has decided that the HAM protocol and decision matrix used in the HAM model will become part of the NED Planning Guide and NEWild. These are computer programs developed by the NEFES to assist landowners in defining their land ownership objectives. HAM uses data originally published by NEFES; however, until HAM they lacked simple protocol for describing habitat components. The NED Planning Guided and NEWild when completed will used directly by landowners and by resource professionals working with them.

Two articles were developed from the research and submitted to the Northern Journal of Applied Forestry. Both are back from review and are being prepared for resubmission

B. Dissemination of Findings

#1 NEFES indicates that the matrix and species functional group matrix will be incorporated in the NED Planning Guide and NEWild.

#2 Two articles were submitted to the *Northern Journal of Applied Forestry*—"Assessing Forest Biological Diversity of Pennsylvania" and "Inventory Methodology to Assess Habitat Structural Features." Both have been reviewed and changes for resubmission are concluding.

#3 Two two-day workshops for landowners and VIP/Coverts volunteers were held.

#4 An invited paper given to 70 participants at the Maintaining Biodiversity: The Essence of Intelligent Tinkering Conference held at Shippensburg State University.

C. Site Information

The NEFES continued HAM validation on US Forest Service lands as did the Audubon Society on privately owned lands managed by Procter & Gamble Corporation. Because these assessments were conducted by independent agencies, we have no further information about those specific sites.

D..**Economic Analysis**

No new information.

Potential Contributions and Practical Applications

A. Potential Impact of the Project Work

The largest potential impact of this project remains its incorporation in the NED Planning Guide and NEWild. These computer programs provide user-friendly interfaces for understanding land use objectives and potential impacts of management decisions. Until HAM the NEFES lacked a process for incorporating biodiversity concepts into their model.

C. New Hypotheses

No new information

5. Farmer Adoption and Direct Impact

A. Changes in Practice

Numerous requests for training workshops, as well as the fact that managers have already begun to implement these ideas, indicate that this project will have significant effects on the management of Northeastern forests.

B. Operational Recommendations

No new information

C. Evaluations

No new information

6. Producer Involvement

Number of growers/producers in attendance at:

50 Workshops

70 Conferences

__ Field Days

__ Other events (specify) __________

7. Areas Needing Additional Study

Two problems arise when inventorying herbaceous species. Most natural resource professionals can only identify a fraction of the 2000 species in Pennsylvania's forests.

A pocket guide of uncommon and rare plants and one on identifying herbaceous species by their leaf structure instead of the flowering body should be created for field use. In addition, workshops on using existing herbaceous plant keys and herbaceous plant identification should be conducted.

Second, herbaceous plants change in species composition and percent cover throughout the season. Any species list acquired through the inventory will only consist of a portion of the actual composition on the site. It is also difficult to estimate percent cover in the ground layer during winter, since most of the vegetation decays rapidly or is covered by snow.

One way to address the problem of ephemeral vegetation is to create an assessment matrix similar to the habitat-biodiversity model. This vegetation assessment model would use a site's physical and geographic characteristics to estimate potential herbaceous species presence. Thus, managers could record permanent site data (e.g., soil type, slope, drainage class, physiographic province) one time, and use that information to learn about the vegetation which might grow there at any time during the year.

A proposal to address these ideas was submitted to the Environmental Protection Agency this past year. Unfortunately, while it was of interest to them it was not funded. After addressing reviewer we had planned to resubmit it during this funding cycle but will delay until next year.

8. Photographs

Not new photographs were taken this year. We ask that you refer to materials provided last year.

APPENDIX A

Tally Sheets

Surveyor:________________ Date:____________

BLOCK 1

VEGETATIVE COVER

Property Owner:________________ Town:________________ Province:____________ Stand#:_____ Stand Ac:_____

PLOT #	FOREST TYPE	% ROCK COVER	% GROUND COVER	% FOREST LITTER	% SHRUB COVER	SHRUB TYPE DCE		COVER READINGS	% OVERSTORY COV	% MIDSTORY COV	MIDSTORY TYPE DC	MAST -shrub -mid -over SOFT	MAST HARD
1							over	— — — — — — — — — —					
							mid						
2							over	— — — — — — — — — —					
							mid						
3							over	— — — — — — — — — —					
							mid						
4							over	— — — — — — — — — —					
							mid						
5							over	— — — — — — — — — —					
							mid						
6							over	— — — — — — — — — —					
							mid						
7							over	— — — — — — — — — —					
							mid						
8							over	— — — — — — — — — —					
							mid						
9							over	— — — — — — — — — —					
							mid						
_0							over	— — — — — — — — — —					
							mid						
TOT													

BLOCK 2

BASAL AREA

SP	DBH	QUA	HT	CAV	SP	DBH	QUA	HT	CAV

BASAL AREA

SP	DBH	QUA	HT	CAV	SP	DBH	QUA	HT	CAV

BLOCK 3

WITHIN STAND FEATURES	
Temp Pond	
Perm Pond	
Seeps	
Perm Stream	
Loose Soil	
Rock Piles	
Rock Crev	
Caves	
High Perches	
Low Perches	
Dead Cavities	
Live Cavities	

DEAD & DOWNED — BLOCK 4

LINE LENGTH:________

PLOT #	d	d^2	PLOT #	d	d^2	PLOT #	d	d^2	PLOT #	d	d^2	PLOT #	d	d^2	PLOT #	d	d^2	PLOT #	d	d^2

BASAL AREA — BLOCK 2 Cont' — BASAL AREA

SP	DBH	QUA	HT	CAV	SP	DBH	QUA	HT	QUA	SP	DBH	QUA	HT	CAV

STAND SUMMARY

PLOT #	AVG DBH	# CAV TREES	# SNAGS	d^2 PLOT SUM	LINE LENGTH ft.
1					
2					
3					
4					
5					
6					
7					
8					
9					
0					
SUM				a	b

(______ * 373) / (______) = ________ cu. ft./ac
a b

COMMENTS

PLOT #	
1	
2	
3	
4	
5	
6	
7	
8	
9	
0	

GROUND LAYER BLOCK **BLOCK 5** GROUND LAYER BLOCK

PLOT #	SEEDLINGS	OTHER PLANTS	PROBLEM PLANTS	UNCOMMON PLANTS

SHRUB LAYER BLOCK **BLOCK 6** SHRUB LAYER BLOCK

PLOT #	TREE SPECIES	PROBLEM SPECIES	OTHERS	UNCOMMON SPECIES

BLOCK 5

GROUND LAYER BLOCK | GROUND LAYER BLOCK

PLOT #	SEEDLINGS	OTHER PLANTS	PROBLEM PLANTS	UNCOMMON PLANTS

BLOCK 6

SHRUB LAYER BLOCK | SHRUB LAYER BLOCK

PLOT #	TREE SPECIES	PROBLEM SPECIES	OTHERS	UNCOMMON SPECIES

Surveyor:____________ Date:________ **BLOCK 1** VEGETATIVE COVER

Property Owner:____________ Town:____________ Province:__________ Stand#:____ Stand Ac:____

PLOT #	FOREST TYPE	% ROCK COVER	% GROUND COVER	% FOREST LITTER	% SHRUB COVER	SHRUB TYPE DCE		COVER READINGS	% OVERSTORY COV	% MIDSTORY COV	MIDSTORY TYPE DC	MAST -shrub -mid -over SOFT	HARD
1							over	— — — — — — — — — —					
							mid						
2							over	— — — — — — — — — —					
							mid						
3							over	— — — — — — — — — —					
							mid						
4							over	— — — — — — — — — —					
							mid						
5							over	— — — — — — — — — —					
							mid						
6							over	— — — — — — — — — —					
							mid						
7							over	— — — — — — — — — —					
							mid						
8							over	— — — — — — — — — —					
							mid						
9							over	— — — — — — — — — —					
							mid						
10							over	— — — — — — — — — —					
							mid						
TOT													

BASAL AREA										**BLOCK 2**					BASAL AREA									
SP	DBH	QUA	HT	CAV	SP	DBH	QUA	HT	CAV	SP	DBH	QUA	HT	CAV	SP	DBH	QUA	HT	CAV	SP	DBH	QUA	HT	CAV

BLOCK 3

WITHIN STAND FEATURES	
Temp Pond	
Perm Pond	
Seeps	
Perm Stream	
Loose Soil	
Rock Piles	
Rock Crev	
Caves	
High Perches	
Low Perches	
Dead Cavities	
Live Cavities	

DEAD & DOWNED — BLOCK 4

LINE LENGTH:______

PLOT #	d	d^2	PLOT #	d	d^2	PLOT #	d	d^2	PLOT #	d	d^2	PLOT #	d	d^2	PLOT #	d	d^2	PLOT #	d	d^2

BLOCK 2 Cont'

BASAL AREA

SP	DBH	QUA	HT	CAV

SP	DBH	QUA	HT	QUA

BASAL AREA

SP	DBH	QUA	HT	CAV

STAND SUMMARY

PLOT #	AVG DBH	# CAV TREES	# SNAGS	d^2 PLOT SUM	LINE LENGTH ft.
1					
2					
3					
4					
5					
6					
7					
8					
9					
0					
SUM				a	b

(______ * 373) / (______) = ______ cu. ft./ac
a b

COMMENTS

PLOT #	
1	
2	
3	
4	
5	
6	
7	
8	
9	
0	

GROUND LAYER BLOCK		BLOCK 5	GROUND LAYER BLOCK	
PLOT #	SEEDLINGS	OTHER PLANTS	PROBLEM PLANTS	UNCOMMON PLANTS

SHRUB LAYER BLOCK		BLOCK 6	SHRUB LAYER BLOCK	
PLOT #	TREE SPECIES	PROBLEM SPECIES	OTHERS	UNCOMMON SPECIES

GROUND LAYER BLOCK | **BLOCK 5** | GROUND LAYER BLOCK

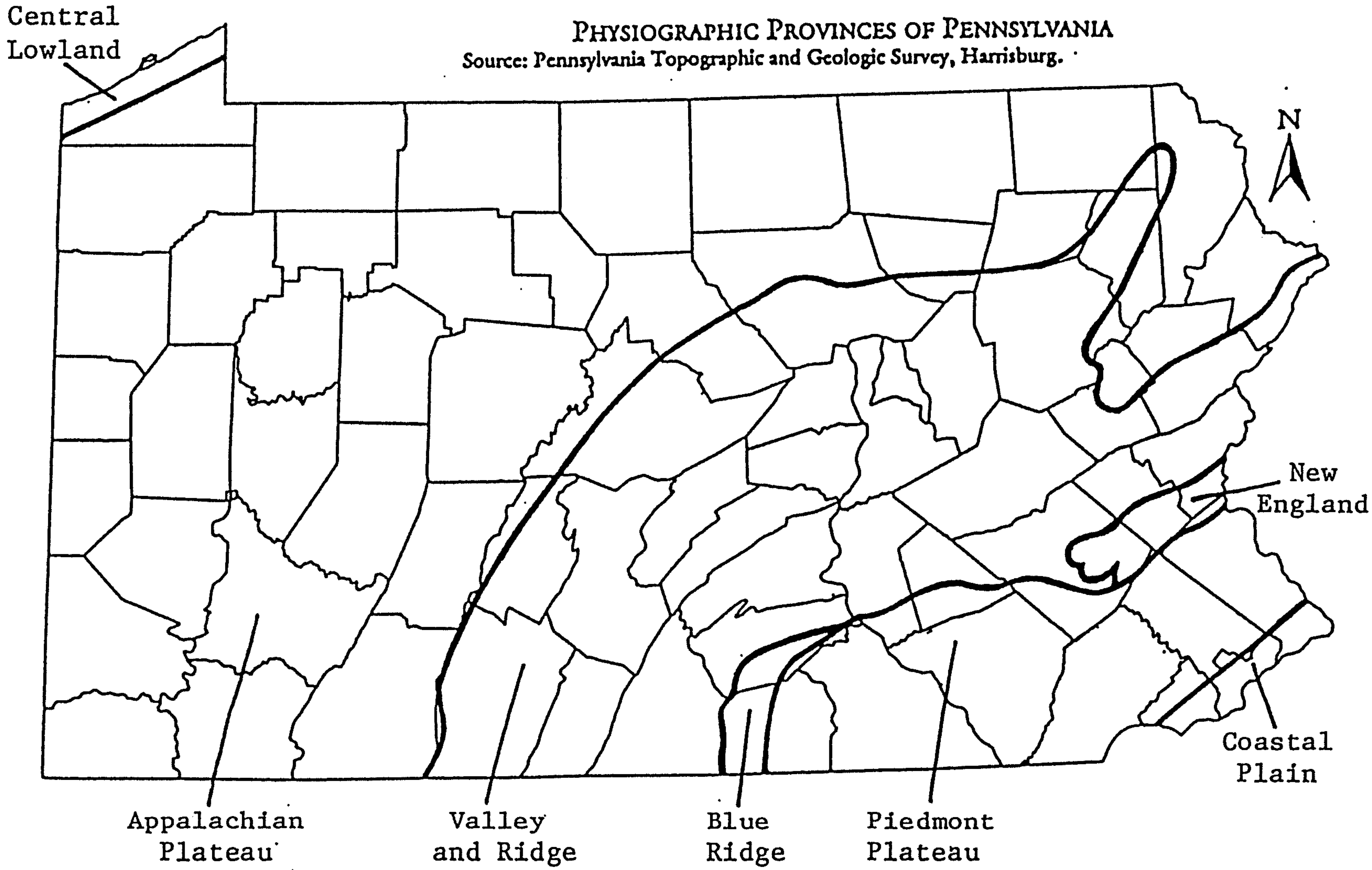
PLOT #	SEEDLINGS	OTHER PLANTS	PROBLEM PLANTS	UNCOMMON PLANTS

SHRUB LAYER BLOCK | **BLOCK 6** | SHRUB LAYER BLOCK

PLOT #	TREE SPECIES	PROBLEM SPECIES	OTHERS	UNCOMMON SPECIES

APPENDIX B

Map of Pennsylvania Showing Physiographic Provinces



PHYSIOGRAPHIC PROVINCES OF PENNSYLVANIA

Source: Pennsylvania Topographic and Geologic Survey, Harrisburg.

APPENDIX B.

Biodiversity Manual
"*Assessing Biodiversity Through Habitat Structure.*"

CHAPTER 1

AN INTRODUCTION TO BIODIVERSITY

The last word in ignorance is the man who says of an animal or plant: 'What good is it?' If the land mechanism as a whole is good, then every part is good, whether we understand it or not. If the biota, in the course of eons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering.

These are the words of Aldo Leopold. Even in the 1940s, he recognized preserving biological diversity as an important concern. Although the term "biodiversity" did not actually appear until the 1970s, certain time-honored practices prove that land managers have been aware of the concept for much longer. Foresters have long avoided monocultures, seeking instead to grow a variety of species in forests; in preserving this variety of species, they have also preserved genetic diversity. Best management practices (BMPs) instituted to reduce negative harvesting impacts also maintain ecosystem processes that ensure healthy, productive forests.

By asking yourself, "What does biodiversity mean to me as a forest steward?" you have taken the most difficult first step toward understanding biodiversity. But where can you find help in defining and assessing biodiversity? This workshop provides you with a practical definition of biological diversity and introduces you to an indicator of a stand's biodiversity. Perhaps most importantly, it will help you start asking the types of questions that are most relevant to biodiversity concerns.

The objectives for this workshop are to:

- Increase your <u>awareness</u> and <u>understanding</u> of biodiversity
- Inform you of the potential <u>impacts</u> of your actions on indicators of biodiversity
- Help you make <u>informed choices</u> about land management

In effect, we want this workshop to take the concept of biodiversity out of the textbook and put it to work in our forests.[1]

DEFINITION OF BIODIVERSITY

The Office of Technical Assessment published the most widely accepted definition of biodiversity in 1987:

> ***The variety and variability among living organisms and the ecological complexes in which they occur.***

Although it may seem difficult to apply this definition in a practical way, the underlying concepts encompassed by the broader term "biodiversity" are rather simple. There are three basic components to biodiversity.

•Species diversity - This is what most people think of when they hear the word biodiversity. Species diversity depends on both the *richness* of different animal and plant species living in an ecosystem and the *evenness* of the species' distributions. Figure 1 illustrates the difference between these two terms. Group 1 is richer than Group 2, because it contains more species. Groups 3 and 4 are both more diverse than the first two, because they have a greater abundance of animals living there. But is Groups 3 more diverse than Group 4? They both have the same number of species (richness=3), and the same overall number of individuals (abundance=9). But Group 4 has only one representative of two of the species, whereas Group 3 has an equal number of each of the three species. Group 3 is more evenly distributed and is, therefore, more diverse.

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[1] *When we refer to "you" throughout this manual, we are speaking to natural resource managers (i.e. foresters, wildlifers, etc.) and partially trained landowners. Because we are assuming that the reader has at least some silvicultural background, we do not explain such basic terms as "stand" and "rotation."*

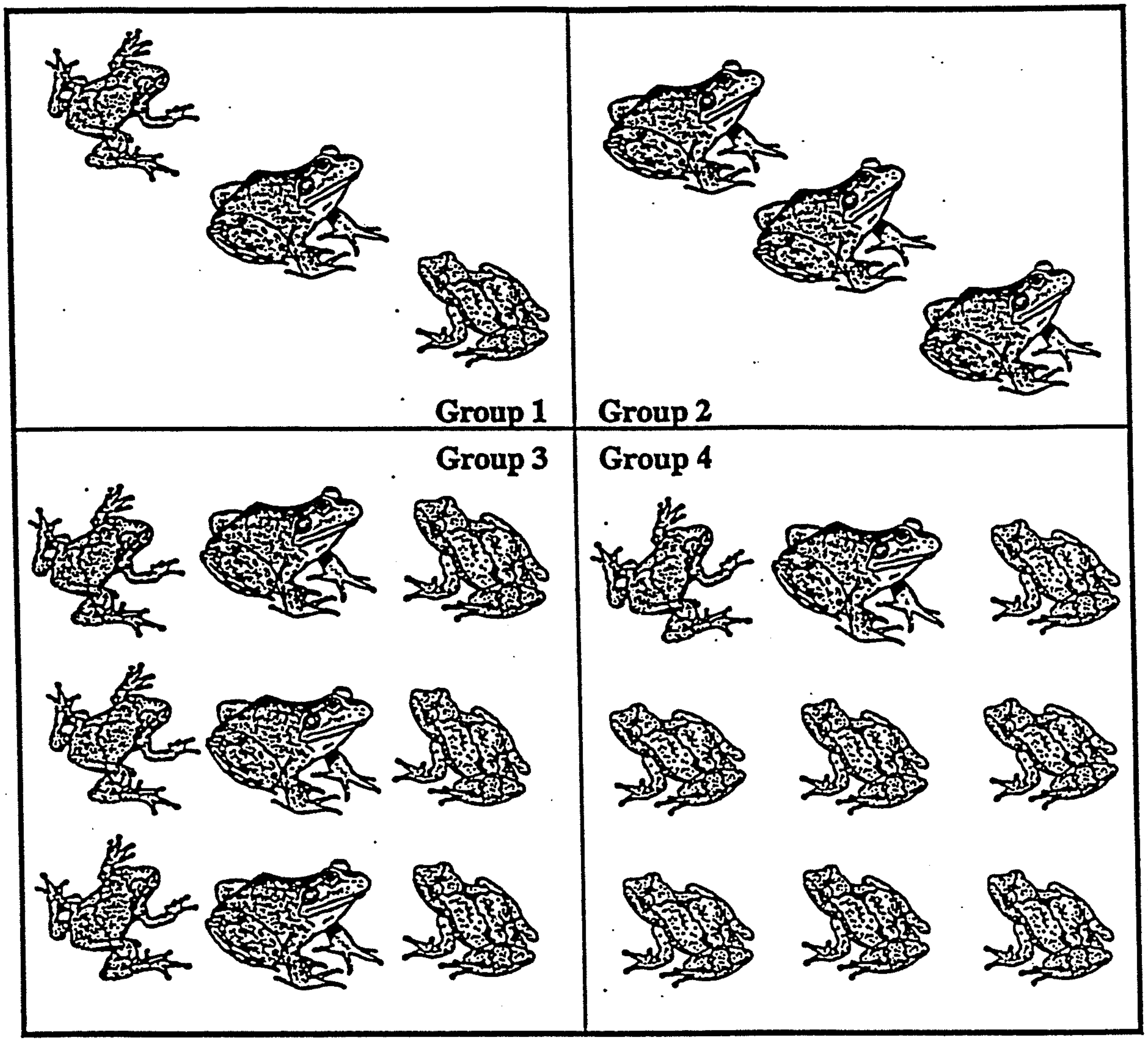


Figure 1. An illustration of the difference between species richness and evenness.

Even historically, species diversity was a management issue. Both foresters and wildlife managers have long recognized the hazards of maintaining monocultures. In a forest with only one tree species, a single insect invasion or disease outbreak has a greater chance of devastating out an entire stand. Increasing the level of diversity increases the probability that some species will prove resistant to an infestation or pathogen.

•Genetic diversity - It is impossible to fully explain the premise of genetics without launching into a lengthy discussion. A common textbook metaphor refers to genes as the "building blocks" of all life. We can extend this metaphor to explain diversity. Consider for a moment a child's set of blocks. If that child loses all of the pieces except for the rectangles, then the types of structures that child can build will be much more limited than if the squares, triangles, cones, and cylinders were still available. The shrunken block "pool" has restricted the variability of the structures. The only way the child can get access to the different shapes is by playing with other children and sharing their blocks. Similarly, if a species has only two or three different "shapes" within its gene pool, its variability will be restricted. The best way to ensure a variety of genes in population A is to allow those individuals plenty of opportunities to breed with individuals from populations B and C, thus sharing entirely different gene pools.

•Ecosystem diversity - This is defined as the variety of communities or ecosystems in an area. Ecosystem diversity can affect species and genetic diversity as well. For instance, a red pine plantation may have very low levels of species diversity when considered alone, but within the landscape it may be the only place where pine warblers or red squirrels can live. A forest containing several age classes also contributes to ecosystem diversity, with associated effects on species and genetic diversity. There is a greater chance that a pest invasion will leave at least one or two age classes unharmed.

Living creatures constantly interact with other living organisms and with non-living parts of their environment. Nutrient cycling and food webs are two of the more widely understood interactions, but even these are intricate and often confusing. The entire list of microbial and chemical interactions would be too lengthy to present here; in fact, it is probably much more detailed than scientists today can even imagine.

Providing a wide array of options can be one way we help to ensure that the habitat components which species need are present within their environment. Something as small and as seemingly unimportant as a temporary spring pond may provide key habitat for many wildlife species, especially salamanders and other amphibians. Plant species like grapes may be able to grow only in the high levels of sunlight which reach the forest floor in clearings or along edges. Ruffed grouse need at least four main cover types. Their young chicks need clearings in which to feed on insects. Other cover types provide winter food and shelter in bad weather conditions; for instance, Eastern hemlock provides buds for food and thermal protection from heavy snows. Adult males require the dead logs found on the ground of mature forests; they perform their breeding display, called drumming, perched atop these logs.

Maintaining a variety of conditions over the landscape will help more species find their particular niches. However, it is not always best to maintain a maximum number of species on every acre of land. Some authors recommend maintaining a "diversity of diversity" across the landscape. This entails not only managing for different species compositions, but also for a variety of habitat features throughout the stand and the landscape.

HISTORY

Pennsylvania's history has strongly affected its forests and all components of biodiversity. Long before humans arrived, natural factors including glaciers, wind, insects, and disease had already taken a toll. Eventually, native Americans began to periodically clear or burn parts of the forest. By the time Europeans arrived, the forest was probably a mosaic of different species, ages, and sizes of trees.

The earliest colonists considered the great expanses of wilderness found in the New World to be evil and frightening. They began clearing large areas of timber to promote the advancement of their civilization. To the settlers that kept coming, it seemed that the forest must continue forever to the north and the west. The loggers never dreamed that the acres of trees they were cutting would end, and the lure of quick profits was undeniable; early in this century, most of Pennsylvania had been harvested. Only when stumps nearly covered what had once been called "Penn's Woods" did professional foresters such as Gifford Pinchot finally begin to question what was next, and to plan for the future.

But it may have been too late to help some species. Within the last 300 years, 70 native vertebrates and 119 vascular plants have disappeared from Pennsylvania; an additional 351 plant and animal species have been listed as threatened or endangered. The loss of just one species can be devastating. American chestnut trees were once the most common, rapidly growing, valuable trees in the Appalachian ridgetop forests from Maine to Alabama. Within 50 years, the species had all but disappeared from its range. Today, the roots send up sprouts which will grow only to the sapling stage, when the fungus again kills the crowns. The implications are staggering - in only 300 years, human activity has reduced the diversity of Pennsylvania by at least 540 species! This figure doesn't include the invertebrates, fungi, and non-vascular plants that have disappeared--and the most generous researchers estimate that over 50% of the species in these lower taxa still remain undocumented.

Each taxonomic group, and each of the species within them, are unique; thus, the mechanisms for species loss vary for each. However, there are several activities which are generally identified as having major impacts on diversity across all taxa. Four of these activities, along with their implications to forest management, are described below. As you read through this section, consider whether the diversity is being affected primarily at the species, genetic, or ecosystem level.

•Wetland disturbance and loss - There are 500,000 acres of wetlands remaining in Pennsylvania today and over 45% of those (221,000 acres) are classified as forested wetlands. Many mammals, birds, reptiles, amphibians, invertebrates, and microorganisms depend on wetlands during some part of their life cycles. The disturbance of this critical habitat can only have a negative effect on these organisms. Even the wetlands created or restored in mitigation projects are inferior to natural wetlands. There is no way to monitor every interaction that occurs within a natural wetland community, and to ensure that all of these are present in a constructed site.

•Pollution - Non-point source pollution is any pollution that cannot be traced to a single source. Examples include overland run-off of gasoline, oil, pesticides, or sediments into water systems. Point source pollution is the opposite - it can be traced to its source. Discharge of untreated industrial wastes directly into air, landfills, or water are several examples. Both degrade habitat potentials for many species of wildlife. The effects of pollution can quickly spiral upward in several different ways. One spiral begins when the lowest organisms on the food chain become unable to survive in an area. Soon there will be no food source for the next link on the food chain, then the next link, then finally the top carnivores. A different spiral can begin if, for example, a fungus which produces a bacteria-killing chemical disappears from an area. Once that chemical no longer checks the bacteria's growth, the bacteria will be able to proliferate. Depending on the species of bacteria, the impacts could range from simply increasing the rate of vegetative decomposition in the soil, to contaminating water supplies, or even to an unexpected disease outbreak.

•Habitat fragmentation - Large expanses of forests have become separated into numerous disjunct patches. In the Poconos, for example, large forests are interrupted by housing developments. Each of these patches may support separate populations of the same plant and animal species, but these species' genetic diversity and their existence may be at risk. Smaller tracts of forest simply cannot maintain the number or abundance of species found in larger areas. Additionally, increased inbreeding within populations may make each separate population less likely to survive the impacts of an insect invasion or disease outbreak. Even plants, though they are not mobile like animals, will experience the effects of inbreeding; the distance and physical structures between two populations can effectively eliminate the plants' ability to cross-pollinate. Without having access to different gene pools, the individuals in a population may lose their ability to adapt to environmental changes over time. In other words, they may lose their evolutionary potential; one by one, the populations may disappear.

Some people might want to disagree, to argue that once the populations have been separated, they can actually evolve into new species. This might be the case if the initial disturbance were a one-time random occurrence. For instance, two populations of a squirrel species, the Kaibab and Abert, are a perfect example of how isolation and speciation may occur in nature. Their ranges are only four miles apart at the narrowest point between the north and south rims of the Grand Canyon, but the deep canyon contains habitat unsuitable for the squirrels and presents a barrier between the two species. Genetic studies are still being conducted, but recent evidence shows increasing variation in the body size, molting characteristics, food selection, and breeding habits of these populations.

A more common example would be two species originally separated by housing construction; after the house is established, the populations are further disturbed by the people who move into those houses, by the pollution and waste they create, and by the expansion of more developments The process has only begun when those initial foundations are dug.

The physical separation of these populations may decrease the species ability to survive. Every species has a hypothetical *minimum viable population* level, below which they will not be able to survive for an extended period of time. Once, millions and millions of passenger pigeons filled the skies, but uncontrolled hunting decimated the populations .

What many people do not realize is that hunting did not *directly* cause the extinction of the passenger pigeon. Even when several thousand birds remained, they did not breed. For some reason which will probably remain a mystery forever now, the birds required huge colonies of nesting adults to successfully reproduce. Hunting may have lowered the numbers initially, but the species disappeared into extinction because the minimum viable population did not exist.

•Exotic Species - The native species of Pennsylvania evolved in concert with one another, with many interactions and dependencies involved. Introducing foreign species can cause problems which these species are not able to tolerate. For instance, chestnut blight introduced on logs from Asia destroyed the American chestnut forests. Gypsy moths are continuing to wreak havoc on the oaks that replaced the chestnuts. In wetlands, purple loosestrife is making it difficult for other plant species to compete; it is taking over at the expense of all other plants and their associated diversity.

Even in our waterways, zebra mussels, which have no natural predators, are out-competing native mollusk species, causing clogging in the flow pipes of dams and plugging up boat outtakes. The fish, birds, and other organisms that have relied on the native species are apparently declining as their food source becomes more sparse.

LANDOWNER PERSPECTIVE

Forest land owners' objectives reflect their desire to correct and avoid the types of mistakes made in the past. They shy away from extensive clearcutting, frown upon importing exotic species, and are beginning to understand that controlling wildfires may not always be the best idea, through unfortunate demonstrations like the 1988 fires that raged through Yellowstone National Park. Furthermore, numerous surveys of non-industrial private forest land owners show that timber is actually low on their list of reasons for owning land. However, they do recognize the need to harvest to produce forest products. The problem is that they hear conflicting information about harvesting, ecosystem management, and especially biodiversity, concepts which they may not clearly understand. Or, they may incorrectly extrapolate ideas from region to region--what may be an acceptable management practice in hardwood forests of Pennsylvania may not be appropriate in southern or western forests.

Historically, landowners have always been interested in more than just timber, although gaining an economic return is indisputably important (Figure 2). Forest managers must intertwine objectives such as improving wildlife habitat, enhancing recreation possibilities, and accentuating aesthetic quality with providing a financial return for the landowner.

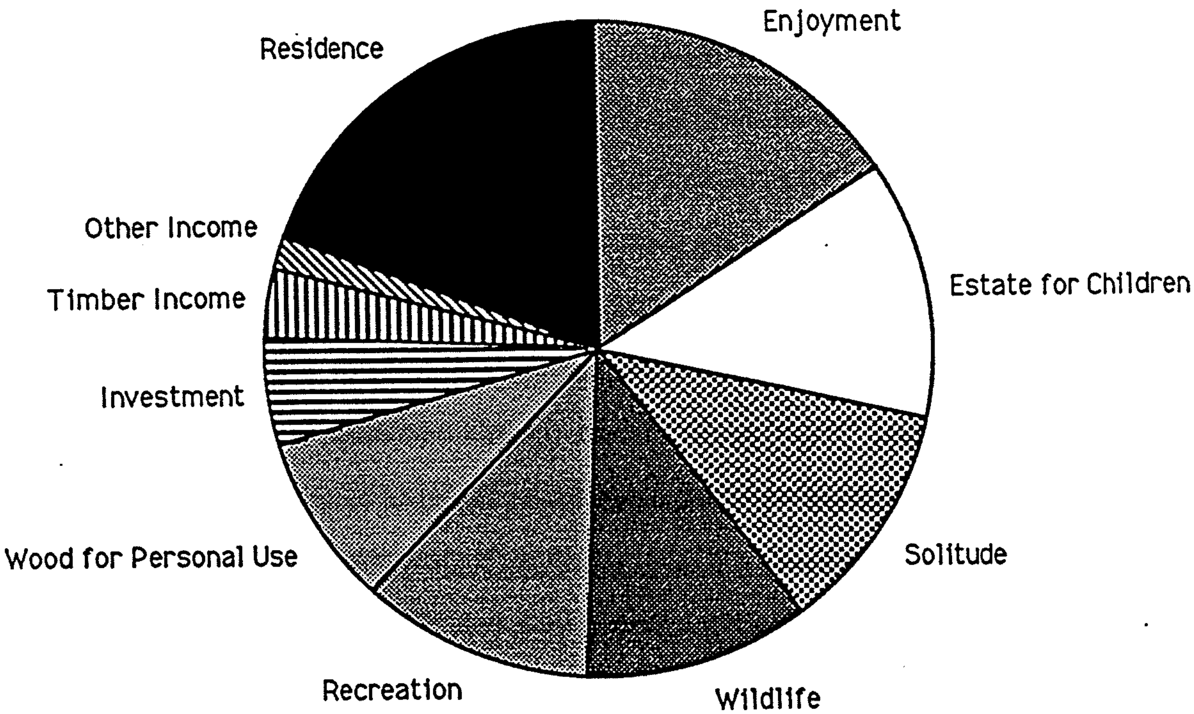


Figure 2. Reasons given by private landowners for owning land

Successful management of private forest lands involves close interaction between landowners and resource professionals. With the help of concerned professionals, landowners are beginning to understand that careful planning is the key to their goals; they can both harvest timber *and* meet other objectives. It is up to the resource professional to help landowners understand the potential consequences of their actions, and choose the best plan for their needs. Working together, landowners and foresters can help to ensure that productive, diverse forests will endure long into the future.

IMPLICATIONS OF BIODIVERSITY

About 75% (12.5 million acres) of Pennsylvania forests are non-industrial private lands with the potential to impact biodiversity. The majority of these landowners do not have an management plan. Instead, they have vague ideas such as, "I want to see a lot of wildlife," or, "I want my forest to look nice." Although landowners may not be familiar with the term "biodiversity," they are not entirely unaware of its implications. For instance, the first of these two example goals certainly involves species diversity--in order to maintain species diversity, habitat diversity must be considered. The second goal, however, may cause problems. Many landowners want to maintain their forested lands in a tidy, park-like condition. This type of structure (i.e. tall overstory, little midstory and shrub layers, and grassy ground cover) severely limits the types of animal habitats that exist. The concepts in this manual will help you show landowners how management can improve their forests' biodiversity while meeting their own objectives at the same time.

Resource professionals must keep landowner objectives in mind when preparing a management plan or silvicultural prescription. Even if landowners do not specify an interest in biodiversity, it doesn't mean that they are unconcerned. They may be aware of the concept without knowing the word. As professional resource managers, you should be able to point out how biodiversity management can enhance a landowner's objectives. For example, if a landowner's property is part of an extensive forest and one of the owner's goals is to see more wildlife, you could explain that a regeneration cut can provide habitat for early successional species (including popular game species like the white-tailed deer and the ruffed grouse), thus increasing the abundance of wildlife in the area. However, if the property is in a patchwork of farm fields and small woodlots, using uneven-aged management may allow forest interior songbirds to remain, maintaining the number of species in the area. Natural resource managers seeking to provide a healthy forest to future generations must identify and manage for biodiversity, both at the stand and landscape levels.

It is easy to understand why timber is important--landowners can use the money from timber sales to reinvest in the management of the stand. They can improve wildlife habitat, upgrade roads, or even pay property taxes. With timber income, landowners are less likely to be forced to sell their land. This is very important, because the fewer times the land is subdivided and sold, the less fragmentation will occur. Biodiversity management results in a healthy forest stand. Biotic and abiotic factors combine to increase the level of soil productivity, which can improve tree growth and provide higher timber volumes in the future. The superior genetic stock in a healthy stand also ensure benefits to timber production.

Managing for biodiversity affects features of both stands and ecosystems, including aquatic systems, wildlife habitats, unique forest features, nutrient cycles, food chains, and forest ecosystem health. It may also increase timber potential and maintain a wider variety of land management options. Harvesting *will* affect biodiversity. The question is, can we affect it positively. We must learn to:

•evaluate proposed silvicultural prescriptions
•assess future changes
•lessen negative impacts

Managing for biodiversity means managing at a landscape scale. Because large areas seem impractical to manage, we respond by breaking up that landscape into smaller management units, *stands*, and by doing most of our work at these smaller levels. The biggest problem happens here--in our efforts to do what is best for the stand, we often forget the big picture, the larger ecosystem of the area. We literally "can't see the forest for the trees."

Figure 3a. *Apples in a Dish* by Auguste Renoir

A new metaphor may help to explain this concept. This painting by Auguste Renoir is a classic Impressionist work. By using only small brush strokes, Renoir painted *Apples in a Dish* to endure for generations.

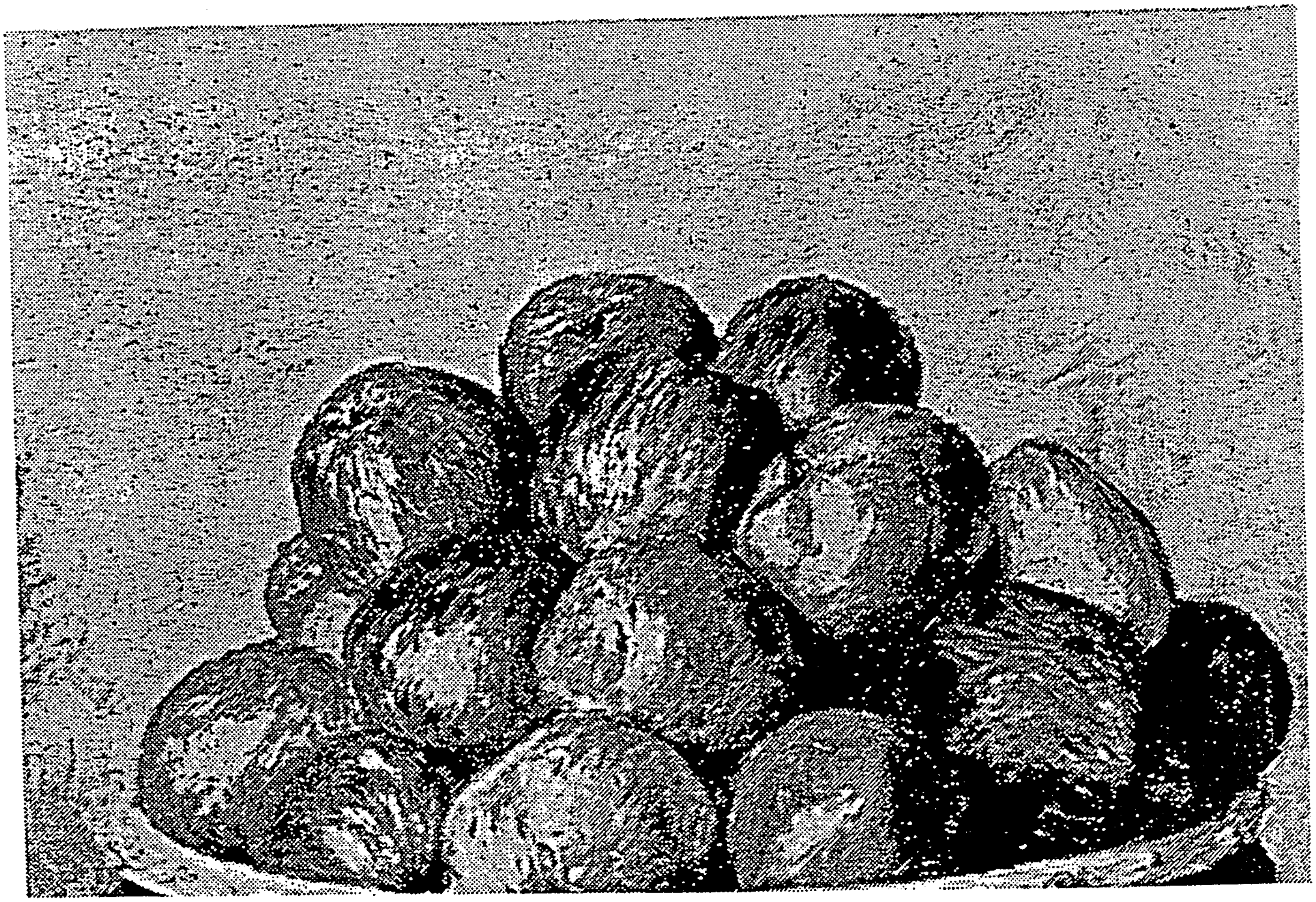


Figure 3b. Detail of *Apples in a Dish*

This close-up shows only the apples from the painting. You can still tell that they are apples, but you lose the perspective. You cannot tell if they are in a dish, a bowl, or a basket. Unlike a Renaissance painting (such as da Vinci's Last Supper), looking closer at an Impressionist painting does not show exquisite details.

Figure 3c. Detail of *Apples in a Dish*

.Figure ?c shows several of the apples from an even closer perspective. At this level, it is difficult to distinguish that the picture is of apples; you can barely tell what they are if you know what you are looking for. You can even identify the individual brushstrokes Renoir used.

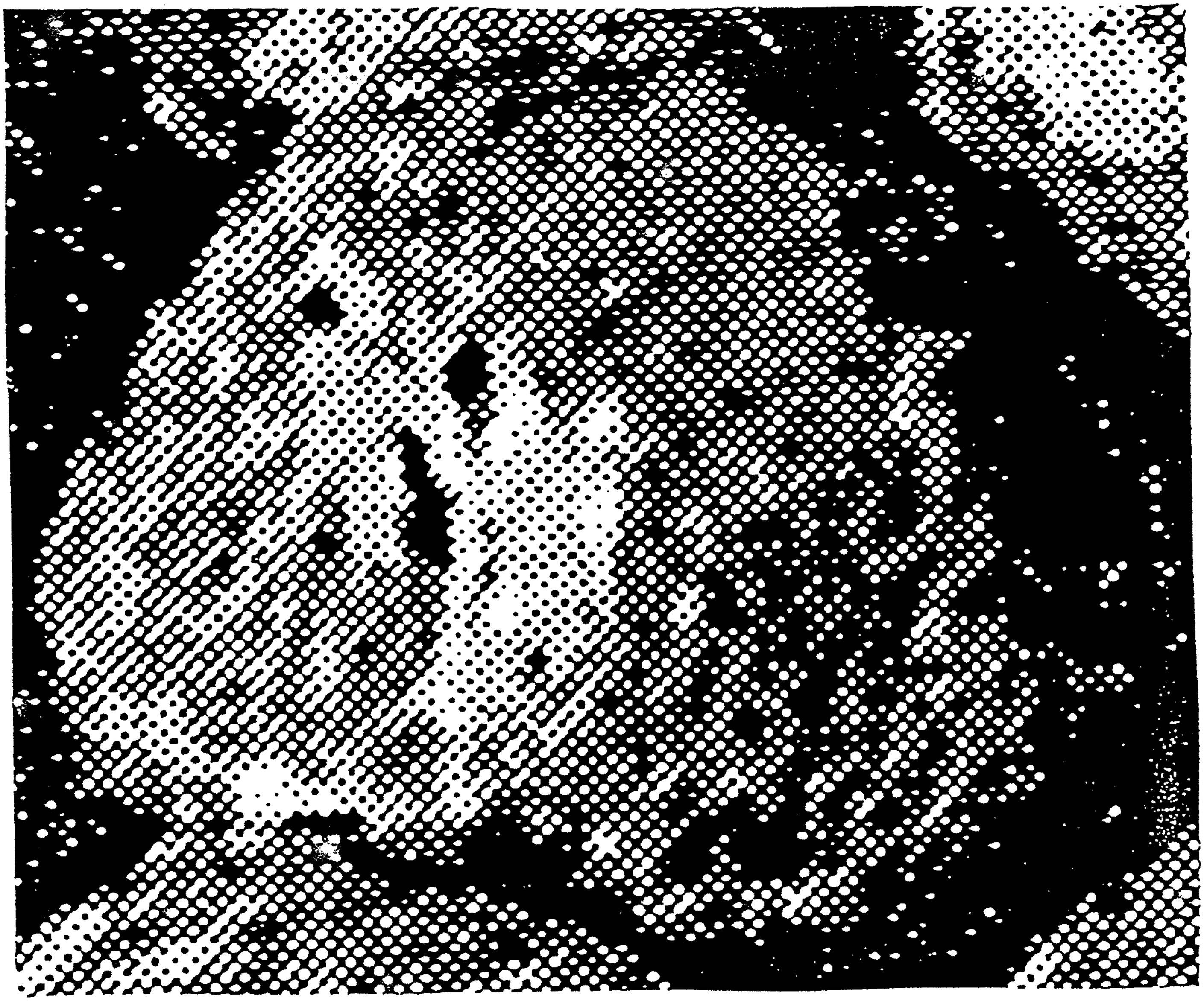


Figure 3d. Detail of *Apples in a Dish*

You can probably guess what this is, although it's nearly impossible to tell by sight. This is one of the apples. From this close viewpoint, you can differentiate even the individual dots which comprise the photograph of the painting. At this level, there are no clues to the big picture, no ideas about what is being represented.

Figure 4a. Eastern hemlock tree

It's easy to understand how this quick art history lesson relates to forest management. This is an Eastern hemlock tree. Looking at it alone, you cannot tell whether it is growing in a bottomland forest, along a highway, near a picnic table, or even in someone's front yard. You cannot determine its "habitat potential" because you do not know what features surround it.

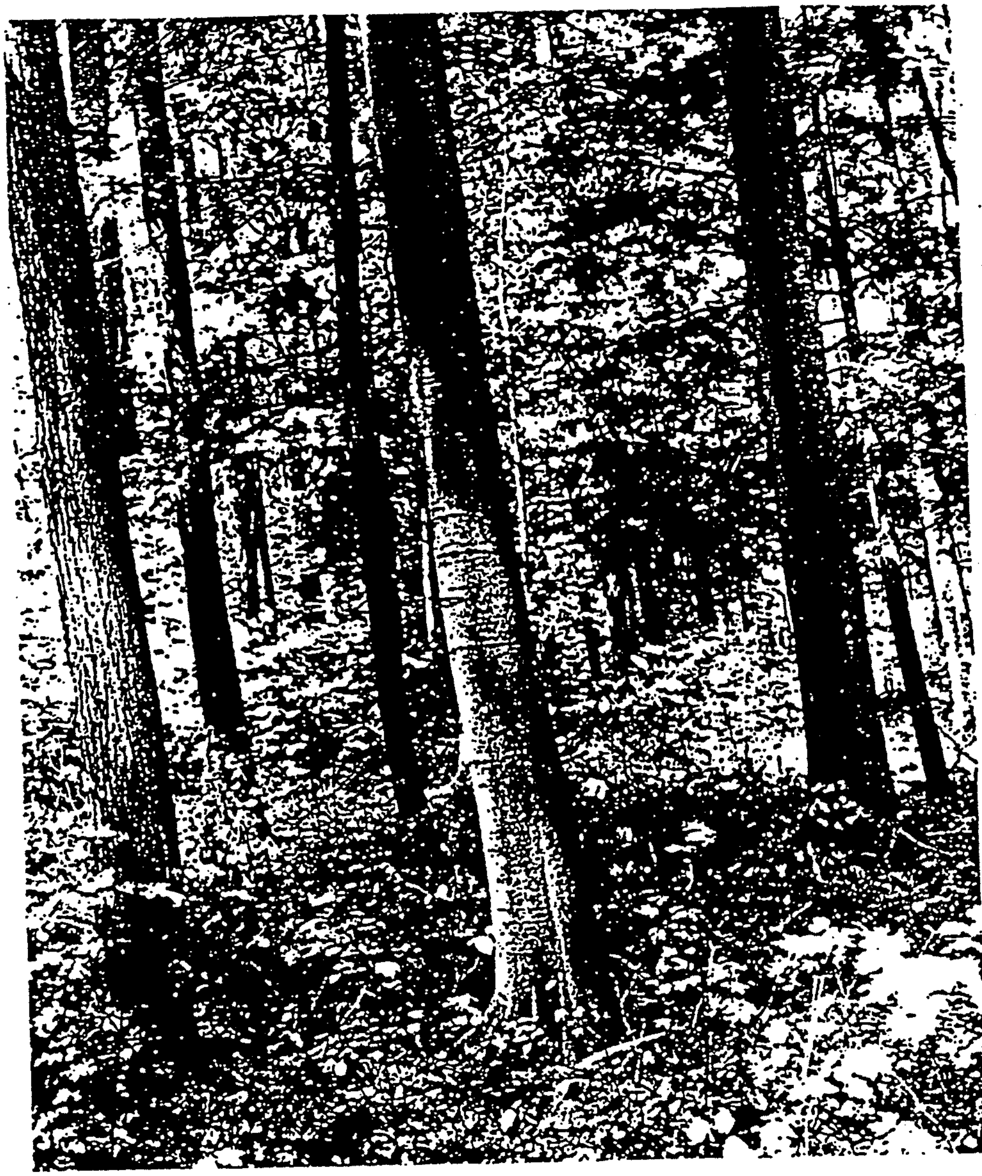


Figure 4b. Hemlock-beech stand

If you move back a little from the tree, you gain a new perspective. You now know that the tree is part of a hemlock-beech stand. The individual trees are still distinct, and you can see some of the understory structure and features, but you still cannot see the entire stand.

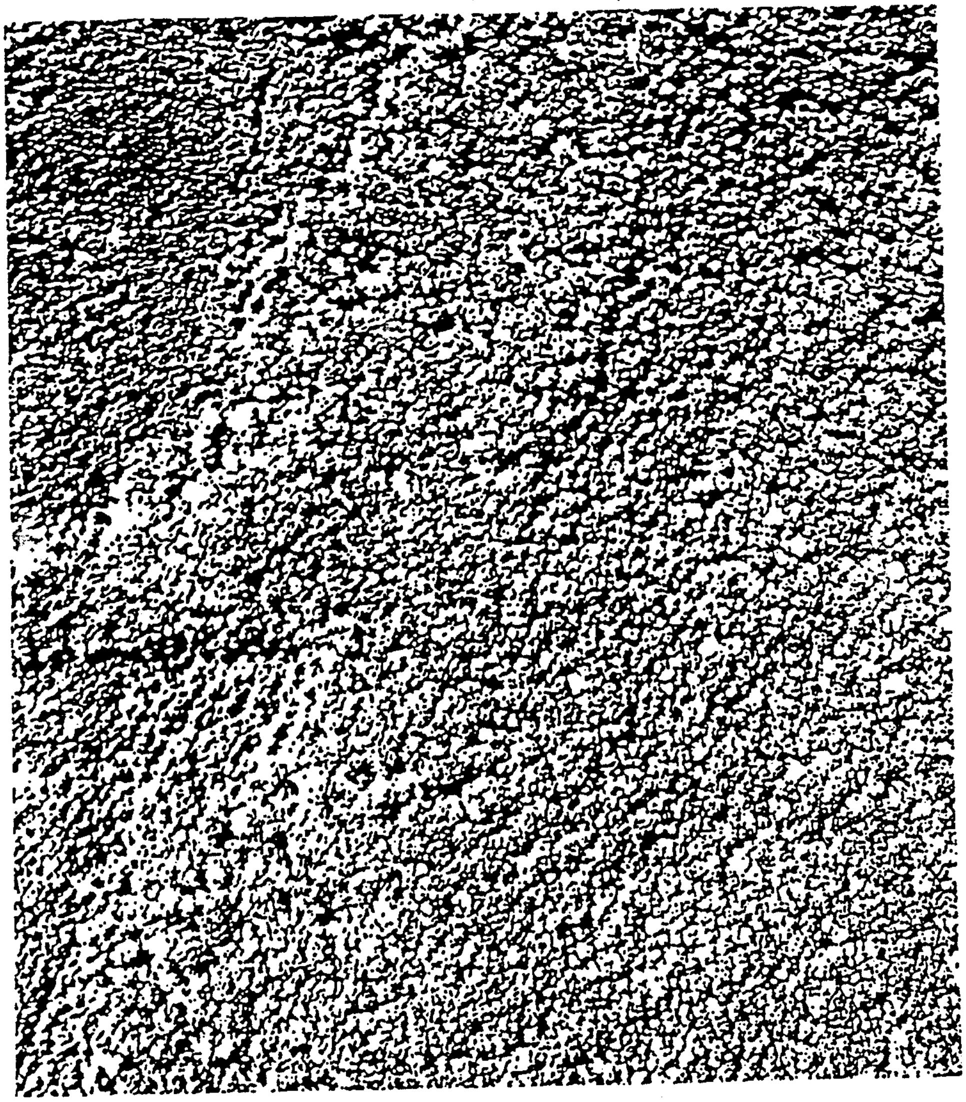


Figure 4c. Overhead view of stand

Moving back still more, you can see the entire stand from above. From a picture like this one, you can still tell whether the trees are deciduous or coniferous, but you may not always be able to distinguish the species. You may be able to see some of the stand's features, such as large bodies of water, but you can no longer distinguish individual features that comprise the lower levels of the forest. You still cannot tell how the stand fits into the overall landscape.

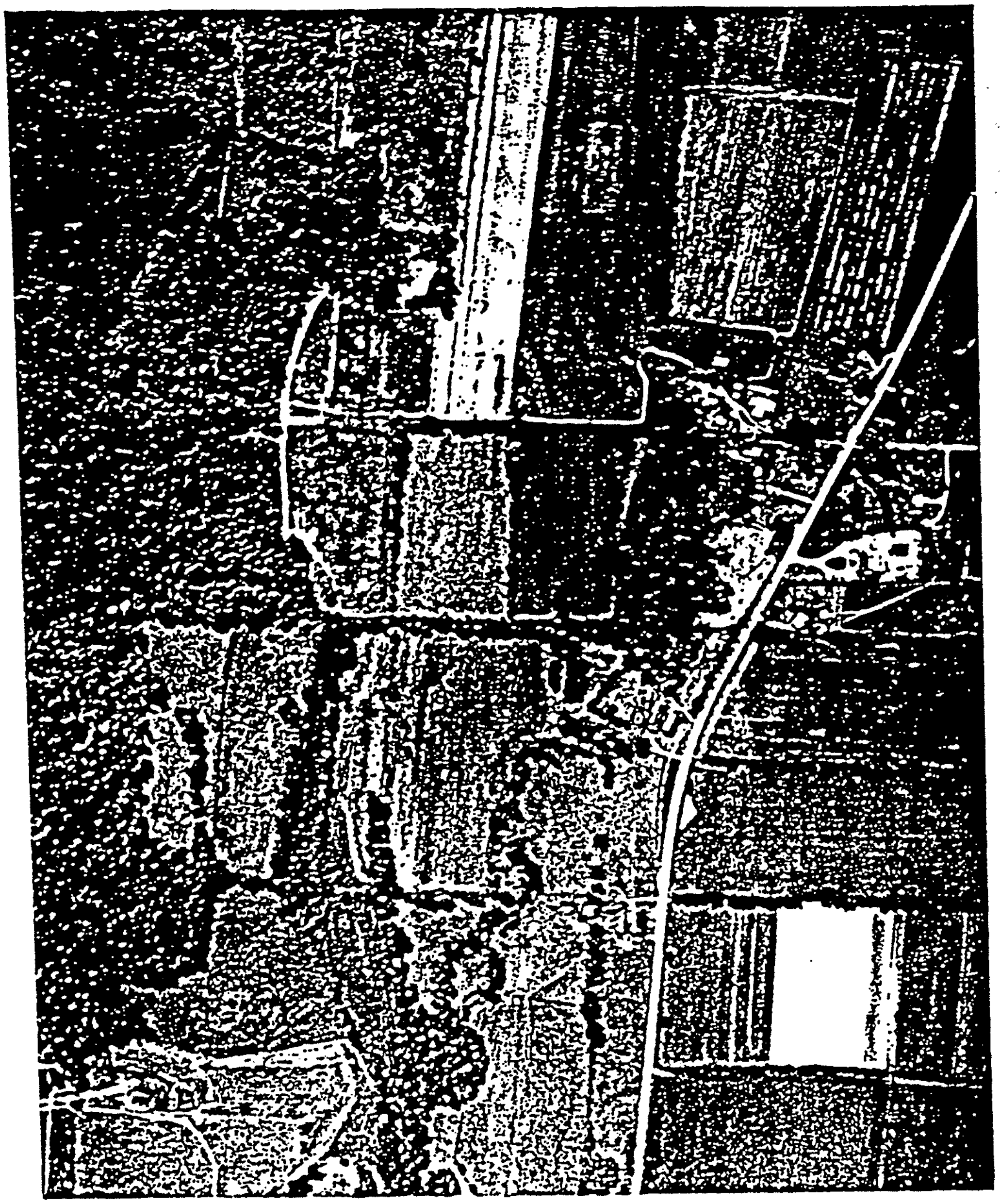
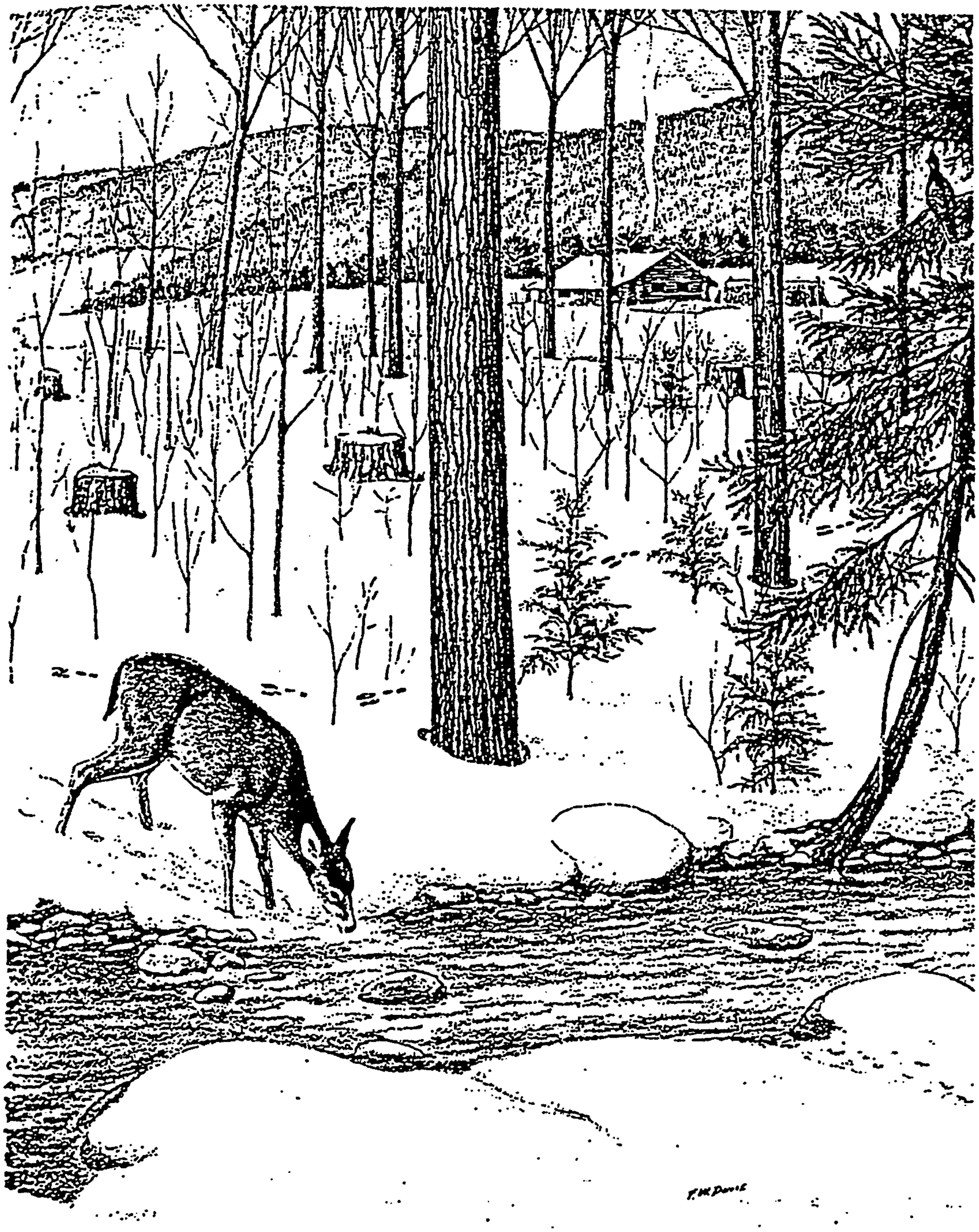


Figure 4d. Aerial view of landscape

Finally, by looking at this bird's-eye view of the landscape, you can see the variety of land uses which occur around the stand. You can see forests, fields, buildings, and roads.

You should never rely on the view from only one level for the purpose of determining the stand prescription. If you used only the aerial photos, you could not hope to know enough about the stand's specific features, such as species composition, dbh, and merchantable heights. On the other hand, if you used only the closest perspective, you could not tell anything about the ecosystem as a whole.

Just as Renoir did not place different-colored brush strokes randomly across a canvas with hopes of creating a long-lasting masterpiece, resource professionals cannot hope that randomly managed trees or even stands of trees will maintain the healthiest landscape. The best management practices consider landscape impacts long before logging bids are ever accepted.



CHAPTER 2

WILDLIFE AS A BIODIVERSITY INDICATOR

Although maintaining biodiversity is usually not listed by landowners as one of their goals, responsible foresters should still be informed enough to make the landowner aware of its importance. Once you have established biodiversity as a management concern, you may be unsure about what to do next. If timber harvesting were your objective, you would measure board feet, basal area, and other forest characteristics. If maintaining a high quality trout stream were the goal, you could measure dissolved oxygen, water flow rates, and other similar factors. However, partly because of its abstract quality and partly because of its broad scope, no research team has ever developed a complete biodiversity assessment. Indices incorporating species richness and numbers can compare the levels of biodiversity at different sites, or during different seasons at the same site. These and other similar indices are only *indicators* of biodiversity.

Another indicator which has received a great deal of attention is vegetative structure--the vertical and horizontal layers of leafy and woody vegetation in a forested area. Different combinations of vegetative structure provide different wildlife habitats. Thus, monitoring vegetative structure provides information about both plant and animal diversity at the same time. This methodology involves measuring several important components of vegetative and non-vegetative structure, all of which will be described in Chapter 3.

WILDLIFE HABITAT AS A BIODIVERSITY INDICATOR

Potential wildlife habitat serves as the indicator of diversity in our methodology. Because wildlife species are quite capable of moving, hiding, and otherwise eluding a surveyor, it is extremely difficult to try to count the animals in an area. Therefore, our methodology involves measuring vegetative and physical structural features to determine what species could potentially exist. Essentially, we have designed this method of estimating biodiversity with three facts in mind:

1) Habitat structural features are stationary and can be measured;

2) Wildlife species will inhabit a forest stand if their forest type and structural requirements are met;

3) Silvicultural management practices change habitat structure, resulting in predictable shifts of wildlife populations.

Our methodology provides an *indicator* of a stand's potential wildlife habitats. However, the simple presence of a habitat does not guarantee the presence of the species that uses it.

The next problem we face in this system is that it is impossible to measure a site's "wildlife habitat" value *as a whole*. Wildlife is a broad term - our system incorporates over 200 species of amphibians, reptiles, birds, and mammals. We must reduce this large group into several smaller ones (much as we break the forest into smaller, manageable stands) called **functional groups**. A functional group is a group of wildlife species which share a need for a particular combination of vegetative structural features. Some examples of functional groups are burrowers and cavity-nesters. Although they do share habitat requirements, the animals within a functional group are not necessarily similar in appearance--they could include any combination of amphibians, reptiles, birds, and mammals.

It is clear that managing an area for cavity-nesters would probably involve different practices than managing for a functional group that requires temporary ponds and downed logs. Managing for biodiversity in a landscape involves enhancing critical, unique habitat components.

One significant point to remember is that species diversity includes both animals *and* plants. Although the product of this methodology is a list of wildlife species which could inhabit an area, you must remember that the stand's vegetation itself is a large part of an area's biodiversity. An uncommon orchid in an otherwise poor quality stand may be that stand's most valuable feature in the eyes of the landowner.

EFFECTS OF SILVICULTURAL OPERATIONS

Traditional silvicultural methods can be tools for maintaining biodiversity at the stand level; they will also affect landscape diversity. Although silviculture has primarily dealt with establishing, tending, and harvesting trees, its focus is extending to biodiversity concerns. The term "biodiversity" may not have existed in the past, but foresters have long realized that their activities affect wildlife. Today we understand that the effects reach beyond wildlife--they extend down into the smallest levels of microorganisms and up to the global scale. Today, hunting, farming, and bird-watching landowners alike are all beginning to recognize a need to coordinate their personal actions with the wider issue of biodiversity.

All activities performed in the forest involve trade-offs. We need to understand and recognize the gains and losses of our activities at all land scales to be able to use silvicultural techniques as tools for maintaining, and perhaps enhancing, biodiversity. The advantages of a clearcut, for instance, are a large immediate financial return, as well as an increase in habitat for early successional species. However, no additional income will be produced from that site for at least the next 50 years; any wildlife species that requires mature forests will not inhabit the harvested area for many years.

Understanding how a forest will react to a treatment or harvest requires understanding how a single tree will respond. Silviculture involves growth patterns of trees, whether they are seedling-sized or mature. We must then look beyond the trees to see how the forest community as a whole is affected by harvesting techniques. We need to look at the forests surrounding our own stands when considering biodiversity, to see how our actions might impact them as well.

Harvesting techniques change both the vertical and horizontal structures of a stand and landscape. **Vertical structure** is determined by the presence and positions of vegetation at different heights. A mature mixed hardwood forest with midstory, shrub, and ground vegetation layers would have a more diverse vertical structure than a densely growing pole-sized red pine plantation. **Horizontal structure** is measured more on a landscape level. It is related to the areas, positions, and patterns of different land uses. Within a completely forested landscape, however, there can still be differences in horizontal structure. The varying heights between stands of different age classes will contribute to horizontal structure in one way. As a different example of horizontal structure, a red pine plantation with very little vertical differentiation can be important to landscape diversity if it is completely surrounded by an oak-hickory forest.

Uneven-aged harvesting techniques affect both vertical and horizontal structure. Small gaps created in the canopy allow a mix of intermediate shade tolerant and shade tolerant species to become established. Visually, it is more difficult to detect changes in horizontal structure over the landscape caused by uneven-aged selection cutting. Obviously, the removal of only several trees from one area will be less visible than even the smallest clearcut. But just because the impacts aren't as noticeable does not mean that they do not exist. If, for example, most of the mature conifers (along with other hardwood species) from a mixed species stand were removed in a selective harvest, horizontal structure would change--from an aerial perspective, there would be less differentiation because of the lack of evergreens. Species and genetic diversity would also be impacted--obviously, conifers comprise a unique feature of predominantly hardwood forests.

Even-aged harvesting systems also change both vertical and horizontal structure, but to a greater degree. Clearcutting and shelterwood cuts affect the vertical structure of the stand by eliminating either all or significant numbers of the trees within the harvested area. When the majority of the upper canopy is removed, shade intolerant plant species (e.g. white oak, yellow-poplar, and black cherry) grow. Denser shrub and ground layers, as well as dead and down wood, create habitat for early successional wildlife such as the golden-winged warbler, least shrew, and Eastern cottontail. In return, species that need older (>60 years) forest (e.g. Eastern gray squirrel and pileated woodpecker) must go elsewhere to find suitable habitat, possibly to a neighboring stand. Even the composition and distribution of leaf litter may change. The effects of even-aged practices on horizontal structure are obvious, producing a mosaic of different size-classes across the landscape.

The potential for more wildlife species to be present increases as more size classes are represented. In New England, where the wildlife species composition is similar to Pennsylvania's, about 45% of wildlife species need all four size classes (i.e. seedling, sapling/pole, small sawtimber, and large sawtimber) at different times of the year. Only 1% of the species live in older forests (> 95 years) year-round. Of course, this does not mean that even-aged management is superior to uneven-aged management in terms of biodiversity. The two systems simply have different impacts.

There are two main types of clearcuts: conventional, and wildlife or insurance. The conventional clearcut removes all standing timber from a site, from sapling to sawlog. There is little consideration for maintaining species diversity in the stand after the harvest. All stems down to one-inch DBH are removed, so the remaining habitat is confined to the ground level. The stand will mature through the sapling and pole stages, eventually reaching the sawtimber stage in about 80 to 100 years. Throughout its development, the stand's canopy is completely closed, limiting the number of species by limiting available habitats.

A wildlife or insurance clearcut considers wildlife habitats by maintaining variety in the vertical and horizontal structure of the stand. A wildlife clearcut leaves den trees, high perches, hard and soft mast-producing trees, and standing dead wood. Den trees will provide shelter for cavity-nesting wildlife, such as the great crested flycatcher. The same species can forage on the food produced by the mast trees. High perches will create sighting spots for predatory birds and maintain some of the vertical structure of the stand.

An ecotone, sometimes called an edge, is the boundary between two different stages of succession; in general, it is where two different habitats meet. Ecotones can appear as a gradual change in species composition (such as where a forest slowly advances into a field) or an abrupt change (such as where a hemlock stand meets a red oak stand within only a few steps). They can be quite obvious, such as where a pond meets a forest, but they can also be subtle and easily overlooked, such as where a sapling stand interfaces with a small pole sized stand. Ecotones create a transitional area between habitats, containing a mixture of species from both. Some people consider the ecotone an entirely unique habitat. Whether the transition is abrupt or gradual, obvious or subtle, an ecotone has a more diverse structure and supports a large number of animal species. Aldo Leopold noted that the exact reason that animal life along edges was so abundant was unknown, but he speculated that the combination of several habitats, including food, shelter and increased types of plant life, was the reason for the high concentrations of wildlife within these areas.

Even the **intermediate cuts** performed under the auspices of even-aged management affect forest structure. Consider, for instance, a small pole-sized stand. Trees about 6 inches DBH are perfect for firewood, so landowners often conduct "thinnings" while removing some trees for their fuel value. When some trees are removed, more growing space, nutrients, and sunlight become available to the remaining trees. Thus, they are able to move more quickly to the large pole-sized and even small sawtimber-sized classes. Although sapling and pole-sized stands usually have very little understory, removing trees for firewood creates openings in the canopy. When sunlight reaches through them to the ground, a shrub layer is able to grow beneath the canopy, until the canopy closes again. This is obviously a benefit to the stand's vertical structure. The branches and limbs not removed with the firewood will also provide some degree of structure, although they will quickly decompose.

Too often, when firewood removal is an objective for a stand, much of the wood is harvested from the site closest to a road or to the house. But harvesting firewood across the entire stand on a scheduled basis might be better for wildlife habitat. Once certain wildlife species have become established under the thinned stand conditions (i.e., some shrubs and slash present), they will not have to relocate if periodic thinnings maintain their preferred habitat type. Improvement cuts performed in older stands can also affect structure. The changes depend on which trees are removed or retained. Removing suppressed trees eliminates a portion of the midstory. The gaps created by removing co-dominant trees can temporarily increase the density of the ground and shrub layers. Also, tops left from these larger harvested trees remain longer in the stand to provide habitat structures which some species need.

You must consider road construction as a part of any silvicultural activity, whether main haul roads or smaller skid roads. The construction of a road disturbs forest litter, exposes and compacts soil, and removes most (if not all) woody and herbaceous cover from the road area. Soil loss and compaction result in less productive sites, because they interfere with soil processes. They may also interfere with amphibian (especially salamander) movement in the area. Finally, because roads create edges, the same concerns discussed under ecotones are also relevant here.

Preservation, or non-management, also involves trade-offs. Even in an untouched stand, changes will naturally occur in species composition, growth, and mortality. (In fact, silvicultural activities are often described as simply speeding up these natural processes.) Although the effects of a windthrow might look like those of a group selection harvest, there are several important differences. The dead wood remaining on the ground following a windthrow provides important structure to many species while it decomposes. However, windthrow does not give you the opportunity to choose which individuals are removed from the stand - there is no way to control what remains as growing stock. Additionally, some species (e.g. black cherry and yellow poplar) actually require large disturbances to reproduce; they cannot grow in shaded forest stands. As a stand matures, preservation tends to simplify and reduce its internal biodiversity, perhaps to the benefit of the greater ecosystem. Landowners must be willing to sacrifice their control and the income the stand could potentially provide, in return for knowing that they may be providing a unique feature within the landscape.

Some so-called "forestry" practices are simply irresponsible decisions no matter how well they are "planned." **High-grading,** which involves removing all high-quality, high-value material from the stand, leaves a forest manager with little or no control over a stand's structure. **Diameter-limit** cutting, or removing all trees larger than some specified diameter, also relinquishes control over structure. Not specifying the type and amount of material to be left behind hinders your ability to maintain species diversity. Keeping the less desirable trees reduces the stand's health due to depleted gene pools. Repeated use of this practice results in poor quality, unhealthy forests in the future. High-grading and diameter-limit cutting severely limit future management opportunities.

Another trade-off is applicable here - diameter-limit cutting provides the highest immediate financial return from a stand, and is probably the most common harvest performed in Pennsylvania forests today. It may be acceptable if the forest will soon be cut for highway construction or some other land conversion. But if you intend to maintain the land in a forested condition, diameter-limit cutting is extremely harmful to the future stand. It too frequently leaves only poor quality and genetically inferior trees to grow and regenerate the stand. So, although you may realize a substantial economic return a single time, any future returns from the forest are likely to be reduced.

Diameter-limit cutting may also affect wildlife habitat, aesthetics, and recreation. The absence of large trees may preclude many songbird and mammal species from living on a site, although early successional species may find their preferred habitat. Many people feel that large trees are the most beautiful to look at; they enhance an area's aesthetic quality. And if an area is perceived as ugly or unpleasant, fewer people will care to hunt, birdwatch, mountain bike, or even just walk through the site. Ultimately, it is the landowners' objectives for both the present and future that determine whether the sacrifices and gains resulting from any decision or action are acceptable. Landowners' objectives are the driving force behind stand management decisions.

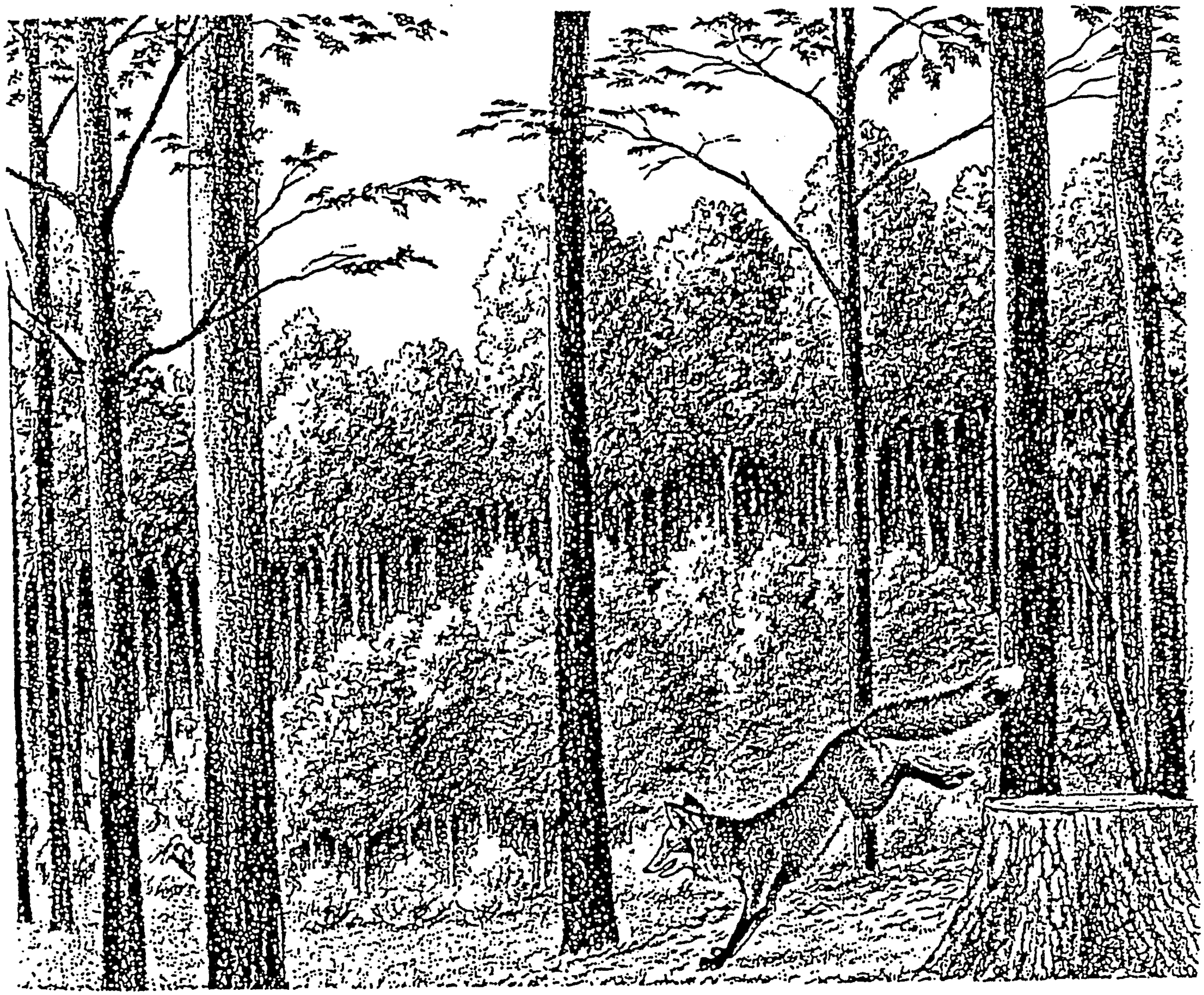
This may be a good place to address yet another trade-off which occurs in forest management - aesthetics. Maintaining a pleasant visual quality to a forest can be very important to many people. In a recent study, 79% of non-industrial private forest landowners identified scenic beauty as a very important forest benefit. Landowners and recreationists often refer to the relaxing, beautiful, even meditative qualities that make a particular area more desirable. For aesthetic reasons, landowners may express their desire to have all of the slash removed after a logging operation. Land managers should explain the costs of that aesthetic concession. Slash provides important habitat for invertebrates, amphibians, reptiles, birds, and small mammals. These species become food for larger predators, such as the red tailed hawk and the Eastern screech owl, expanding the food chain and increasing diversity within the stand. Decaying material also creates habitat for fungi and bacteria, important components in every ecosystem.

Creating slash piles stratifies the ground cover to create multiple layers for nesting, feeding, and perching sites. Slash piles also serve as obstacles to keep deer from browsing young vegetation. And, unlike an electric deer fence, slash costs nothing and maintains a more natural looking landscape. As slash decomposes, it releases nutrients to the new, young trees growing in the stand. However, building piles so they are most usable by wildlife and least destructive to the environment requires piling and stacking wood by hand. Placing the largest pieces of wood closest to the ground elevates the smaller pieces that are on the top of the pile, slows their decomposition, and provides the best cover for wildlife (Figure 5). Building piles randomly with a bulldozer can damage seedlings and herbaceous cover, and create erosion.

Figure 5. Well-constructed brush pile

We realize that forest resource managers already recognize some of the factors important to wildlife habitat, such as snags and den trees. As another example, a rocky forest floor may often seem like little more than a nuisance when walking through a stand. But those rocks also provide critical wildlife habitat. Rocks release sunlight energy as heat, and serve as basking sites for many reptile species. If the rocks are large enough or piled together, they may provide cover to small rodents. Even though they are not a living feature of a stand, rock piles and crevices may be just as important to leave undisturbed in a stand as snags are. You should look at the combinations of the herbaceous cover, wildflowers, soft and hard mast, possible den and nesting sites; look past the harvesting techniques, at the changes that could or will occur within the stand.

Remember, these are only guidelines and examples, *not regulations*; they are intended to help you learn what to look for when assessing biodiversity. Harvesting trees returns a dollar profit, but also results in changes to a stand's biodiversity today and in the future. Recognizing the effects of these changes and the trade-offs involved is an important part of managing for biodiversity.



CHAPTER 3

PROCEDURES FOR ASSESSING BIODIVERSITY

In order to best estimate a stand's habitat potential, and correspondingly its biodiversity, we need to change the way we examine stands. Traditional forest inventory measurements such as basal area, species composition, and stand age give a good indication of a stand's overstory structure, but only part of the overall picture. We must also consider the vegetative layers below the overstory (and even below DBH), as well as the non-living habitat components of stands. We need to look at the stand from the ground level to the canopy, from the leaf litter all the way to the high perches, to properly address the question of habitat structure.

Professional resource managers usually focus on the most visible forest feature--trees. Even among the trees, they tend to focus primarily on commercial timber species. Sustained timber production *is* important for its associated benefits, but other features must be considered. Critical within-stand features such as water (e.g., seeps, streams, and springs), rock outcrops, high and low perches, and snags and cavities are all valuable habitat structural components.

For this new assessment of a stand's biological diversity, there are four basic steps: (1) pre-field work, (2) non-sampled within-stand observations, (3) sample plot data collection, and (4) post-field work. In this chapter, we describe each of these types of measurements in separate sections.

The methodology we provide does several things:

- Increase your <u>awareness</u> of biodiversity
- Encourage you to consider the <u>landscape</u> scale
- Provide for the <u>sustainability</u> of biodiversity in future forests
- Produce an <u>indicator</u> of a stand's biodiversity

PRE-FIELD WORK

The first thing you should do before going to the stand is fill in the the heading on Block 1 of the tally sheet (Appendix A). An example of a partially completed tally sheet is included for your reference as the final pages of this chapter. The blank form in the appendix is provided for you to copy and use. Using the map in Figure 6 (which also appears in Appendix B for more convenient reference), determine which physiographic province the stand is in. This is important for the species assessment that will follow the inventory, because not all wildlife species inhabit all parts of the state.

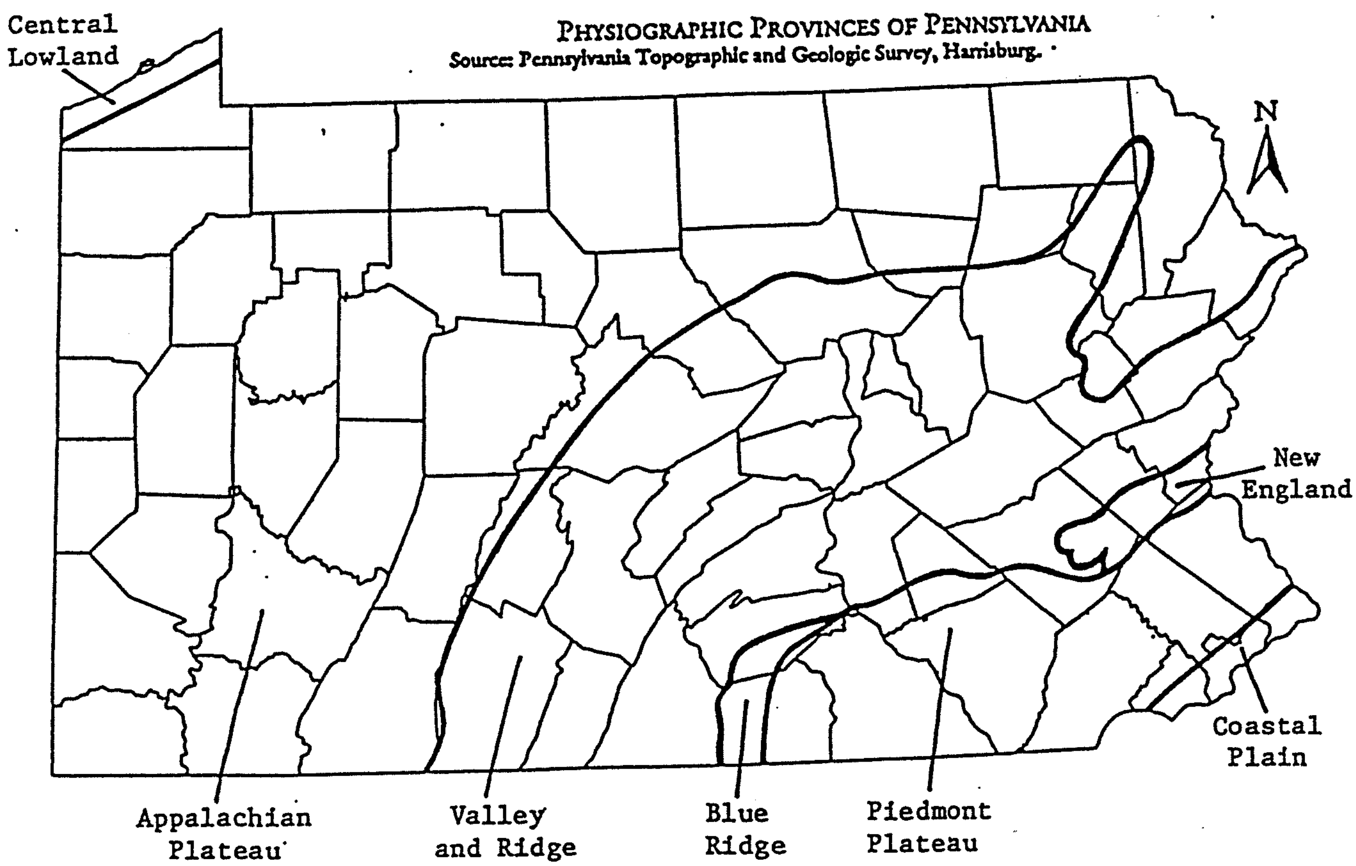


Figure 6. Physiographic provinces of Pennsylvania

The next thing you should do is examine aerial photographs to tentatively determine the individual stand boundaries within the property you will inventory. Traditionally, stands have been defined by overstory characteristics such as tree height, age, or crown width. But because this methodology incorporates other vegetative layers, you can define stands with understory characteristics as well. You might enter a stand to find ground and shrub layers growing at various densities in different areas. These lower vegetative layers may reflect differences in soil conditions or overstory openings--you may find it necessary to adjust the stand boundaries by the condition of these more detailed characteristics. (Of course, you will not be able to make these adjustments until you are on the site.)

After the stands have been delineated, determine plot locations and travel routes so that most of the stand is represented in the inventory. Be sure to plan your between-plot travel routes in at least two directions, preferably perpendicular to one another, as well as perpendicular to the land contours. Topographic maps will help you determine the contours. Planning travel routes in this manner ensures a more accurate estimation of the true volume of dead and down material.

WITHIN-STAND FEATURES

Several structural features required by certain wildlife species often occur in low numbers and are not easily sampled. The most effective way to record these features is simply to note whether they occur in or immediately adjacent to the stand. The entire time you are in the stand, observe whether any of the following features are present and record them by checking (√) the appropriate space in Block 3 of the tally sheet.

Water Sources

Temporary ponds must be greater than 6 inches deep and greater than 1 square yard; water must be present from early spring until late summer. The exact month differs for each species that uses temporary ponds. (See Appendix C for details.) Areas covered by a fine layer of silt and depressions filled with blackened leaves may serve as dry season indicators of temporary ponds. Permanent ponds are any size or depth, but larger is generally better; water must be present year-round, although the top layer can freeze.

Permanent streams are first- to third-order streams which contain flowing water throughout the year and are less than 15 feet wide. As was the case for permanent ponds, the top layer of water can freeze. Seeps are small springs often located on the toe of a slope, which usually flow year-round. Lush vegetation often grows nearby.

Perches

High perches may be live or dead overstory trees that clearly tower above all other forest vegetation (e.g., supracanopy white pines), or a single tree or group of trees standing above herbaceous ground vegetation (e.g., a lone elm in a pasture or a snag in a clearcut).

Low perches are any exposed perches less than 10 feet tall. Examples include fences, isolated deciduous shrubs, clumps of woody sprouts, tree tops remaining after harvesting, and short tree stubs.

Subterranean habitats

Loose soil is simply soil that can easily be burrowed through. Rock piles are either natural or manmade, as long as they provide places where small mammals, amphibians, and reptiles can hide. Rock crevices are openings in rocks which lead below the frost line. Small mammals and reptiles use crevices. Caves are larger openings in rocks that lead below the frost line. Mammals from bats to bears, as well as many species of amphibians and reptiles, all use caves.

Cavity trees

Cavity trees are often recorded in standard inventories, but simply standing at plot centers to look for cavities does not provide a very accurate estimate of cavity density or size. By watching while you walk through the stand, you can check their presence on the tally sheet. If you notice an especially large cavity, or a tree or area with an exceptionally large number of cavities, make a note of it in the Comments block of the tally sheet. Live or dead cavity trees must be greater than 4 inches in DBH. The cavity opening itself must be at least one inch in diameter. Generally, the larger a tree's DBH, the more species of wildlife that can use it.

SAMPLE PLOT MEASUREMENTS

The remainder of this chapter is devoted to the measurements you will make at each plot. Some of these methods you will undoubtedly be familiar with. Others you may have never even considered before. The measurements begin at the ground level; that way, you will be less likely to inadvertently destroy the low-growing vegetation while collecting the overstory data.

Forest Types

Before you collect the data on the ground layer, you must first determine the predominant forest type at each plot. Although a number of forest types are found in Pennsylvania, only eight are used with this methodology. They are:

- **aspen-birch**
- **northern hardwoods**
- **red maple**
- **spruce-fir**
- **hemlock**
- **red oak**
- **mixed oak/pine/red maple**
- **white/red pine**

You may notice that Pennsylvania's most common forest type, oak-hickory, does not appear in this list. That is because the assessment method was adapted from a New England report of wildlife habitat requirements. We are currently developing the criteria needed to include the oak-hickory forest type, but for now, please choose either the red oak or mixed oak/pine/maple type as appropriate.

Because several types may occur within a stand, you must decide which type is predominant in each plot. This will cover any instances when there is a small inclusion of a unique forest type (e.g. a group of aspen within a northern hardwood stand). At the end of your stand assessment, determine the forest type for the overall stand--that which is most predominant over all plots. Knowing where inclusions are may help you recommend special projects to the landowner.

Aspen-birch forests grow throughout the state, usually on sites disturbed by major natural or human-caused occurrences. This category includes any stand dominated by aspen, birch, or a combination of the two. The aspen sub-group is usually dominated by quaking aspen, but big-toothed aspen forms a large component on wetter sites.

Northern hardwoods are found throughout the state and are second only to the red oak type in percent covered. The northern hardwood type is dominated by sugar maple, beech, and birch, with varying associations of black cherry, basswood, and white ash. It also includes yellow birch, northern red oak, paper birch, hemlock, and white pine.

For our purposes, the red maple type includes only hardwood stands located on *wet* sites, the swamp hardwoods. Red maple, ash, and elm are the predominant species, but swamp oak, hemlock, sycamore, and black tupelo can also be major components. If the stand is mostly deciduous and on a wet site, then identify it as red maple.

The spruce/fir type is found at higher elevations in glaciated sections of the state. The canopy is dominated by a combination of balsam fir and red spruce, but plantation species such as Norway spruce are also included in this forest type. There are several pure stands of both balsam fir and red spruce scattered throughout the region.

The hemlock forest type is, of course, dominated by the very shade tolerant Eastern hemlock. The Eastern hemlock can survive on a variety of sites, but is most aggressive on cool, wet sites, where it will out-grow other forest types such as the northern hardwoods. The high shade tolerance of hemlock will produce pure stands of hemlock, but often it is associated with yellow or black birch and sugar and red maple.

The red oak forest type is what many would call the oak/hickory type. The species include northern red oak, white oak, chestnut oak, hickories, and beech, with minor components of sassafras, and even some hawthorn.

The mixed oak/pine/red maple forest type is found in varying combinations depending on the soil type. The dominant species include northern red oak, white pine, and red maple. It's often found in areas where the forest was previously dominated by pines and is now being taken over by hardwoods or vice versa.

The white/red pine forest type includes both red pine and white pine, whether grown in plantations or naturally seeded in. Select this forest type for stands of any pine species.

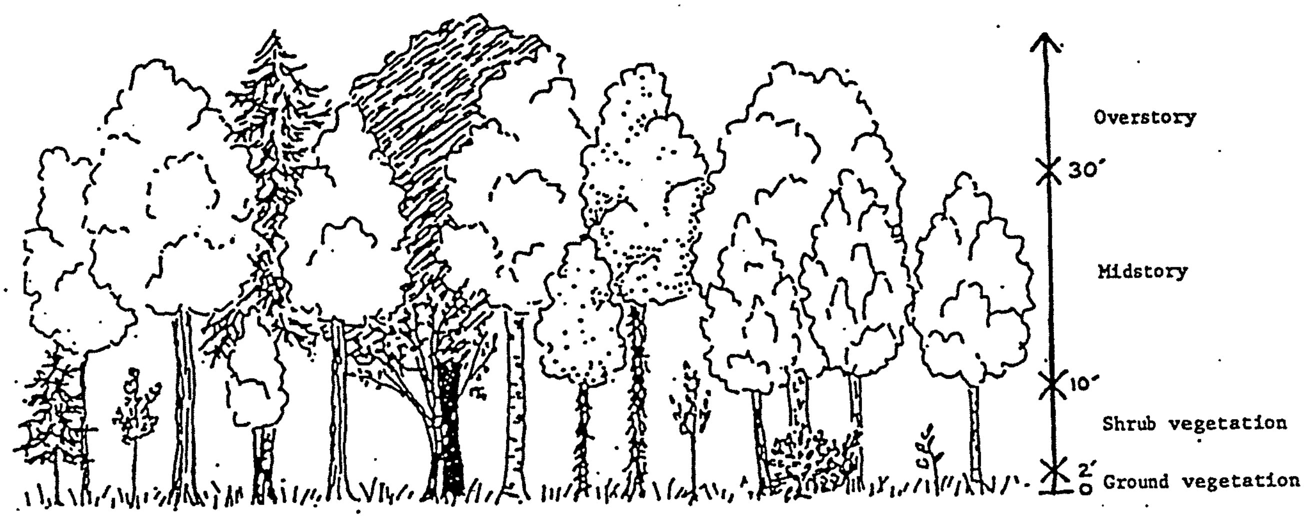


Figure 7. Explanation of vegetative layers

Ground Structure

A circular milacre plot (radius = 3.72 feet) is useful for determining percent cover and species composition of the ground and shrub layers. However, if you already use the 6-foot radius plot suggested by the SILVAH program, continue to do so. There is no reason to use two different sized plots. Be sure to use the same plot size consistently throughout the stand.

First, determine the percent of ground area of the milacre (or 6-foot) plot which is covered by rocks (to the nearest 10%) and enter the value in the "% rock cover" column in Block 1 of the tally sheet. Also, estimate the percent cover of the leaf litter within the plot. Record this value in the "% forest litter" column. If you need to accustom your eyes to estimate percent cover, refer to the templates in Appendix D.

Next, determine the percent of the area covered by ground vegetation, any plants growing up to 2 feet in height (Figure 7). Enter the value (to the nearest 10%) in the "% ground cover" column in Block 1.

While you are looking at the ground layer, you should note in Block 5 of the tally sheet what species appear. There are over 2,000 herbaceous plant species in Pennsylvania. It would be impossible to learn them all, but you should ask yourself several general questions about the species you see: How many tree seedlings are there? Which plants seem likely to interfere with regeneration? Do any plants seem uncommon in the area? If you see a plant that you don't recognize, just list a '?' in the appropriate column. Be sure to indicate the plot number beside any uncommon species you observe. This will help the landowner locate an area that may warrant special attention.

Any inventory is just a 'snapshot in time' of the site. This is especially true of the ground layer. Because the ground layer is composed of many herbaceous plants, the percent cover and species composition change almost weekly. Some species only appear in the early spring (e.g. spring beauties), some, such as mayapples grow until mid-summer, and still others (e.g. Christmas ferns), year-round.

Shrub Vegetation

Data from the shrub layer is similar to that obtained from the ground layer. The shrub layer includes all vegetation between 2 and 10 feet tall (Figure 7). Determine percent shrub cover in the milacre (or 6-foot) plot, and enter the value to the nearest 10% in the "% shrub cover" column in Block 1.

As you did for ground vegetation, list the shrub species growing in the plot in Block 6. Then determine whether the types of shrubs growing in the area are deciduous (D), coniferous (C), or ericaceous (E). (Ericaceous species include blueberry, rhododendron, and mountain laurel.) Enter the shrub type letter(s) in the "shrub type" column in Block 1.

If any of the shrubs produce hard or soft mast, check (√) the appropriate box in the "mast'" column of Block 1. Soft mast is soft fruit, such as apples, cherries, blueberries, and barberries. Hard mast is hard fruit, like beechnuts, acorns, hickory nuts, and conifer seeds.

Midstory vegetation

Midstory vegetation is between 10 and 30 feet tall (Figure 7). There are two aids in determining the midstory cover before your eye is trained to estimate it accurately. The first is the **grid** method. To use this, you look through an acetate overlay (Appendix E) and count the squares occupied by midstory vegetation. You should take five readings, either randomly or systematically, within a 12 foot radius of the plot center. A chart below the grid provides the conversion formulas you will then need to determine the percent coverage. Figure 8 illustrates the use of the grid.

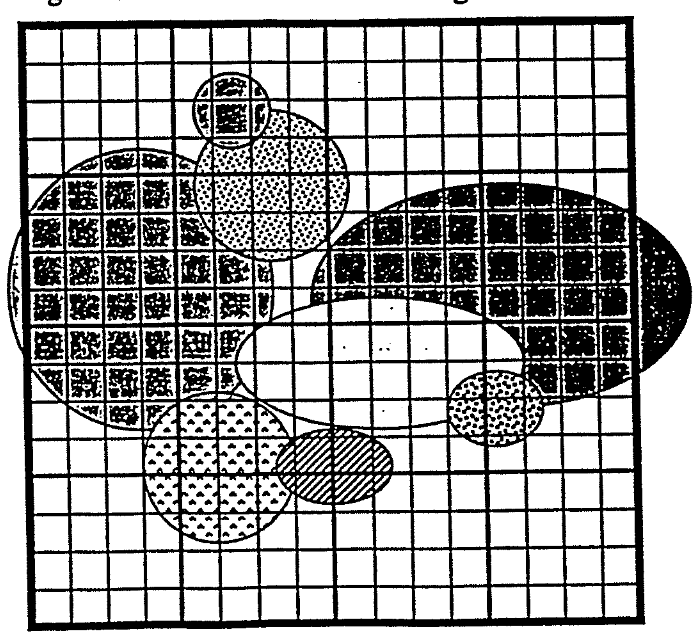
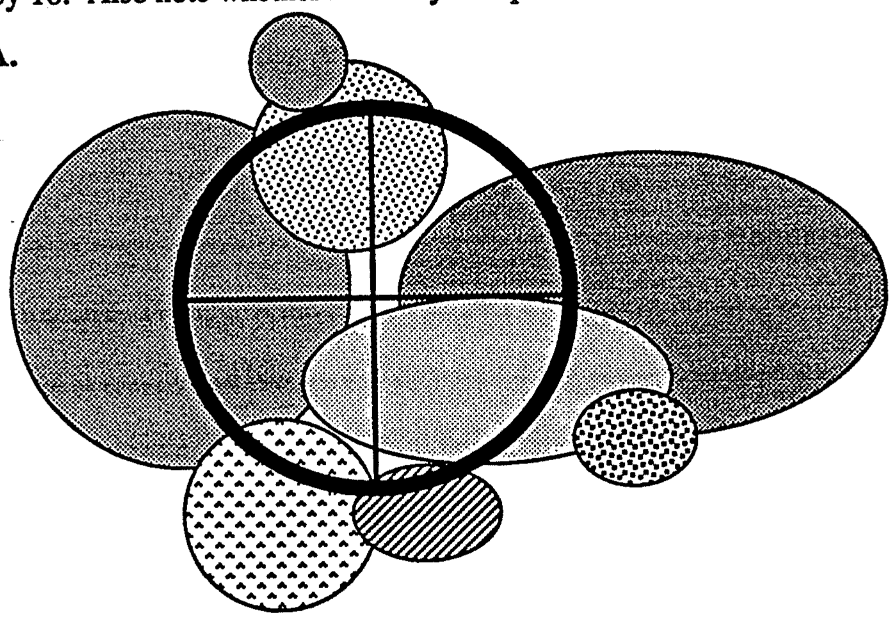


Figure 8. Grid method of estimating vegetative cover, showing about 50% cover

The second method uses an **ocular tube**, which you hold vertically over your head and look through. If vegetation occurs where the crosshairs meet, record that reading as having vegetation present (Figure 9B). At each plot, take 10 readings (random or systematic) within a 12 foot radius of your plot center. Record the measurements in the "Cover readings'"area on Block 1. Our example illustrates readings taken using the ocular tube. The percent cover will be the number of plots with vegetation present multiplied by 10. Also note whether midstory composition is deciduous or coniferous.

A.



B.

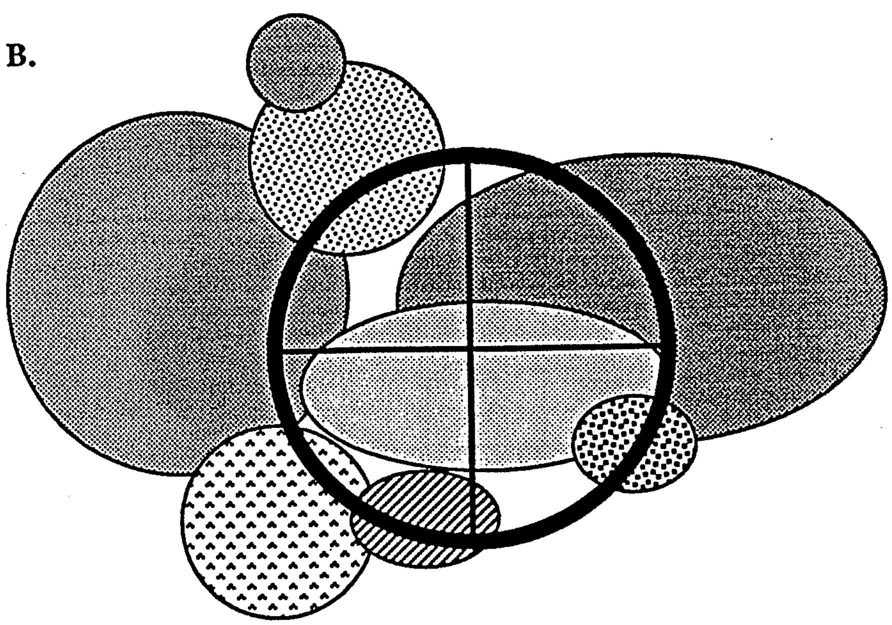


Figure 9. Ocular tube positions--9A shows vegetation absent
9B shows vegetation present

Overstory vegetation

Overstory vegetation, anything greater than 30 feet in height (Figure 7), will be measured for cover using the same method you chose to sample the midstory cover. Record percent cover to the nearest 10% in the appropriate column in Block 1 of the tally sheet. Individual readings can be recorded in the "Cover readings" section of Block 1.

Next, use a basal area plot to determine the number of snags and cavity trees per acre, and the type of mast (hard or soft) within the stand. For each tree in the 10 BAF plot, record the species, DBH, whether the tree is acceptable or unacceptable growing stock (or dead), and the number of cavities. Record these in Block 2 of the tally sheet. (You can use the "Height" column to record height, numbers of trees, or any other relevant information.)

Using the conversion chart in Appendix F, determine the number of snags and cavities per acre and record the values in the appropriate row in the "# snags/acre" and the "# cavity trees/acre" columns in the Stand Summary block.

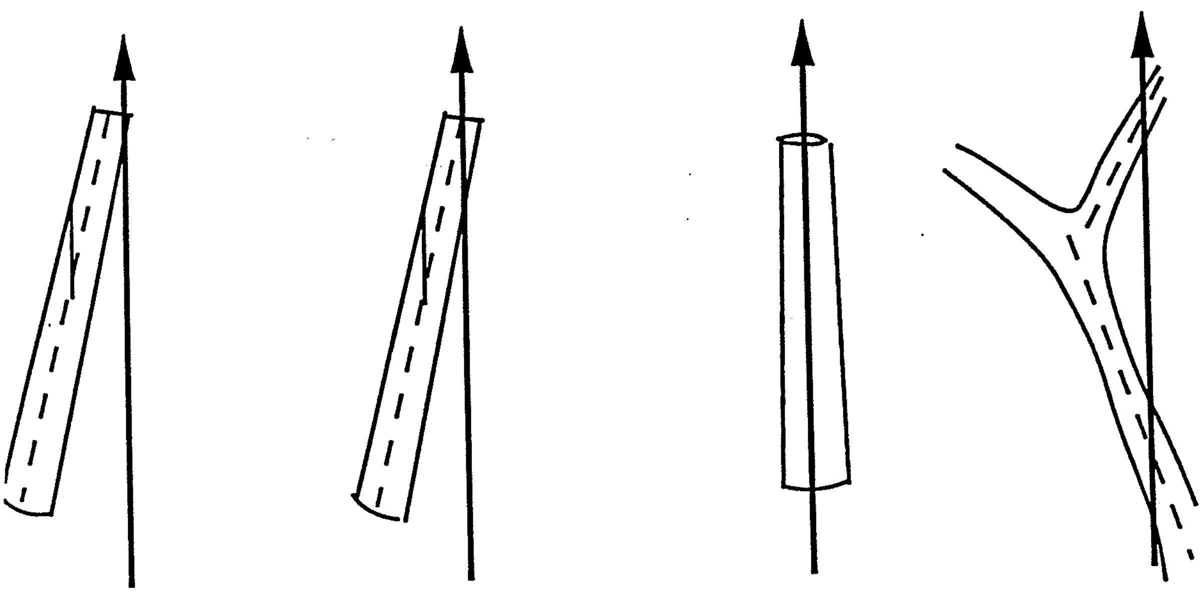
Between-plot data

While you are walking between plots, use the line-intersect method to determine the amount of dead and downed woody material in the stand. All you have to do is remain on your bearing to the next plot and record the diameter of the logs you walk over (or under).

Remember that, within a stand, the between-plot distance should remain constant (for example, one plot every 300 feet, or every 5 chains), although the line intersect method can give accurate results with 'uneven' distances. Record the distance between plots in the top section of Block 4 on the tally sheet.

While walking to your next plot, record the diameter of all dead and down logs at the point where they intersect your transect in the column labeled "d." Measure only dead and down logs with a diameter of at least 3 inches and length of at least 3 feet.

Figure 10 shows some typical and not-so-typical situations you may encounter using the line-intersect. If the bearing intersects the end of a log, record the diameter only if the central axis is crossed (figure 10a). If the bearing intersects the exact end of a log's central axis, record the diameter of every second such piece (figure 10b). If the bearing coincides with a log's central axis, do not measure it (figure 10c). If the bearing crosses a curved log more than once, record the diameter at each crossing (figure 10d).



. Transect does not intersect central axis of log.
DO NOT TALLY

B. Transect intersects with exact end of central axis of log.
TALLY EVERY SECOND PIECE

C. Transects coincides with central axis of log.
DO NOT TALLY

D. Transects crosses central axis of log two or more times. (Branches must be at least 3 inches in diameter.)
TALLY EACH CROSSING

Figure 10. Possibilities in the line-intersect method for tallying dead and down material

When you reach the next plot, record the square of each diameter in the 'd^2' column, sum the 'd^2' column, and enter the sum in the "Stand Summary" block. Remember--if you have 'n' number of plots, you will have 'n-1' line-intersect plots.

Once you have summarized your data, you can analyze the stand's capacity to support different wildlife species by using either a manual matrix or a computer program. These are described in detail in Chapters 4 and 5.

POST-FIELD WORK

Forest Size Class

Finally, you will need to determine the size class of the forest. Seedling stands are smaller than one inch at DBH. Sapling/pole stands are between 1.0 and 10.9 inches at DBH. Small sawtimber stands range from 11.0 to 16 inches at DBH, and large sawtimber stands are those with average DBH larger than 16 inches. Northern hardwood forest types may also be labeled as uneven-aged stands. There is room in the "Comments" block of the tally sheet to indicate the size class.

Landscape analysis

Because the surrounding area can influence and be influenced by the property you are inventorying, it is necessary to look at the larger landscape. Aerial photos offer the opportunity to evaluate the property in a landscape setting. Look at an area with approximately a one-mile radius from the center of the stand. Ask yourself the following questions about the area:

- Does the property repeat the landscape pattern?
- Which forest types are underrepresented in the landscape? On your forest?
- Which size classes are underrepresented in the landscape? On your forest?
- Would any of your proposed treatments eliminate a habitat from the landscape?

Surveyor: John Doe   Date: 9/28/94   **BLOCK 1**   VEGETATIVE COVER

Property Owner: M. Smith   Town: Randomville   Province: Blue Ridge   Stand#: 1   Stand Ac: 46

PLOT #	FOREST TYPE	% ROCK COVER	% GROUND COVER	% FOREST LITTER	% SHRUB COVER	SHRUB TYPE DCE		COVER READINGS	% OVERSTORY COV	% MIDSTORY COV	MIDSTORY TYPE DC	MAST -shrub -mid -over SOFT	HARD
1	EH	50	50	50	80	DcE	over	= ± = ± = ± ± ± ± =	60	30	DC	SMo	Mo
							mid	− + − + − + − − − −					
2	EH	70	50	40	60	DcE	over	± ± ± ± = = = ± ± ±	70	10	DC	SMo	M
							mid	− − + − − − − − − −					
3	RM	50	50	30	70	DcE	over	± = = = ± ± ± ± ± =	60	10	DC	SMo	M
							mid	− − − − − − + − − −					
4							over	_ _ _ _ _ _ _ _ _ _					
							mid						
5							over	_ _ _ _ _ _ _ _ _ _					
							mid						
6							over	_ _ _ _ _ _ _ _ _ _					
							mid						
7							over	_ _ _ _ _ _ _ _ _ _					
							mid						
8							over	_ _ _ _ _ _ _ _ _ _					
							mid						
9							over	_ _ _ _ _ _ _ _ _ _					
							mid						
10							over	_ _ _ _ _ _ _ _ _ _					
							mid						
TOT													

BASAL AREA   **BLOCK 2**   BASAL AREA

Sp	DBH	QUA	HT	CAV	Sp	DBH	QUA	HT	CAV	Sp	DBH	QUA	HT	CAV	Sp	DBH	QUA	HT	CAV	Sp	DBH	QUA	HT	CAV
EH	16	A																						
EH	14	A																						
YB	10	U		1																				
WO	26	A																						
EH	18	U		2																				
YB	16	A																						
EH	18	A																						
EH	16	A																						
EH	14	X		1																				
RM	18	U		1																				
EH	20	A																						
RM	8	A																						
RM	10	A																						
RM	10	U																						
RM	16	U		1																				
SM	16	A																						
EH	18	A																						
RM	18	A																						
RM	12	U																						

BLOCK 3

WITHIN STAND FEATURES

Feature	
Temp Pond	✓
Perm Pond	
Seeps	✓
Perm Stream	
Loose Soil	✓
Rock Piles	
Rock Crev	
Caves	
High Perches	
Low Perches	✓
Dead Cavities	
Live Cavities	

DEAD & DOWNED — BLOCK 4

LINE LENGTH: 300

PLOT #	d	d^2	PLOT #	d	d^2	PLOT #	d	d^2	PLOT #	d	d^2	PLOT #	d	d^2	PLOT #	d	d^2	PLOT #	d	d^2
1	4	16																		
1	6	36																		
2	8	64																		
2	4	16																		
3	4	16																		
3	4	16																		
3	5	25																		

BASAL AREA — BLOCK 2 Cont' — BASAL AREA

SP	DBH	QUA	HT	CAV	SP	DBH	QUA	HT	QUA	SP	DBH	QUA	HT	CAV

STAND SUMMARY

PLOT #	AVG DBH	# CAV TREES	# SNAGS	d^2 PLOT SUM	LINE LENGTH ft.
1		29		52	300
2		6	9	80	300
3		7		57	300
4					
5					
6					
7					
8					
9					
0					
SUM				a 189	b 900

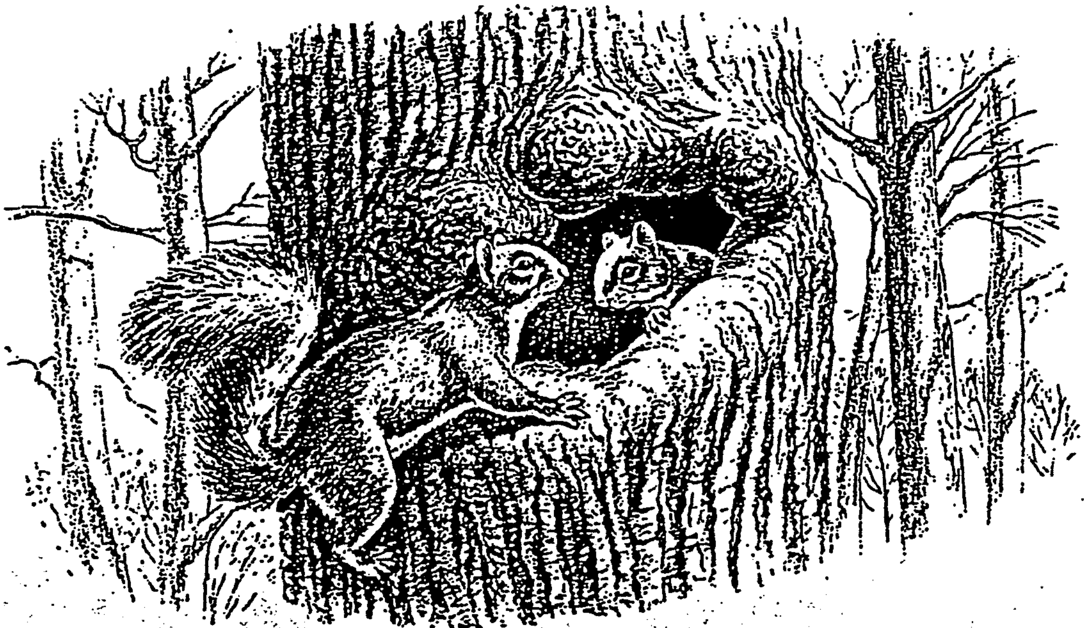
(189 (a) • 373) / (900 (b)) = 78 cu. ft./ac

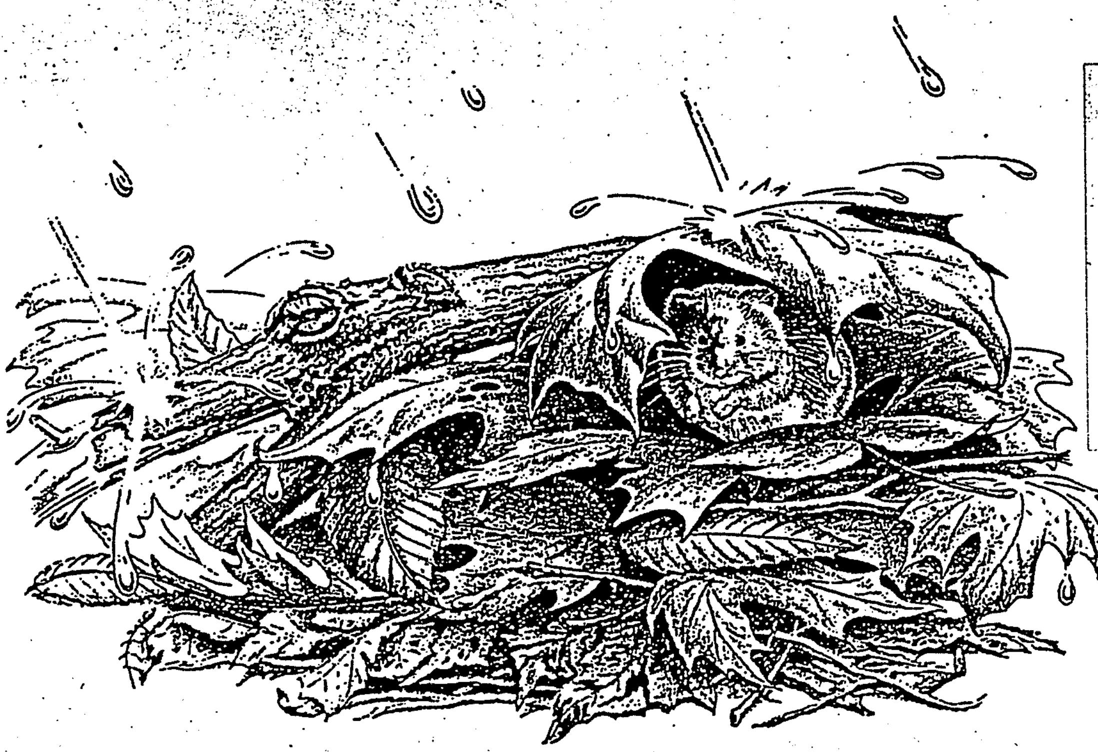
COMMENTS

PLOT #	COMMENTS
1	(Small sawtimber stand)
2	
3	
4	
5	
6	
7	
8	
9	
_0	

GROUND LAYER BLOCK		BLOCK 5	GROUND LAYER BLOCK	
PLOT #	SEEDLINGS	OTHER PLANTS	PROBLEM PLANTS	UNCOMMON PLANTS
1	RM	violet	barberry	ladyslipper (1)
	Black birch	VA creeper		
	EH	?		
		?		
		rattlesnake weed		
2	RM	violet	barberry	? (2)
	EH	VA creeper		
		blueberry		
3	RM	violet	barberry	
		?		
		Skunk cabbage		

SHRUB LAYER BLOCK		BLOCK 6	SHRUB LAYER BLOCK	
PLOT #	TREE SPECIES	PROBLEM SPECIES	OTHERS	UNCOMMON SPECIES
1	EH	barberry	mt. laurel	
2	EH	barberry	mt. laurel	
3	EH	barberry	mt. laurel	
			spicebush	





CHAPTER 4

USING THE MATRIX

Once you have determined the conditions of your stand, you can use that information to predict what species could potentially survive there. There are two methods of doing this - with a manual matrix or a computer program. The systems are intended to interface the existing structure and composition of forest vegetation with the habitat requirements of more than 200 wildlife whose species known to inhabit Pennsylvania. The wildlife species included in this assessment are listed in Appendix G.

The accuracy of habitat structural feature information required by wildlife species varies for each species. Certain species habitat requirements are well-documented, while for others only limited data is available. Information used in developing the species/structural feature matrix is treated as a working hypothesis that requires testing. Through use, the assessment model and the species structural feature requirements will be refined. However, this model represents a test of the methodology.

The models are quick and useful tools for predicting shifts in wildlife species due to silvicultural management activities that modify structural features. The models also yield information that gives managers and landowners the opportunity to decide whether they are increasing or eliminating certain habitats. The user should be aware that:

1. Information about structural features for some species is limited and assessment outcomes should be treated as hypotheses.
2. In order to make the manual format manageable, species were clustered and these groups may not reflect all of the required structural features for individual species in the group. For example, the least flycatcher was placed into a group whose "main" structural feature is dense (>70%) overstory cover. The least flycatcher also requires ground cover between 30-75%. However, because no group was formed in the cluster analysis with these two features (dense overstory cover and partial ground cover), the least flycatcher was placed in the overstory users' group.

Manual matrix

The following pages take you through a sample run of the manual matrix. A blank matrix sheet and completed stand summary sheet are provided on pages 50 and 51 for you to follow along with the example and cross out the appropriate group numbers that correspond to the specific questions. Blank matrix sheets and summary sheets appear in Appendices H and I for you to copy and use.

Empty Sample Matrix

GROUP #	TEMPORARY WATER	PERMANENT WATER	SUBTERRANEAN	DEAD & DOWN	% ROCKS	% LITTER	≤30% GROUND COVER	>75% GROUND COVER	>50% SHRUB COVER	DECIDUOUS SHRUBS	CONIFEROUS SHRUBS	ERICACEOUS SHRUBS	DECIDUOUS MIDSTORY	CONIFEROUS MIDSTORY	CAVITY TREES & SNAGS	≤15% OVERSTORY	16 TO 30% OVERSTORY	31 TO 70% OVERSTORY	>70% OVERSTORY	MAST	HIGH PERCH	LOW PERCH
1	1																					
2	1			4		6																
3		2																				
4		2	3			6																
5		2		4		6																
6		2			5																	
7		2					7															
8			3																			
9			3	4																20		
10				4	5																	
11				4		6													19			
12				4		6				10	11											
13				4											15							
14					5																	
15								8														
16								8	9	10												
17								8		10		12										
18								8							15							
19								8									17			20		
20									9	10		12										
21										10		12				16				20		
22										10	11	12						18				
23										10			13									
24											11	12										
25											11			14								
26													13							20		
27														14					19			
28															15							
29															15		17					
30															15					20		
31																16					21	
32																	17					
33																		18				
34																			19			
35																					21	22
36																						22
37																						

Stand Summary Tally Sheet

Property name: Hemlock Acres **Stand #:** 1 **Area:** 4

Physiographic province: Blue Ridge

Forest type: Eastern Hemlock **Size-class:** Small Sawtimber

Structural features - Stand summary:

Temporary water: Yes

Permanent water: No

Subterranean habitats: Yes

Dead & down material: 70 cubic feet

% rock cover: 50 percent

Forest litter: 40 percent

% ground cover: 50 percent

% shrub cover: 70 percent

Shrub types: deciduous (50 %) coniferous (10 %) ericaceous (40 %)

% midstory cover: 15 percent

Midstory types: deciduous (60 %) coniferous (40 %)

Snags and/or cavity trees: None

% overstory cover: 65 percent

Mast: Hard and Soft Mast

High or low perches: High (No) Low (Yes)

Stewardship prescription: ______________________________

Example Matrix Exercise

GROUP #	TEMPORARY WATER	PERMANENT WATER	SUBTERRANEAN	DEAD & DOWN	% ROCKS	% LITTER	≤30% GROUND COVER	>75% GROUND COVER	>50% SHRUB COVER	DECIDUOUS SHRUBS	CONIFEROUS SHRUBS	ERICACEOUS SHRUBS	DECIDUOUS MIDSTORY	CONIFEROUS MIDSTORY	CAVITY TREES & SNAGS	≤15% OVERSTORY	16 TO 30% OVERSTORY	31 TO 70% OVERSTORY	>70% OVERSTORY	MAST	HIGH PERCH	LOW PERCH
1	1																					
2	1			4		6																
~~3~~		~~2~~																				
~~4~~		~~2~~	~~3~~			~~6~~																
~~5~~		~~2~~		~~4~~		~~6~~																
~~6~~		~~2~~			~~5~~																	
~~7~~		~~2~~					~~7~~															
8			3																			
9			3	4																20		
10				4	5																	
11				4		6													19			
12				4		6				10	11											
13				4											15							
14					5																	
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18								8							15							
19								8									17			20		
20									9	10		12										
21										10		12				16				20		
22										10	11	12						18				
23										10			13									
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25											11			14								
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27														14					19			
28															15							
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31																16					21	
32																	17					
33																		18				
34																			19			
35																					21	22
36																						22
37																						

1. Are there any temporary ponds in the stand?
   If YES, go to question 2.
   If NO, draw a line through every row with the number 1 in it, then go to question 2.

   Yes temporary ponds are in the stand, no groups crossed out.

2. Are there any permanent water sources (seeps, permanent ponds or streams) in the stand?
   If YES, go to question 3.
   If NO, draw a line through every row with the number 2 in it, then go to question 3.

   No permanent water sources are in the stand, so lines are drawn through groups #3, 4, 5, 6, & 7.

Example Matrix Exercise

GROUP #	TEMPORARY WATER	PERMANENT WATER	SUBTERRANEAN	DEAD & DOWN	% ROCKS	% LITTER	≤30% GROUND COVER	>75% GROUND COVER	>50% SHRUB COVER	DECIDUOUS SHRUBS	CONIFEROUS SHRUBS	ERICACEOUS SHRUBS	DECIDUOUS MIDSTORY	CONIFEROUS MIDSTORY	CAVITY TREES & SNAGS	≤15% OVERSTORY	16 TO 30% OVERSTORY	31 TO 70% OVERSTORY	>70% OVERSTORY	MAST	HIGH PERCH	LOW PERCH
1	1																					
2	1			4		6																
~~3~~		2																				
~~4~~		2	3			6																
~~5~~		2		4		6																
~~6~~		2			5																	
~~7~~		2					7															
8			3																			
9			3	4																20		
10				4	5																	
11				4		6													19			
12				4		6				10	11											
13				4											15							
14					5																	
15								8														
16								8	9	10												
17								8		10		12										
18								8							15							
19								8									17			20		
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21										10		12				16				20		
22										10	11	12						18				
23										10			13									
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31																16					21	
32																	17					
33																		18				
34																			19			
35																					21	22
36																						22
37																						

3. Is subterranean habitat present?
   If YES, go to question 4.
   If NO, draw a line through every row with the number 3 in it, then go to question 4.

   Subterranean habitat is present, no groups are crossed out.

4. Is there more than 50 cubic feet of dead and down material (including slash piles) present in the stand?
   If YES, go to question 5.
   If NO, draw a line through every row with the number 4 in it, then go to question 5.

   Ample dead & down material exists, no groups are crossed out.

5. Is there more than 25% rock cover in the stand?
   If YES, go to question 6.
   If NO, draw a line through every row with the number 5 in it, then go to question 6.

   Yes there is more than 25% rock cover, no groups crossed out.

Example Matrix Exercise

GROUP #	TEMPORARY WATER	PERMANENT WATER	SUBTERRANEAN	DEAD & DOWN	% ROCKS	% LITTER	≤30% GROUND COVER	>75% GROUND COVER	>50% SHRUB COVER	DECIDUOUS SHRUBS	CONIFEROUS SHRUBS	ERICACEOUS SHRUBS	DECIDUOUS MIDSTORY	CONIFEROUS MIDSTORY	CAVITY TREES & SNAGS	≤15% OVERSTORY	16 TO 30% OVERSTORY	31 TO 70% OVERSTORY	>70% OVERSTORY	MAST	HIGH PERCH	LOW PERCH
1	1																					
2	1			4		6																
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6. Is more than 25% of the ground area covered by forest litter?
   If YES, go to question 7.
   If NO, draw a line through every row with the number 6 in it, then go to question 7.

> Yes ground cover is ample, no groups are crossed out.

7. What is the percent ground cover? Choose one.
   If it's between 0% and 29%, draw a line through every row with the number 8 in it, then go to question 8.
   If it's between 30% and 75%, draw a line through every row with the numbers 7 and/or 8, then go to question 8.
   If it's greater than 75%, draw a line through every row with the number 7 in it, then go to question 8.

> There is between 30% and 75% ground cover, draw a line through groups #15, 16, 17, 18, & 19.

Example Matrix Exercise

GROUP #	TEMPORARY WATER	PERMANENT WATER	SUBTERRANEAN	DEAD & DOWN	% ROCKS	% LITTER	≤30% GROUND COVER	>75% GROUND COVER	>50% SHRUB COVER	DECIDUOUS SHRUBS	CONIFEROUS SHRUBS	ERICACEOUS SHRUBS	DECIDUOUS MIDSTORY	CONIFEROUS MIDSTORY	CAVITY TREES & SNAGS	≤15% OVERSTORY	16 TO 30% OVERSTORY	31 TO 70% OVERSTORY	>70% OVERSTORY	MAST	HIGH PERCH	LOW PERCH
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8. What is the percent shrub cover? Choose one.
   If it's between 0% and 20%, draw a line through every row with the number 9, 10, 11, and/or 12 in it, then go to question 12.
   If it's between 21% and 50%, draw a line through every row with the number 9 in it, then go to question 9.
   If it's greater than 50%, then go to question 9.

> Shrubs cover is more than 50%, no groups are crossed out.

9. Are at least 25% of the shrubs deciduous?
   If YES, go to question 10.
   If NO, draw a line through every row with the number 10 in it, then go to question 10.

> Yes at least 25% of shrubs are deciduous, no groups are crossed out.

Example Matrix Exercise

GROUP #	TEMPORARY WATER	PERMANENT WATER	SUBTERRANEAN	DEAD & DOWN	% ROCKS	% LITTER	≤30% GROUND COVER	>75% GROUND COVER	>50% SHRUB COVER	DECIDUOUS SHRUBS	CONIFEROUS SHRUBS	ERICACEOUS SHRUBS	DECIDUOUS MIDSTORY	CONIFEROUS MIDSTORY	CAVITY TREES & SNAGS	≤15% OVERSTORY	16 TO 30% OVERSTORY	31 TO 70% OVERSTORY	>70% OVERSTORY	MAST	HIGH PERCH	LOW PERCH
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10. Are at least 25% of the shrubs coniferous?
    If YES, go to question 11.
    If NO, draw a line through every row with the number 11 in it, then go to question 11.

> Less than 25% of the shrubs are coniferous, cross out groups #12, 21, 22, 24, & 25.

11. Are at least 25% of the shrubs ericaceous?
    If YES, go to question 12.
    If NO, draw a line through every row with the number 12 in it, then go to question 12

> Yes more than 25% of the shrubs fall under ericaceous, no groups are crossed out.

Example Matrix Exercise

GROUP #	TEMPORARY WATER	PERMANENT WATER	SUBTERRANEAN	DEAD & DOWN	% ROCKS	% LITTER	≤30% GROUND COVER	>75% GROUND COVER	>50% SHRUB COVER	DECIDUOUS SHRUBS	CONIFEROUS SHRUBS	ERICACEOUS SHRUBS	DECIDUOUS MIDSTORY	CONIFEROUS MIDSTORY	CAVITY TREES & SNAGS	≤15% OVERSTORY	16 TO 30% OVERSTORY	31 TO 70% OVERSTORY	>70% OVERSTORY	MAST	HIGH PERCH	LOW PERCH
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12. Is percent midstory cover >25%?
    If YES, then go to question 13.
    If NO, draw a line through every row with the numbers 13 and/or 14, then go to question 15.

> The midstory is less than 25%, cross out groups #23, 26, & 27. Skip to question 15.

13. Is the midstory composed of at least 25% deciduous species?
    If YES, then go to question 14.
    If NO, draw a line through every row with the number 13 in it, then go to question 14.

> Skip this question.

14. Is the midstory composed of at least 25% coniferous species?
    If YES, then go to question 15.
    If NO, draw a line through every row with the number 14 in it, then go to question 15.

> Skip this question.

Example Matrix Exercise

GROUP #	TEMPORARY WATER	PERMANENT WATER	SUBTERRANEAN	DEAD & DOWN	% ROCKS	% LITTER	≤30% GROUND COVER	>75% GROUND COVER	>50% SHRUB COVER	DECIDUOUS SHRUBS	CONIFEROUS SHRUBS	ERICACEOUS SHRUBS	DECIDUOUS MIDSTORY	CONIFEROUS MIDSTORY	CAVITY TREES & SNAGS	≤15% OVERSTORY	16 TO 30% OVERSTORY	31 TO 70% OVERSTORY	>70% OVERSTORY	MAST	HIGH PERCH	LOW PERCH
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15. Are there snags and/or cavity trees present?
    If YES, go to question 16.
    If NO, draw a line through every row with the number 15 in it, then go to question 16.

> No snag or cavity trees are present on the site, cross out groups #13, 28, 29, & 30.

16. What is the percent overstory cover? Choose one.
    If it's between 0% and 15%, draw a line through every row with the numbers 17, 18, and/or 19, then go to question 17.
    If it's between 16% and 30%, draw a line through every row with the numbers 16, 18, and/or 19, then go to question 17.
    If it's between 31% and 70%, draw a line through every row with the numbers 16, 17, and/or 19, then go to question 17.
    If it's greater than 71%, draw a line through every row with the numbers 16, 17, and/or 18, then go to question 17.

> The overstory between 31% & 70%, cross out groups #31, 32, 34.

Example Matrix Exercise

GROUP #	TEMPORARY WATER	PERMANENT WATER	SUBTERRANEAN	DEAD & DOWN	% ROCKS	% LITTER	≤30% GROUND COVER	>75% GROUND COVER	>50% SHRUB COVER	DECIDUOUS SHRUBS	CONIFEROUS SHRUBS	ERICACEOUS SHRUBS	DECIDUOUS MIDSTORY	CONIFEROUS MIDSTORY	CAVITY TREES & SNAGS	≤15% OVERSTORY	16 TO 30% OVERSTORY	31 TO 70% OVERSTORY	>70% OVERSTORY	MAST	HIGH PERCH	LOW PERCH
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17. Are either hard or soft mast species present?
    If YES, go to question 18.
    If NO, draw a line through every row with the number 20 in it, then go to question 18.

> Yes there are mast species present, no groups are crossed out.

18. Are there high perches in the stand?
    If YES, go to question 19.
    If NO, draw a line through every row with the number 21 in it, then go to question 19.

> No high perches are present in the stand, cross out group # 35.

Example Matrix Exercise

GROUP #	TEMPORARY WATER	PERMANENT WATER	SUBTERRANEAN	DEAD & DOWN	% ROCKS	% LITTER	≤30% GROUND COVER	>75% GROUND COVER	>50% SHRUB COVER	DECIDUOUS SHRUBS	CONIFEROUS SHRUBS	ERICACEOUS SHRUBS	DECIDUOUS MIDSTORY	CONIFEROUS MIDSTORY	CAVITY TREES & SNAGS	≤15% OVERSTORY	16 TO 30% OVERSTORY	31 TO 70% OVERSTORY	>70% OVERSTORY	MAST	HIGH PERCH	LOW PERCH
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19. Are there low perches in the stand?
 If YES, go to question 20.
 If NO, draw a line through every row with the number 22 in it, then go to question 20.

Yes low perches are present, no groups are crossed out.

20. The remaining rows are those wildlife groups that have habitat in the stand. The groups that were not crossed are numbers 1, 2, 8, 9, 10, 11, 14, 20, 33, 36, & 37. Go to the appropriate forest type section and find the appropriate size-class table from Appendix K (which we show on pages 61-62) Find the corresponding group code for the species list.

As a final step, check the physiographic province table in Appendix J for those species whose ranges are limited in Pennsylvania. Cross out any species which appears in the appropriate groups, but are listed as not present in the physical provinance of interest. None of the species listed under the Eastern Hemlock Small and Large Sawtimber Classes are excluded due to the physiographic restrictions in our example.

Eastern hemlock Small and Large Sawtimber Classes

Group 1	eastern American toad spring peeper
Group 2	spotted salamander red-spotted newt four-toed salamander wood frog
Group 3	eastern American toad spring peeper pickerel frog raccoon river otter
Group 4	wood turtle northern short-tailed shrew southern red-backed vole mink
Group 5	spotted salamander red-spotted newt four-toed salamander wood frog
Group 6	northern coal skink northern dusky salamander northern spring salamander northern two-lined salamander rock vole
Group 7	northern waterthrush
Group 8	hairy-tailed mole coyote
Group 9	eastern chipmunk black bear striped skunk
Group 10	Wehrle's salamander northern brown snake northern copperhead long-tailed shrew woodland jumping mouse
Group 11	redback salamander slimy salamander black-and-white warbler ovenbird Maryland shrew masked shrew smoky shrew pygmy shrew
Group 12	hermit thrush Canada warbler ermine bobcat
Group 13	broad-headed skink great crested flycatcher
Group 14	northern redbelly snake northern ringneck snake
Group 15	eastern garter snake
Group 17	northern shrike[S] Nashville warbler song sparrow[L] American goldfinch white-tailed deer
Group 18	European starling[L]
Group 19	ruffed grouse wild turkey deer mouse white-footed mouse
Group 20	black-throated blue warbler
Group 22	ruby-throated hummingbird
Group 23	veery wood thrush American robin American redstart rose-breasted grosbeak
Group 24	white-throated sparrow dark-eyed junco snowshoe hare
Group 25	Swainson's thrush yellow-rumped warbler blackpoll warbler white-winged crossbill
Group 26	blue jay American crow
Group 27	solitary vireo northern parula magnolia warbler pine grosbeak pine siskin
Group 28	barred owl yellow-bellied sapsucker red-breasted nuthatch little brown myotis northern myotis Indiana myotis silver-haired myotis big brown bat
Group 29	eastern screech owl northern saw-whet owl downy woodpecker northern flicker pileated woodpecker
Group 30	hairy woodpecker Carolina chickadee black-capped chickadee brown creeper red squirrel northern flying squirrel porcupine

Eastern hemlock Small and Large Sawtimber Classes

Group 31	Cooper's hawk red-tailed hawk golden eagle[L]
Group 32	red-shouldered hawk[L] golden eagle[L] mourning dove
Group 33	Cooper's hawk northern goshawk eastern pipistrelle
Group 34	sharp-shinned hawk northern goshawk red-shouldered hawk[L] broad-winged hawk great horned owl golden-crowned kinglet ruby-crowned kinglet red-eyed vireo black-throated green warbler Blackburnian warbler bay-breasted warbler scarlet tanager hoary bat

Group 35	brown-headed cowbird olive-sided flycatcher
Group 36	eastern wood-pewee eastern phoebe
Group 37	purple finch evening grosbeak small-footed myotis ?

The species group lists in Appendix K are organized by two stand variables--forest type and size class. Each list is a unique set of species that could be present within that stand if the appropriate habitat requirements are satisfied. So, even if you have two stands which differ only by size class, the stands could potentially have two distinctly different groups of species within them. The complete list of species groups (not separated by forest type or size class) is located in Appendix L.

CHAPTER 5

USING THE COMPUTER SYSTEM

This program was constructed through a system called GNOSIS. The concept of GNOSIS is that you shouldn't have to do all of the work when using a computer--so GNOSIS has enlisted a group of "gnomes" to do it for you. All *you* have to do is insert the diskette, and from DOS, change the default directory to the diskette's drive, type "RUN" and hit RETURN. The gnomes will do the rest. The gnomes of GNOSIS were discovered at the Pennsylvania State University by Dr. Wayne L. Myers and Dr. Michael Foster.

HABITAT gnomes will work only on IBM-compatible machines. The computer must have at least 640K of memory available, and have the capacity to handle a high density disk. The gnomes will ask you a series of questions about the habitat structure characteristics found in the stand (see the following page), then automatically compare these values to the habitat requirements of the wildlife species of concern. If your computer is connected to a printer, the gnomes will let you print a list of the species; otherwise, you can ask them to display the list of species on the screen.

The following pages take you through a sample run of the program. The program includes descriptions of each choice, as well as directions on how to understand each screen and select the appropriate answer. But don't worry about memorizing the entire manual--the gnomes will be there to help if you get confused while you're trying to run the program.

What is the forest type of the stand?

Aspen-Birch | Spruce-Fir | Red oak-White pine-Red maple mix
Northern hardwood | Eastern hemlock | White pine
Red maple | Northern red oak

What is the size class of the stand?

Seedling | Sapling-Pole | Small sawtimber | Large sawtimber

What physiographic province is the stand in?

Central Lowland | Appalachian Plateau | Valley and Ridge
Blue Ridge | New England | Piedmont Plateau
Coastal Plain

Is there at least 50 cubic feet of dead or downed wood on the forest floor?

Yes | No

Is there at least 25% rock cover on the forest floor?

Yes | No

Does forest litter cover at least 30% of the ground?

Yes | No

What is the percent vegetative ground cover in the stand?

0-29% | 30-75% | ≥76%

What is the percent shrub cover in the stand?

0-20% | 21-50% | ≥51%

What types of shrub species are present? (Select all that apply.)

Deciduous | Coniferous | Ericaceous

What types of midstory species are present? (Select all that apply.)

Deciduous | Coniferous

What is the percent overstory cover in the stand?

0-15% | 16-30% | 31-70% | ≥71%

Which of these water sources appear in the stand? (Select all that apply.)

Temporary ponds | Permanent ponds | Permanent streams | Seeps

Which subterranean features appear in the stand? (Select all that apply.)

Loose soil | Rock piles | Rock crevices | Caves

Which of these features appear in the stand? (Select all that apply.)

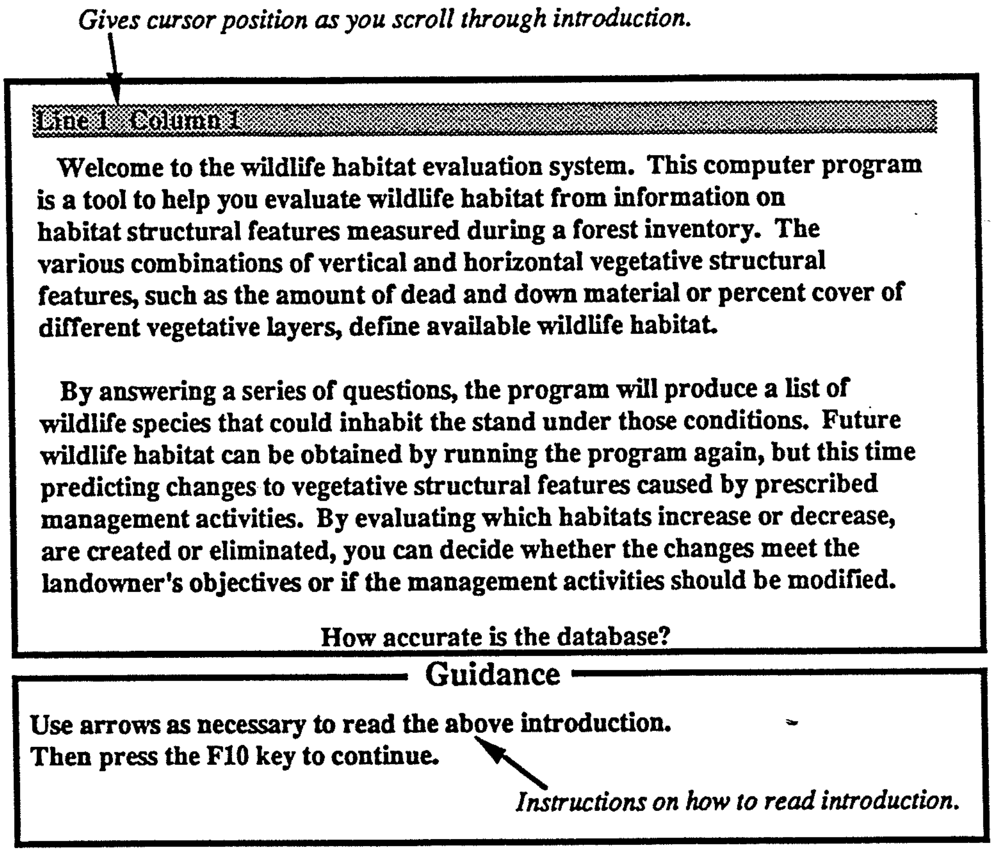
Dead cavity trees | Soft mast producers | High perches
Live cavity trees | Hard mast producers | Low perches

```
C:\>B:

B:\>run

b:\>echo off
SOFTWARE LOADING IN PROGRESS - Please wait for direction.
```

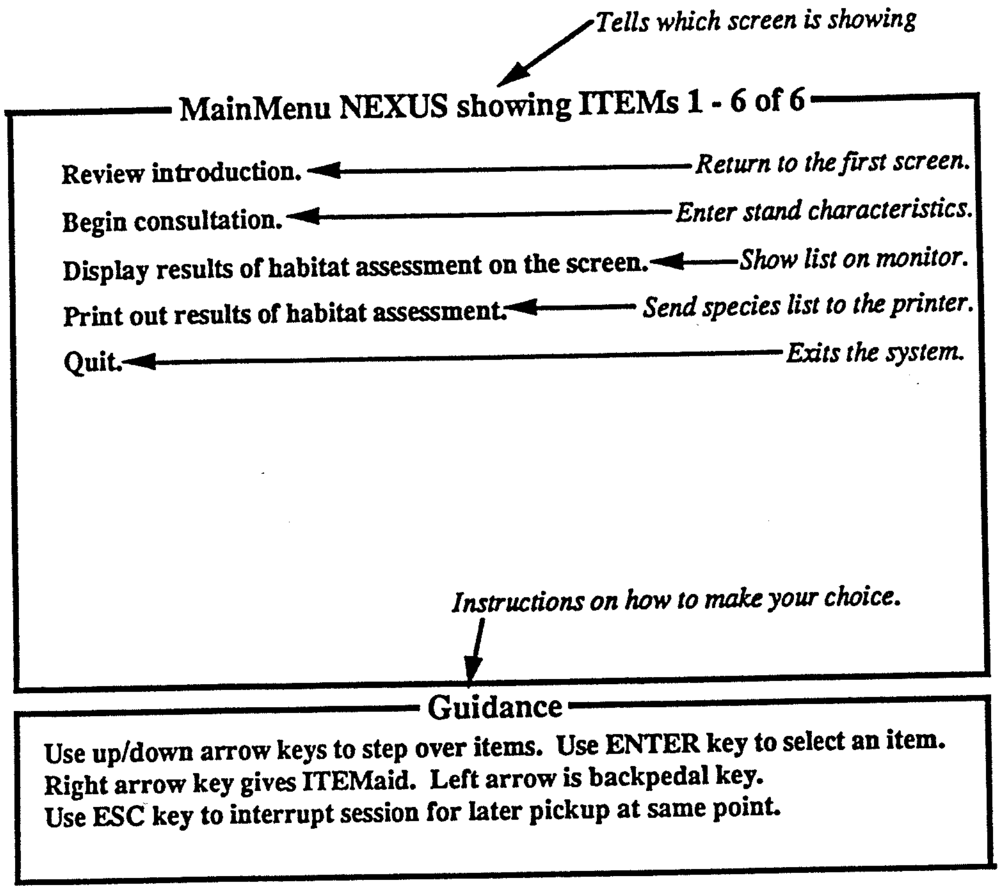
To run the program HABITAT, all you have to do is insert the disk, change the current directory to the diskette's drive (in this case, the B: drive), type "run", and hit ENTER. There will be a slight wait while the computer wakes the gnomes up, especially on the older computers. (It seems that those older gnomes tire more easily.) Be patient, and the gnomes will eventually bring up the next screen.

> **Press the ENTER key for colorful personality.**
> **Other keys give offcolor expression.**

The gnomes behind the scenes are rather quirky individuals. This is their way of asking you if you have a color monitor. If you do, and you want to see the program in color, hit ENTER. Hitting any other key will produce a black and white session. If you have a black-and-white monitor, it will not matter what key you press. Once the gnomes know what you prefer, they will begin the actual program.

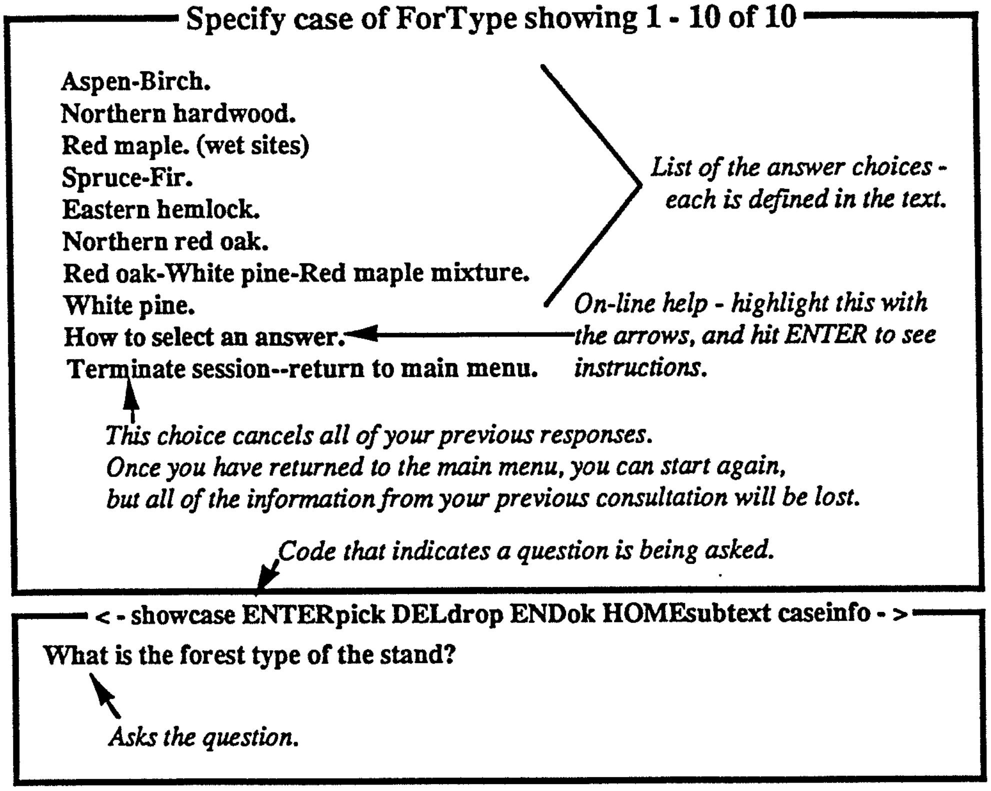


This screen gives you a brief introduction to the system. Notice that the bottom portion of the screen is labeled "Guidance." When you see the word "Guidance" on the lower section, that means that the gnomes are providing you with some instructions. In this case, they are telling you how to scroll through the screen so you can read the entire document, and how to exit the introduction screen and proceed to the program.



At this screen, the gnomes are really ready to go to work. There are several things you should know about the different choices. First, if you select either the "Display..." or "Print..." option before you have entered any stand characteristics, the results will be left over from the previous evaluation. They will not be erased between runs, so you can keep the answers until you need to use the system again. If you select "Begin consultation," and later need to break out of the question sequence (perhaps because of an incorrect response), you will no longer be able to access the results from the previous consultation. Old results are erased each time "Begin consultation" is selected. Additionally, the gnomes will not be able to run the habitat assessment if you have broken out of the sequence--you must answer all of the questions to get an evaluation.

Here again, the gnomes are providing instructions. The "Guidance" tells you how to make your selection. We have chosen "Begin consultation."



After a brief pause (which will be slightly longer because of the older, tired gnomes in the older computers), you will see this screen. This is the first question the gnomes ask you. Before we choose an answer, we will show you how to ask the gnomes for help. Remember, you can ask them to remind you how to choose your answer from any screen.

Specify case of ForType showing 1 - 10 of 10

Aspen-Birch.
Northern hardwoods
Red maple. (wet sites)
Spruce-Fir.
Eastern hemlock.
Northern red oak.
Red oak-White pine-Red maple mixture.
White pine.
How to select an answer.
Terminate session--return to main manu.

Instructions on how to exit the "How to..." mode.

Press an active key to continue.

Highlight your answer with up/down arrow keys.
ENTER for initial selection, and ENTER again or END to finalize.
DEL cancels initial selection. Left arrow for graphic if available.
Right arrow for extended description of answer if available.

Graphics are not available in this program.
However, hitting the right arrow key will cause a definition
similar to the one found in the text to appear on the screen.

After highlighting "How to select an answer," hit ENTER. The gnomes will print out their instruction in the bottom portion of the screen. Then, when you are through reading their advice, simply hit any key on the keyboard to return to the choices and make your selection.

Specify case of ForType showing 1 - 10 of 10

Aspen-Birch.
Northern hardwood.
Red maple.
Spruce-Fir.
EASTERN HEMLOCK.
Northern red oak.
Red oak-White pine-Red maple mixture.
White pine.
How to select an answer.
Terminate session--return to Main Menu.

Highlight your choice and hit ENTER - the choice will appear in all capitals. You must hit ENTER again to tell the computer to save this answer.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

What is the forest type of the stand?

This and the next fifteen pages will show the answers we have given to the gnomes. Between each question, the gnomes will take a short moment to save the information you have provided. When you see the words "A MOMENT FOR THOUGHT ... PATIENCE IS A VIRTUE" at the bottom of the screen, it means that the gnomes are at work. It is important that you DO NOT press any keys until the next question appears. If you do, you may accidentally make a selection for the next question. You cannot change any wrong answers without breaking out of the whole system and starting over.

Specify case of ForSize showing 1 - 7 of 7

Our choice - notice the capital letters.

Seedling.
Sapling-pole.
SMALL SAWTIMBER
Large sawtimber.
Uneven-aged stand. (NOTE: for Northern hardwood type only.)
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

What is the size class of the stand?

Specify case of Province showing 1 - 9 of 9

Central Lowland.
Appalachian Plateau.
Valley and Ridge.
BLUE RIDGE.
New England.
Piedmont Plateau.
Coastal Plain.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

What physiographic province is the stand in?

Specify case of Dead showing 1 - 4 of 4

YES.
No.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

Is there at least 50 cubic feet of dead or downed wood on the forest floor?

Specify case of Rock showing 1 - 4 of 4

YES.
No.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

Is there at least 25% rock cover on the forest floor?

Specify case of Litter showing 1 - 4 of 4

YES.
No.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

Does forest litter cover at least 30% of the ground?

Specify case of GCover showing 1 - 5 of 5

0-29% ground cover.
30-75% GROUND COVER.
76% or greater ground cover.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

What is the percent vegetative ground cover in the stand?

Specify case of SCover showing 1 - 5 of 5

0-20% shrub cover.
21-50% shrub cover.
51% OR GREATER SHRUB COVER.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

What is the percent shrub cover in the stand?

Specify case(s) of SComp showing 1 - 5 of 5

DECIDUOUS.
Coniferous.
ERICACEOUS.
How to select an answer.
Terminate session--return to Main Menu.

When you are asked to choose more than one answer, do so by highlighting and hitting ENTER on each choice separately. Then, when all of your choices are in capital letters, hit ENTER again on your last choice to save them all to the computer's memory.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

What types of shrub species are present?
(Select all that apply.)

Specify case(s) of MComp showing 1 - 5 of 5

Deciduous.
Coniferous.
THERE IS LESS THAN 25 PERCENT MIDSTORY COVER.
How to select an answer.
Terminate session--return to Main Menu.

If there is less than 25% midstory cover, you do not need to specify what types of plants are present. Choose this answer by itself.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

What types of midstory species are present?
(Select all that apply.)

Specify case of OCover showing 1 - 6 of 6

0-15% overstory cover.
16-30% overstory cover.
31-70% OVERSTORY COVER.
71% or greater overstory cover.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

What is the percent overstory cover in the stand?

Specify case(s) of Water showing 1 - 7 of 7

TEMPORARY PONDS.
Permanent ponds.
SEEPS.
Streams.
None of the above.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

Which of these water sources appear in the stand?
(Select all that apply.)

Specify case(s) of Subter showing 1 - 7 of 7

LOOSE SOILS.
Rock piles.
Rock crevices.
Caves.
None of the above.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

Which of these subterranean features appear in the stand?
(Select all that apply.)

Specify case(s) of Snag showing 1 - 5 of 5

Dead cavity trees.
Live cavity trees.
NONE OF THE ABOVE.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

Which of these features appear in the stand?
(Select all that apply.)

Specify case(s) of Mast showing 1 - 5 of 5

SOFT MAST PRODUCERS.
HARD MAST PRODUCERS.
None of the above.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

Which of these features appear in the stand?
(Select all that apply.)

Specify case(s) of Perch showing 1 - 5 of 5

High perches.
LOW PERCHES.
None of the above.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

Which of these features appear in the stand?
(Select all that apply.)

This is the final question. Once you have entered your response, the gnomes will begin their work on comparing the stand characteristics to the wildlife species habitat requirements. While they do this, you will see only a blank screen with what looks like a cursor flashing at the top. This is normal--fast gnomes will only take several seconds to complete their task, but the older gnomes will need a longer time. Have patience, and they will eventually take you once again to the main menu.

MainMenu NEXUS showing ITEMs 1 - 6 of 6

Review introduction.

Begin consultation.

Display results of habitat assessment on the screen.

Print out results of habitat assessment.

Quit.

Guidance

Use up/down arrow keys to step over items. Use ENTER key to select an item.
Right arrow key gives ITEMaid. Left arrow is backpedal key.
Use ESC key to interrupt session for later pickup at same point.

The gnomes will automatically assume that after you have finished your consultation, you will want to see your results. If you want to see them printed to the screen, simply hit ENTER, and they will appear. If you want to print them out, move the highlight with the arrow keys, and hit ENTER on the "Print out results..." choice.

Line 1 Column 1

Redback salamander
Slimy salamander
Eastern American toad
Northern brown snake
Northern redbelly snake
Northern ringneck snake
Northern copperhead
Cooper's hawk
Northern goshawk
Ruby-throated hummingbird
Eastern phoebe
American crow
Ovenbird
Common yellowthroat
Purple finch
Evening grosbeak

Guidance

Use arrows as necessary to read the above introduction.
Then press the F10 key to continue.

This is the final list of species whose habitat requirements are met by the stand's present characteristics. Again, remember that this is not a guarantee that all of these species will be there. This is simply the results based on a "snapshot in time" of the stand. If you like, return to the main menu and begin the consultation again, but this time enter the characteristics which you project will be present after some management activity. You can compare the two lists to determine which species may be affected--some may disappear from the list, and others may only show up only after the changes.

Sometimes, there may be slight discrepancies between the results you get from the manual matrix and the computer system. These differences will most likely be negligible, and result from the need to group similar species together in the matrix. The matrix may take a bit more time to complete, but you get to see the limiting factors for the groups of species which do not appear in the results. But once you understand how to operate the computer system, the gnomes will provide results much more quickly.

GLOSSARY

Acceptable growing stock (AGS) - good quality commercial trees capable of being sold now or in the future as sawtimber.

Cull - a tree which cannot be sold as either sawtimber or pulpwood due to an unacceptable proportion of rot, crook, or sweep.

Dead - standing dead trees.

Dead and down material - all woody material that is dead and lying on the ground that is at least 3 inches in diameter and at least 3 feet long.

Diameter-limit - removal of all tree species above a specified diameter.

Ecotone - the transition zone between two communities; the two communities having some of the same ecological features, but having a characteristic ecological structure all their own.

Even-aged - all trees are the same age or at least of the same age class; a stand is considered even-aged if the difference in age between the oldest and youngest trees does not exceed 20 percent of the length of the rotation.

First to third-order streams - the first three stream assignments given in a watershed, usually the three smallest stream delineations.

Functional group - a group of species that respond in a similar way to a variety of changes likely to affect their environment.

Ground layer - forbs, grasses, and woody seedlings that occur in the 0 to 2 foot vertical height zone in forest and nonforest cover types.

High-grading - harvesting the best trees and leaving the poorer quality slow growing trees behind to grow into the next stand.

Horizontal structure - the position and pattern of different land uses, usually measured at the landscape level.

Intermediate cuts - treatments that are conducted during development from the regeneration stage to maturity.

Litter - the surface layer of the forest floor consisting of freshly fallen leaves, needles, stems, twigs, bark, and fruits.

Midstory layer - deciduous and coniferous saplings and poles that occur within the 10 to 30 foot zone beneath the overstory canopy.

Noncommercial (NC) - a tree species which cannot be sold for either sawtimber or pulpwood solely on the basis of its species; i.e. hophornbeam, black gum.

Overstory crown closure -
minimal - forested stands with less than 15% closure or nonforested cover types.
partial - forested stands with overstory closure between 15 to 70%.
closed - forested stands with overstory closure greater than 70%.

Overstory inclusions - isolated patches of conifer stems in hardwood stands, or hardwood stems in conifer stands (can be just a group of several stems or patches 0.25 to 2 acres, depending on stand size).

Overstory layer - vegetation greater than 30 feet tall.

Percent cover - the percentage of ground 'covered' by foliage. Within each vertical height layer, relative percent cover has a maximum of 100%, absolute cover can exceed 100%.

Preservation - to keep something the way it is; to leave it alone or not to be disturbed.

Sapling - any tree species ≥ 1.0" DBH, but ≤ 5.5" DBH.

Seedling- any tree species < 1.0" DBH.

Seep - a small spring usually found at the base of a hill, associated with lush ground vegetation.

Shrub layer - deciduous, coniferous, and ericaceous shrubs and seedlings that occur within the 2 to 10 foot zone in forested and nonforested cover types, usually, but not always, with an overstory canopy present.

Slash piles - piled brush.

Snag - any dead tree at least 4 inches in diameter at breast height and at least 6 feet tall.

Specialist - a species that requires a special combination of habitat/structural features to survive and reproduce (e.g., a cavity nester).

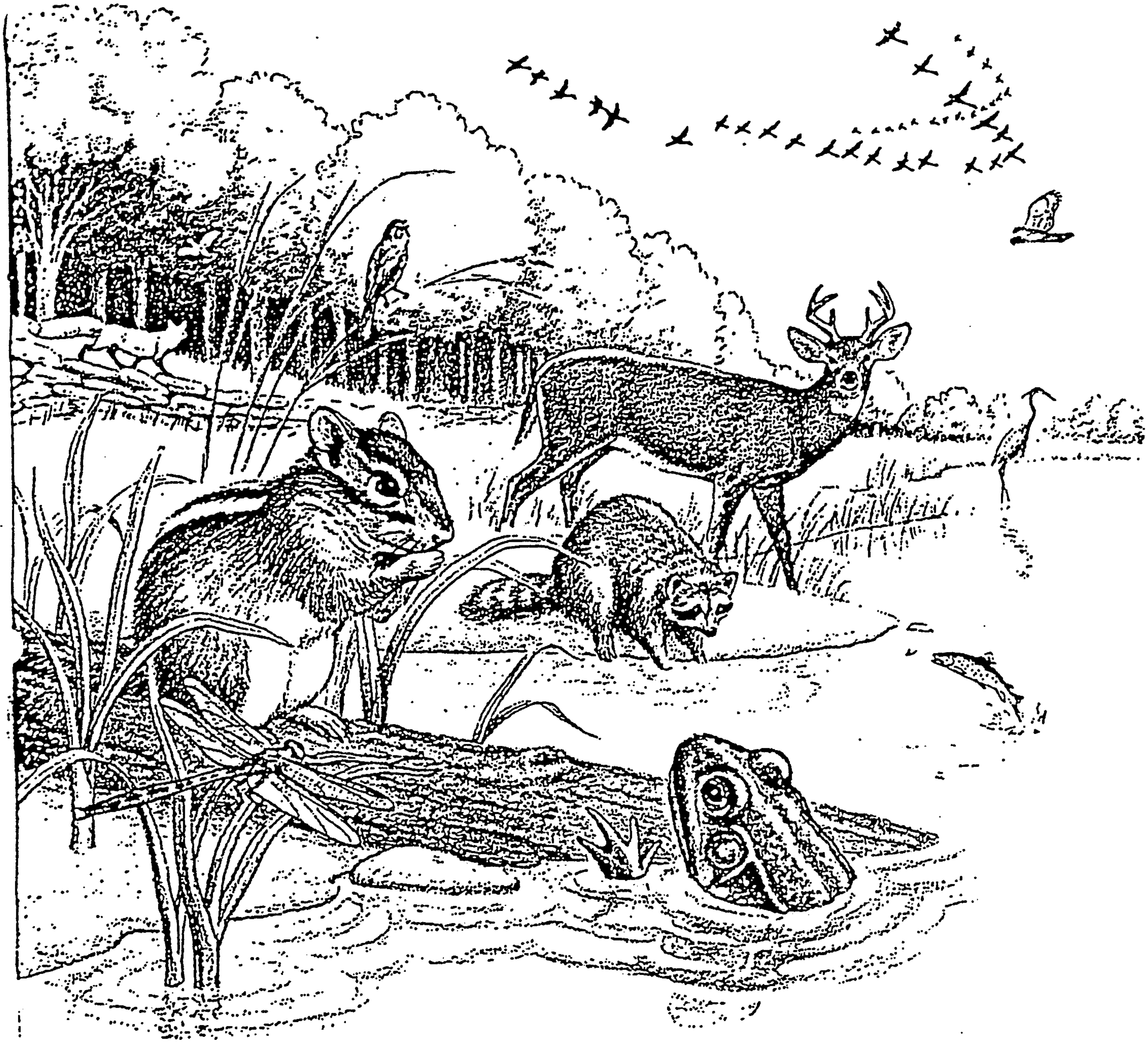
Unacceptable growing stock (UGS) - a commercial tree species which does not have the potential to be sold as sawtimber.

Vegetation structure - the vertical and horizontal layers of leafy and woody vegetation in a forested area.

Uneven-aged - a stand that contains at least three age classes intermingled intimately on the same area.

Vertical Structure - is the measurement of vegetative structure at varying heights within the stand.

Wildlife habitat - the specific combinations of food, cover, water, and space required by each species to survive and reproduce.



APPENDICES

APPENDIX C

Temporary Pond Requirements of Amphibians

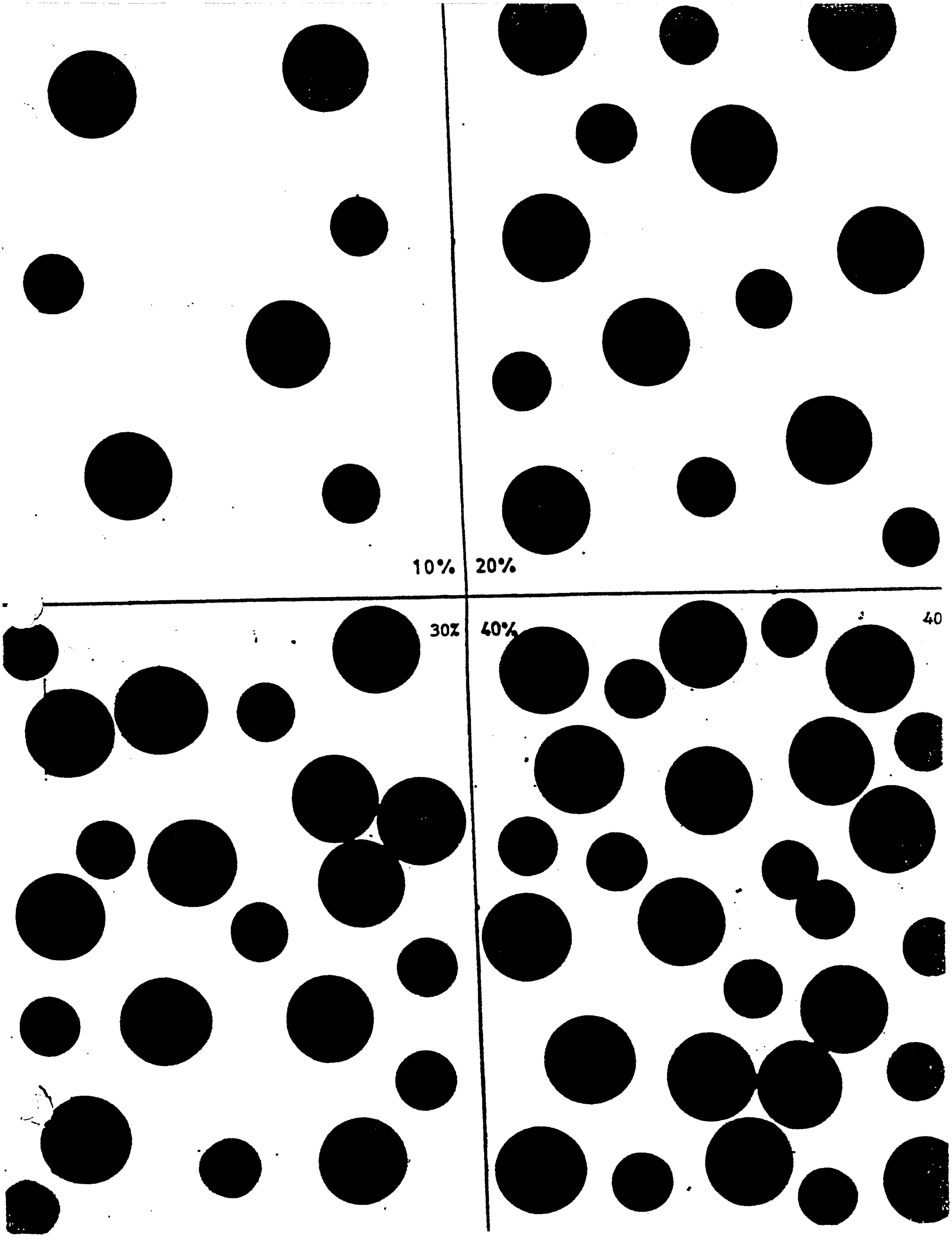
	Temporary Pond Characteristics		
Species	Depth	Size	Duration
Marbled salamander[1] *Ambystoma opacum*	> 6"	>1000 ft^2	September to June/July
Jefferson salamander *Ambystoma jeffersonianum*	>6"	>1 sq yd [2]	February to August
Spotted salamander[1] *Ambystoma maculatum*	>6"	>1 sq yd [2]	February to August
Red-spotted newt[1] *Notophthalmus v. viridescens*	6" to several feet	from < 1000 ft^2 to edges of large lakes	March to September
Northern leopard frog[1] *Rana pipiens*			March to May
Four-toed salamander *Hemidactylium scutatum*			March to July
Eastern American toad[1]	>12"	>500 ft^2	March/April to May/June
Fowler's toad *Bufo woodhousii fowleri*	>3"		April to July
Northern spring peeper[1] *Hyla c. crucifer*			March to June/July
Gray treefrog[1] *Hyla versicolor*			April to July
Wood frog[1]	>6"	>500 ft^2	February to June/July
Green frog[1] *Rana clamitans melanota*	>2"		April to October
Bog turtle *Clemmys muhlenbergii*			March to May and September to November

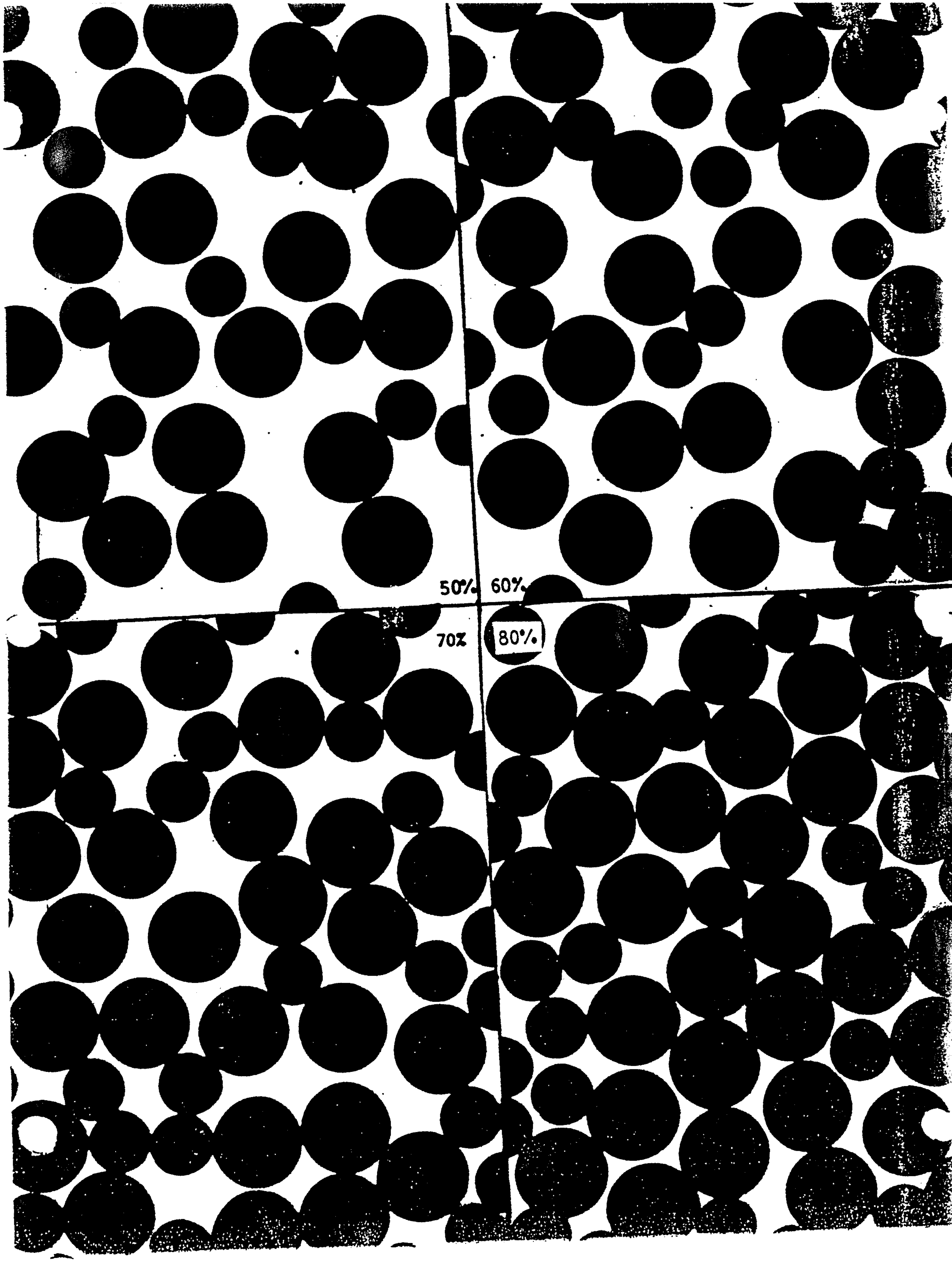
[1] will also use edges of permanent ponds and lakes

[2] although salamanders have been seen in temporary ponds of this size, larger ponds are more productive

APPENDIX D

Percent Cover Estimators


10%
20%
30%
40%
40



50%
60%
70%
80%

APPENDIX D.

Helene Harvey's Thesis
"*Inventory Process For Determining Forest Stand Structure And Assessment Model For Wildlife Habitat.*"

The Pennsylvania State University

The Graduate School

INVENTORY PROCESS FOR DETERMINING FOREST STAND HABITAT STRUCTURE AND ASSESSMENT MODEL FOR WILDLIFE HABITAT

A Thesis in

Forest Resources

by

Helene Marie Harvey

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science

December 1994

ABSTRACT

Forest managers require tools to rapidly assess the effects of management activities on wildlife habitat. This first requires a method to easily and accurately inventory the structural features that comprise wildlife habitat. Four existing inventory methods were evaluated to determine their capability in providing estimates of wildlife structural features in conjunction with a silvicultural inventory. Sample estimates of structural features were obtained from basal area plots, small circular fixed area plots, point-centered quarter plots, and line intersect plots. Sample estimates were compared, when possible, to actual population figures obtained from a census of three stands in order to determine the accuracy of the methods.

Analysis indicated that using a combination of the methods sufficiently determined amounts of structural features present. The line intersect accurately determined the cubic foot volume of dead and down material; a 1/1000 acre circular plot efficiently measured species composition and percent cover of the ground and shrub layer; percent cover of the midstory and overstory layers were efficiently measured using either an ocular tube or grid; and a basal area plot accurately determined the number and basal area of snags (dead trees).

A Delphi process and a brief literature review were used to acquire data on habitat structural features required by wildlife species. Information of varying degrees was acquired on over 200 wildlife species. This information was consolidated into a presence/absence matrix for cluster analysis purposes to group species using similar habitat features. Cluster analysis formed 35 groups.

A wildlife habitat assessment process was developed using the habitat structural features information; a manual format and computer format were developed. Through a series of questions certain species are eliminated when a particular structural feature

required by that species is not present in the stand. The end result is a list of species or species groups that have the necessary structural features to exist in the inventoried stand. By predicting changes to the structural features caused by proposed management activities, a manager can go through the process again and determine those habitats that may increase or be eliminated.

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Chapter 1

INTRODUCTION

Maintenance of biological diversity is an important environmental topic today. People are concerned about the unprecedented loss of species and the potential economic and environmental consequences associated with that loss. Many private and public foresters are also concerned about the impacts to biological diversity from forest operations. The National Association of State Foresters (NASF 1993) believes that maintenance of biological diversity is the most important issue facing forest resource management now and in the immediate future.

Biological diversity, the variation and variety of organisms and their interactions, has three levels: species, genetic, and community or ecosystem (Nigh et al. 1992). Although each level is equally important, species diversity, the number and abundance of species in an area, receives the most attention (Barnes 1993; O'Connell and Noss 1992).

Whether attention should mainly focus on the loss of species diversity can be debated. All three levels are seriously affected by other threats such as forest stand simplification, habitat loss and fragmentation, and high-grading (CAC 1992). Conversion of forestland to other uses (forest fragmentation) is often cited as the greatest threat to biological diversity (CAC 1992; Probst and Crow 1991; SAF 1991). These threats often result from either poor management practices or the failure to assess the impact of management actions on all resources.

Seventy-five percent of Pennsylvania's 17 million acres of forestland is owned by non-industrial private forest (NIPF) landowners (Alerich 1993). These landowners have the potential to impact biological diversity positively as well as negatively. While most NIPF landowners are not likely to make management decisions based solely on biological diversity concerns, most landowners will do what they perceive is "the right thing to do"

(O'Donnell and Bihun 1992). If landowners are convinced that proper management of their woodlot for biological diversity results in an improved environment with more opportunities to meet their objectives, such as seeing a wider variety of wildlife on their property, they will be more inclined to implement practices that conserve biological diversity (DeGraaf et al. 1992).

In response to society's concerns, changing landowner objectives, and also their own concerns about all forest values, natural resources managers are looking for more information on which to base their management recommendations. In recent meetings, such as the 1993 "Penn's Woods - Change & Challenge" conference, many public, private, and industrial foresters expressed the need for tools to asses the impacts of management activities on other forest values, such as forest health and biodiversity (Finley and Jones 1993). Foresters want a way to measure the health of the forest just as temperature and blood pressure are used to assess human health (Kessler 1993).

Government agencies are also looking for indicators of forest health. The U.S. Environmental Protection Agency recently identified dominant vegetation, vegetative structure, and wildlife habitat as three forest health monitoring indicators to assess the condition of biological diversity in its national Environmental Monitoring and Assessment Program (ERTA 1993). Vegetative structure is a matrix composed of different horizontal and vertical layers of plants and their spacing and includes features such as downed woody debris, snags and cavities, and water sources. Wildlife habitat suitability varies with combinations of vegetative structure (DeGraaf et al. 1992).

Complete information on all vegetation and vegetative structure is rarely collected except in research projects. Most forest inventories, especially those conducted on private land, acquire data only on commercial tree species. Recommendations from these inventories usually focus on producing a sustainable source of high quality sawtimber. These recommendations sometimes include considerations for providing habitat for major game species. These same inventories may also collect data that describe broad wildlife habitats in forestry terms (forest types, size classes, stocking levels). It seems reasonable that these inventories can be modified to collect data to describe other habitat features.

The idea of acquiring wildlife habitat data from timber or forest inventories is not new. Salwasser and Tappeiner (1981) summarized the writings of researchers and forest managers in the 1930s who collected information on vegetation and wildlife habitat relationships. Recognizing the need to integrate both timber and wildlife needs into management plans, some of these early forest managers opposed forest management treatments that reduced wildlife diversity (e.g., they opposed planting monocultures) and advocated others that increased good game habitat (e.g., maintaining openings).

With the passage of the Forest and Rangeland Renewable Resources Planning Act in 1974, the USDA's Forest Survey unit expanded their operation to include estimates of natural resources other than timber (Cost 1979; Coulombe 1978). Realizing that vegetation influences wildlife populations, they devised an inventory that would measure forest structure: "species composition, quantity, quality, and spatial arrangement of all forest vegetation" (Cost 1979, p. 29). Other government and private agencies also expanded information acquired from timber inventories to assess and recommend wildlife management opportunities (Lennartz and Bjugstad 1975).

With the move from single resource management (timber) to a more holistic approach, information needs from forest inventories shifted, as managers required accurate and easily used information on the relationship between wildlife species' habitat requirements and vegetation composition (Anderson et al. 1977). Patton (1992, p. 15) suggested using "new approaches to managing forest wildlife by using plant-animal relationships in a form useful for decision making."

Recent literature explores the basis for evaluating forests for more than just game and rare species. Wildlife species distribution and habitat tables are available for

Pennsylvania (Hassinger et al. 1993a, 1993b). Relationships between wildlife species, vegetative types, and structural features are published for the New England states (DeGraaf et al. 1992); most of these species also inhabit Pennsylvania. Included in DeGraaf et al. (1992) is a small ownership habitat evaluation form; however, no method is offered for sampling structural features other than the observed presence or absence of the feature.

Standard methods to determine vegetative structure do not exist; they vary with the objective of the inventory (Cost 1979). However, by developing a methodology to inventory for those vegetative structural features listed in DeGraaf et al. (1992), it should be possible to predict which groups of wildlife species could inhabit a forest stand. By predicting changes to vegetative structural features that will occur due to prescribed treatments, it should be possible to assess the impact of those vegetative changes on wildlife habitat (which habitats will increase or decrease, be created or lost). Finally, by evaluating the changes, natural resource managers can provide landowners with options to reduce habitat loss of uncommon species.

Several assumptions underlie this hypothesis: 1) Specific wildlife species can be expected to frequent a forest stand if the required forest type and vegetative structural features exist; 2) The research literature provides at least limited descriptions of habitat structural features required by wildlife species, or these descriptions can be obtained from wildlife experts; 3) Silvicultural management practices that change vegetative structural features result in predictable shifts of wildlife species (Anderson and Shugart 1974; Verner 1984); and 4) Data acquisition methods can be cost-effective and compatible with existing silvicultural inventories conducted by foresters.

The objectives of this study are to: 1) Analyze different sampling methods and efficiencies to provide a methodology to rapidly assess the nature and quality of habitat structural features in combination with existing silvicultural inventories conducted by resource professionals or trained landowners; 2) Provide wildlife habitat assessment techniques; 3) Obtain information on the habitat structural features required by wildlife species common to Pennsylvania forests through a Delphi process; and 4) Develop wildlife functional groups based on information obtained from DeGraaf et al. (1992) and the Delphi process.

Chapter 2

LITERATURE REVIEW

Vegetative Structure And Wildlife Habitat

Each wildlife species is associated with a particular *habitat* which provides the requirements for survival and reproduction. Some species, called *specialists*, are limited in their habitat selections while others are *generalists* that can live in a wide variety of conditions (Elton and Miller 1954; Rotenberry 1981).

For management purposes, wildlife species usually are categorized by broad classes such as Leopold's (1933) farm, field, and forest habitats. Since the 1930s, researchers and managers have devised standardized habitat classifications such as Elton and Miller's (1954) based on geographical and vegetative characteristics. Forest wildlife habitat is usually described by vegetation type (e.g., old growth Douglas-fir) and topographic location (e.g., high elevation mountain) (Patton 1992).

Within vegetation types, researchers have tried to quantitatively determine the amount of food, cover, and environmental factors that influence a species' habitat selection. Lack (1933) was one of the first to propose that breeding birds selected habitats based on vegetative structural features such as tree height. As more studies were conducted researchers noticed that the presence and arrangement of structural features such as the number of vertical vegetative layers, presence of cavities, amount of downed woody debris, and vegetation composition also played important parts in the composition of bird and small mammal communities (Ambuel and Temple 1983; Anderson et al. 1983; Dueser and Shugart 1978; Elton and Miller 1954; Rotenberry 1981; Yahner 1988; Zeedyk and Evans 1975).

The number of vegetative layers present in a forest seems to affect bird species diversity more than the actual forest type. MacArthur et al. (1962) and MacArthur (1964) found that bird species diversity increases as the number of vegetative layers increases, attributable to the different layers supporting ground, shrub, and canopy birds. They also noted that within a deciduous forest, plant species composition is not as important as the number of vegetative layers in determining the diversity of bird species.

However, more vegetative layers are not necessarily better for all species. In reviewing several studies, Balda (1975) noted that bird species diversity may actually decline at higher vegetation cover densities caused by the inability of certain bird species to move through the dense foliage. In fact, sometimes the lack of vegetative layers is needed for a species to be present. An early study conducted on the least flycatcher (*Empidonax minimus*) determined that the amount of open space between the shrub layer and the bottom of the upper canopy was a critical factor in determining flycatcher use (Breckenridge 1956). Therefore, it is important to know which layers are needed by each species in order to predict which species will inhabit a forest stand and how they will be affected by management activities.

Other habitat features, such as snags or trees with cavities, will also affect species diversity and density in a stand (Conner 1978). However, the simple presence of a feature does not guarantee the presence of the species that uses it. Swallow et al. (1986) found that the actual use of cavities depended more on the surrounding habitat structure than on snag or cavity characteristics. This suggests the need to expand the inventory focus to as many habitat components as possible.

Another component given more consideration recently is the size of the habitat available for use, especially by species requiring large forested tracts. After reviewing recent and past studies on how the size of forest areas affect bird communities, Askins et al. (1990) concluded that the species composition of bird communities does differ depending on the size of the forest. However, they also state that vegetation structure, composition, and/or heterogeneity "are more important than forest area in predicting the occurrence of many species" (Askins et al. 1990, p. 20).

One drawback to some of the earlier studies was that they had not measured specific amounts of vegetative structural features needed by breeding birds (e.g., what percent ground cover was needed) and so had limited application to forest or wildlife managers (Balda 1975). Even if actual quantities are known, it is likely that wildlife respond to a range of related habitat combinations rather than to some mean condition (Hooper and Crawford 1969; MacArthur et al. 1962). However, if wildlife habitat needs and combinations are known (both quantitative and qualitative variables) it should be possible to monitor wildlife population trends by monitoring habitat trends (Verner 1983). One benefit is lower inventory costs since vegetation variables are usually monitored through forest inventories.

The Forest Service recognized this idea when it was mandated to expand its inventory with the passage of the Forest and Rangeland Renewable Resources Planning Act (Cost 1979; Coulombe 1978). In 1977, the Forest Service's Southeastern Region's Forest Inventory and Analysis Unit began collecting specific information on structural features such as tree cavities, snags, percent cover, etc., in order to assess habitat conditions for breeding birds (Sheffield 1981). Other forest inventory information used to assess habitat include stocking levels, forest type and age, stand size, crown class, tree height, and merchantable bole height (Durham et al. 1985; James 1971; Sheffield 1981).

Habitat Evaluations

In order to evaluate whether an area contains suitable habitat it is first necessary to know what type of habitat a species finds suitable. Many models of habitat suitability have been developed for individual species based on food, cover, and reproductive requirements such as the habitat suitability models of the U.S. Fish and Wildlife Service (Clark and Hutchinson 1989; Coulombe 1978). These models are based on literature reviews. The information is transferred onto graphs or charts relating required habitat features to a suitability index, ranging from 0.0 for unsuitable to 1.0 for optimum, for species of interest. Indices can be compared from one area to another determining which is more suitable for a certain species (Clark and Hutchinson 1989; Lines and Perry 1978). Figure 1 shows an example of a habitat suitability graph.

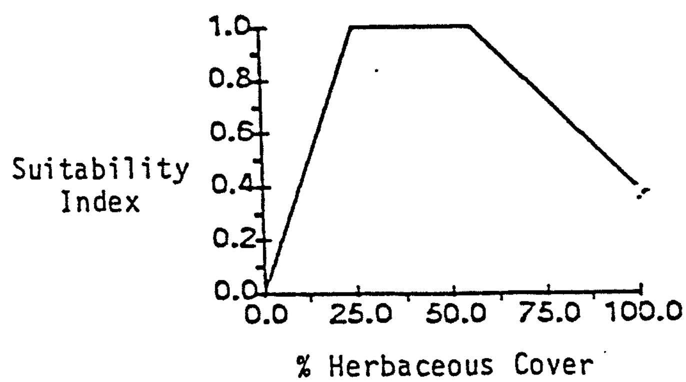

Figure 1. Herbaceous cover suitability graph for the white-footed mouse (*Peromyscus leucopus*). (Adapted from Palmer et al. 1993.)

The majority of habitat models, and subsequent habitat evaluations, have been developed for major game species (Clark and Hutchinson 1989; McClure et al. 1978). Although amphibians and reptiles constitute a large portion of the vertebrate species in

The majority of the habitat evaluations discussed above involve selecting one or more wildlife species and measuring habitat features required by those species. However, the sampling methodologies suggested by government and industry are labor intensive and costly. These methodologies are not useful to most non-industrial private forest landowners because they could not afford such an investment and, in most instances, do not require a rigorous inventory. Easily obtainable habitat estimates are needed (Clark and Hutchinson 1989).

Guild Or Group Approaches

Most species habitat evaluation procedures focus on a few game or rare species because it is usually impractical to consider the impacts of management activities on all species (Fry et al. 1986). However, game species constitute less than 12% of wildlife species (Barnes 1993). Although each species has specific habitat requirements, many species can be combined into species groups, or guilds, which can then be monitored. Guilds are a recommended approach if interest lies in predicting the impacts on whole communities (Barnes 1979; Fry et al. 1986; Probst and Crow 1991; Short 1982). Mannan et al. (1984, p. 426) defined a guild as "a group of species that exploit environmental resources in a similar way." If the resources used by a guild are changed through a management activity, then all guild members will increase (or decrease) in abundance in direct response to the changes (Mannan et al. 1984; Severinghaus 1981; Verner 1984).

Often one species in the guild is used as an indicator species, a species that represents the entire guild or community (Coulombe 1978). The guild-indicator species approach assumes that all guild members "use identical rather than similar resources" and that if a habitat change affects one species it will similarly affect the rest of the guild species (Block et al. 1986, p. 109). A potential problem with the guild-indicator approach is that although resource use may considerable overlap in reality no two species use 'identical' resources. Therefore, it is possible for an indicator species to increase in abundance to a change in habitat while other guild members might decrease. To be an effective indicator, a species habitat preference should be well understood and the variety of habitats it occupies should be small (Larson and Bock 1986).

Guilds are defined by the researcher and can be based on habitat. Short (1982) defined guilds based on a feeding and breeding habitat matrix to show the relationship between vegetation layers and wildlife species. He noted that the number of species increased positively with the number of guild or habitat blocks available.

Response To Habitat Modifications

Using several species in the guild, rather than one species, allows the researcher an opportunity to measure responses to changes in habitat. "The lack of consistent responses to habitat alterations among species eliminates the possibility of predicting the response of guild members by monitoring the abundance of a single 'indicator' species" (Mannan et al. 1984, p. 429). They suggested using the abundance of all species in the guild as a better approach (also suggested by Verner 1984, and Severinghaus 1981). It is also cheaper and easier to monitor a group than an individual species since more than one species can be monitored at any given site for the same expense. One drawback is that declines in some species in the guild can be overlooked when other species are increasing. This states the case for using more than one approach or looking at several environmental variables for determining the impacts of management treatments (Mannan et al. 1984).

In order to predict the effects of vegetation management treatments (i.e., harvesting, brush control, prescribed burning, etc.) on wildlife species, it is first necessary to understand which vegetation features will increase or decrease due to a particular treatment and also which specific structural features are used by wildlife. Land managers must be educated about the effects management has on wildlife habitats and be provided tools to assess the potential impacts on wildlife from different management alternatives (Lines and Perry 1978).

However, managers must recognize that similar management activities do not always produce the same response by all species within a guild. Mannan et al. (1984) found that slight to moderate changes in percent canopy cover, tree species composition, or average tree size (such as those caused by a thinning) resulted in inconsistent guild responses. The inconsistent response indicates that although guild members supposedly use identical resources, the individual species in the guild may have different sets of specific habitat requirements and thus respond differently to subtle vegetation changes.

Manager's must also recognize that whether management activities, with their associated vegetation changes and their effects on wildlife, are viewed as positive or negative ultimately depends on the landowner's management objectives (Lennartz and Bjugstad 1975).

Inventory Methods

Knowing what to measure is only half of an inventory process; knowing how to effectively measure a habitat variable is 'the rest of the story.' An effective wildlife habitat inventory should:

- be relatively consistent; different people evaluating the same habitat should come up with similar decisions about that habitat;
- be able to measure habitat variables both before and after any management operations;

- easily and accurately measure all habitat variables;
- be affordable (Barnes 1979; Buckner and Perkins 1974; McCuen and Whitaker 1975)

Inventory methods can be broadly divided into plot and plotless techniques (Schemnitz 1980).

Plot techniques

Plot techniques are those that rely on measuring variables of interest found within a designated fixed area. Depending on the variable of interest, the shape and size of the plot have advantages and disadvantages.

A square is more efficient than a circle of equal area in determining plant species distributions because it intersects more plant species, due to the plants having a clumped distribution and the circle having a larger radius for the same area (Brown 1954). The circle has the smallest border to area ratio reducing edge bias (edge bias refers to whether a plant near the plot's boundary is included or ignored) and is easily and quickly set up. The rectangle is more likely to encounter a greater variety of plant species than the other shapes, but has the greatest border to area ratio (Brown 1954; Myers and Shelton 1980).

Appropriate plot size depends on what type of vegetation is being measured, with larger plots used for sampling mature trees and smaller plots for tree seedlings. An advantage of larger plots over smaller ones when sample sizes are equal and populations are not uniform (e.g., not a plantation) is that all estimates obtained are more precise because larger plots have smaller variances (Schreuder et al. 1993). Larger plots also have a proportionately smaller edge to area ratio while smaller plots have the advantage of being faster to set up and easier to use, that is, it is easier to keep track of which plants have been sampled.

Compound or nested plots are frequently used to obtain measurements on several vegetation types, such as using a large plot for pole and sawtimber sized trees and successively smaller plots (contained within the larger plot) for saplings, shrubs, and seedlings. The 0.1 acre (0.04 hectare) plot of James and Shugart (1970) is a compound plot often adapted by other researchers in determining habitat variables in bird studies (Ambuel and Temple 1983; Durham et al. 1985; James 1971; Noon 1981). Plots are either placed randomly throughout the stand or subjectively centered on a bird's singing territory or nest location. Within the plot all trees in the overstory are measured and basal area calculated; saplings are either measured on the whole area or sampled on a smaller plot (usually .025 acre). An estimate of the number of shrubs is determined along the north-south and east-west diameters by walking with outstretched arms and counting the shrubs in the two transects. Percent cover is determined at 20 locations within the plot by sighting through a tube containing crosshairs and noting the presence or absence of vegetation (at predetermined vertical heights) at the intersection of the crosshairs.

Although a large fixed area plot has many research advantages, the time required for setup and measurement is costly. Laursen (1984) suggested using a smaller plot size, a 1/300 acre plot, to sample shrub communities because of the non-uniform response of shrubs to different site disturbances (gaps, burning, thinning, etc.) and different site variables (slope, aspect, etc.). He proposed that by taking a sufficient number of plots the problems normally associated with small plots, i.e., having fewer species and less structural diversity per plot and being dominated by a single shrub species, can be reduced.

Belt or strip plots, also known as transects, are basically a series of long rectangular plots and have the same advantages and disadvantages. That is, the transect will pick up a diversity of plant species, but have a high border to area ratio (Myers and Shelton 1980). Transect width depends on plant characteristics and can be extremely small (an inch wide for herbaceous plants) to as large an area as a crew can effectively cover (Rice et al. 1986; Wilde 1954). An advantage of the belt transect when sampling herbaceous vegetation is that only half the sampling area of square plots is required to obtain the same information; one stipulation is that the width of the transect must be 1/16 the size of the length (Larson 1959). Transects often require less sampling units than other plot shapes resulting in fewer degrees of freedom when calculating sampling error; however, this may or may not be offset by a corresponding reduction in sampling unit variation (Schreuder et al. 1993).

Line transects are extremely narrow strip transects that basically have only one dimension--length. Line transects are useful for determining changes from one association or community to another (Brown 1954). Wilde (1954) reported that in an homogeneous area of vegetation, the line transect is just as useful as a fixed plot and advocated the use of the line transect for determining the composition, frequency, and cover of ground species. In heterogeneous areas, the line transect gives a more accurate estimate of crown cover than a fixed plot (Brown 1954).

A disadvantage of both the line and belt transect appears when they are used on steep ground. A correction between the horizontal distance versus the slope distance must be factored into calculations on slopes greater than 20% (Larson 1959).

Plotless Techniques

Plotless techniques have no fixed area, rather the vegetation of interest is sampled based on either its distance from the investigator (such as the closest plant in a certain direction; called a variable distance method) or its size (such as diameter at breast height for a tree) and distance from the investigator (a variable radius method).

The point-centered quarter or quadrant (not to be confused with quadrat) method has been in use for many years. Originally used by Federal surveyors during the 1800s, the method was adapted for ecological work in 1950 (Cottam and Curtis 1956).

Point-centered quarter sample points can be randomly or systematically placed throughout a stand. The points are then divided into four quarters by two imaginary perpendicular lines and the distance between the sample point and the nearest plant of interest (tree, sapling, herbaceous species) is measured in the first quarter. Pertinent information on the plant is gathered. The same information is then taken for the nearest plant of interest in each of the remaining three quarters and the four distances are averaged. An overall average distance is calculated from all the samples in the stand and density is obtained by dividing the square of the overall average distance into the appropriate area unit. For example, if a per acre estimate of the number of trees is needed and if the average distance obtained from all the samples is 11 feet, the calculation is 43,560 square feet/(11 feet)^2 or 360 trees per acre.

Point-centered quarter is considered the best of the variable distance measuring methods for random populations because the mean of the distances is equal to the square root of the mean area per plant; put another way, by squaring the overall average distance you determine the average area per plant (Brower and Zar 1977; Cottam and Curtis 1956; Cottam et al. 1953; Wenger, 1984).

The point-centered quarter method is not useful in plantations (where it overestimates densities) or in populations that are clumped (underestimates densities) (Schemnitz 1980). However, a greater drawback is the difficulty of getting a variance estimate because only the overall average distance is used in calculations. Lindsey et al. (1958) suggested taking subsamples of the original data and computing averages from these subsamples and then calculating a variance from the averages. However, this extra office work would offset any time saved in the woods and is rarely done.

Variable radius sampling, also called Bitterlich or point sampling, is a method of selecting trees proportional to their size (Avery 1975). A calibrated prism (an angle gauge or Relaskop can be used) is held over the sampling point and any tree meeting the sampling procedure is tallied. Basal area can be calculated directly from the sampling instrument's pre-calibrated basal area factor. Other information on tree characteristics, such as DBH, quality, merchantable height, cavities, can also be recorded for each counted tree. DeVries (1986) provides the statistical proof that any tree characteristic can be estimated without bias using an angle gauge. Since its introduction, Bitterlich sampling is the method of choice for forest inventory.

Several studies have found that variable radius sampling is more efficient than fixed area plots in obtaining information on basal area, tree density, and frequency (O'Regan and Palley 1965; Shanks 1954). However, they conclude that fixed area plots are more efficient at sampling lesser vegetation (herbaceous plants and shrubs). Lindsey et al. (1958) found variable radius sampling to take less time and more accurately reflected the true population mean for density and basal area than large size circular plots (0.1 acre and 0.025 acre) or point-centered quarter plots.

Vegetation Variables

Because costs rise with every measurement, only data which are useful in solving the problem and are easily obtained should be collected (Bunce and Shaw 1973; Durham et al. 1985). To determine vegetative structure certain variables need to be measured: percent cover, species composition, and densities of stems, cavities, and dead and down woody material.

Percent cover

Cover is usually defined as the vertical projection of the above-ground vegetation on to the ground or the amount of ground "covered" by vegetation in an area (Brown 1954). When dealing with multi-layered stands, the vegetation is often broken into different vertical height layers (pre-determined by the researcher), such as a ground layer from 0 to 2 feet, shrub layer from 2 to 15 feet, etc. The maximum relative cover in each layer is 100%; a forest stand with four vertical height layers could have a maximum of 400% cover. Brown (1954) considered cover to be the best criterion for determining trends following management treatments while Kerr (1978, p. 125) considered cover to be "an indicator of habitat quality."

Cover can be determined by actual area measurement, by eye, through the use of instruments, from crown width and diameter relationships, or from aerial photo interpretation (although it's most accurate with large scale photos and easiest in less dense stands (Avery 1975)). Cover is rarely determined or measured to the exact percent, but rather estimated into different scales (such as 10% classes). A scale often cited by other researchers was developed by Daubenmire (1959).

Conant et al. (1983, p. 365) noted that neither a plot's shape or size affects the "accuracy of ocular estimation of plant cover," but advise that it's better to take more samples than to increase the plot size. They suggest that training and experience are needed to produce quality results and that "inaccuracies in plant cover estimation usually result from poor visual techniques and not the method used" (Conant et al. 1983, p. 365). With training, cover can be estimated to within ±10% (Bunce and Shaw 1973; Hatton et al. 1986).

Several instruments have been developed to reduce error caused by estimating cover by eye. A spherical densiometer, which is a fish-eye mirror with grid lines etched onto its surface, is held at a convenient height and the number of squares covered by vegetation are counted and divided by the total number of squares. James and Shugart (1970) used a small tube containing a cross-hair at one end. Percent cover is determined by noting the presence or absence of vegetation at the cross-hair at a series of points. The 'moosehorn' is a periscope-like device with a dot grid located at the top on a transparent screen. A person looks through the sighting device and counts the number of dots covering vegetation (Garrison 1949). Cooper (1957) developed an angle gauge (a modification of the Bitterlich method) for determining shrub cover on rangelands. Although it was faster and as accurate as line transect or fixed plots, the angle gauge proved unreliable at shrub densities over 35%.

The relationships used with an angle gauge allowed other researchers to develop relationships between basal area, DBH, and crown width with its associated percent cover. Minckler and Gingrich (1970) found that the area occupied by tree crowns, and thus cover, can be estimated from DBH in upland oak-hickory forests in Southern Illinois. They found that forest and open grown trees had similar DBH and crown width relationships and are not dependent on species, crown class, or site. But because forest trees have overlapping branches, the effective crown area was usually overestimated in forest stands (i.e. crown area was greater than 100% the area of the stand). Overestimating percent cover may be a drawback in tables developed by Leak and Tubbs (1983). They developed a percent crown cover table based on the relationship between crown width, DBH, and basal area factor. Their table was designed to determine crown cover based on the amount of basal area left after a harvest.

Relative density may be a useful substitute to percent cover measurements. Relative stand density is "the proportion of an area actually occupied by trees in relation to the optimum area that would be occupied by trees under ideal growing conditions" (Clark and Hutchinson 1989, p. 6.05-1). SILVAH guidelines (Marquis et al. 1992) estimate relative stand density using information obtained from those trees intersected in basal area plots (i.e., species and DBH).

Species Composition

Species composition can be determined from all of the plot or plotless techniques discussed. In addition to those already mentioned, Schreuder et al. (1993) described the point quadrat method where a needle is lowered from a frame onto ground vegetation and the species the needle hits is recorded. A series of 100 points is taken at evenly spaced intervals.

Density

Density, the number of individuals per area, can be determined from a complete census (time consuming) or estimated from any of the previously mentioned sampling methods. Density is important because it gives an idea of habitat structure and the amount of food and cover available for wildlife.

Cavity density can be estimated from sampling procedures used with plot or plotless methods (Schemnitz 1980). Prince (1968) modified the point-center quarter method to measure only trees greater than 12 inches DBH (30.5 cm.) and simply calculated a ratio of all trees measured with cavities to the total number of trees tallied. He then multiplied this ratio against an estimate of total trees in the stand to compute the number of cavities in trees 12 inches DBH and larger per acre.

Foresters are quite familiar with using basal area as an estimate for total volume of cavity trees; however, management guidelines for cavity trees are usually expressed in the number per acre. The number of cavity trees per acre can be estimated from the diameter of those trees included in a variable radius plot with the following formula.

$$\text{Number of trees per acre} = 43{,}560/(\pi\ D^2\ C^2)$$

where: D = diameter at breast height, and

C = the plot radius factor for a 10 BAF plot; if D is expressed in inches, C = 2.75, if D is expressed in feet then C = 33.

For example, one six-inch DBH tree in a 10 BAF plot would equal 51 six-inch DBH trees per acre $[43560/(\pi\, 6^2\, 2.75^2)]$ (Myers and Shelton 1980).

Dead and down woody debris has been measured by plot and plotless techniques. Warren and Olsen (1964) adapted the principles of the line transect by narrowing the width to a thin line. Used to determine the amount of logging residue, the diameter of the log at the point of line intersection is recorded and the volume per unit area is calculated (see equations below). They concluded that line intersect was faster and as accurate as plot sampling.

DeVries (1979) gives a complete explanation of the theory behind volume determination equations using the line intersect method.

$$\text{Log volume/unit area} = (\pi \div 2L) \times \sum(V_i \div l_i)$$

where: L = length of transect line

V_i = volume of the ith log

l_i = length of the ith log

The volume of the ith log (V_i) can be estimated by:

$$V_i = (\pi \div 4)\, d_i^2\, l_i$$

where: d_i = diameter of the log at point of intersection, and

l_i = length of the ith log

Substituting the formula for volume of the ith log (V_i) into the log volume/unit area equation yields:

$$\text{Log volume/unit area} = (\pi^2 \div 8L) \times \sum d_i^2$$

Thus, only the diameter of the log at the point of intersection needs to be measured.

Since volume is usually expressed in cubic feet per acre, the appropriate expansion factor is added (Howard and Ward 1972).

$$\text{Cubic feet/acre} = ([\pi^2 \sum d^2] \div 8L) \times [(43560 \text{ ft.}^2/\text{acre} \div (144 \text{ in.}^2/\text{foot}])$$

where: d_i = diameter of the log at point of intersection measured in inches

L = length of transect line measured in feet.

Van Wagner (1968) tested whether logs oriented in a particular direction would bias line intersect sample estimates; he concluded that any orientation bias could be overcome by having sample lines run in two or more directions. Howard and Ward (1972) tested the applicability of systematic sampling with the line intersect and concluded that a unidirectional line is sufficient if logs are randomly oriented (i.e., orientation bias does not exist). They also concluded that a substantial number of 100 foot lines would have to be run to reach precision levels of less than ±15%.

Often an investigator is more interested in the number of logs per acre instead of volume per acre. (Note to the reader: this equation was found after the sampling process was completed. It is shown here for the reader's benefit.) A statistically proven method to determine the number of logs per acre is offered by DeVries (1979) who suggests that for every log intersected log length can be estimated and put into the following equation:

$$\text{Number of logs/acre} = [(\pi/2L) \times \sum(1/l_i)] \times 43560,$$

where: L = length of the line in feet,

l_i = length of the ith log in feet.

For example, if two logs, one ten feet in length and the other 15 feet long, are intersected in a 100 foot line segment, the number of logs per acre would be 114, $\{[(\pi/200) \times \sum(1/10) + (1/15)] \times 43560\}$.

Chapter 3

METHODS

Study Area

The study area is located at the Stewardship Woodlot on The Pennsylvania State University's Russell Larson Farm at Rock Springs approximately 10 miles southwest of State College, Pennsylvania. Location and site maps are in Appendix A. The Stewardship Woodlot is situated on the northern lower slope of Tussey Mountain in Centre and Huntingdon Counties and represents a typical forest in the Valley and Ridge Province. Woodlot elevations range from 1180 feet to 1560 feet. The entire woodlot consists of approximately 60 acres and is managed as a non-industrial private forest with multiple objectives, i.e., on a cost recovery basis where income from timber management pays for all improvements (Anundson and Finley 1992). The woodlot is also used as a demonstration area for proper forest management.

Due to personnel and time constraints, only three stands were to be used as study sites. Stand 5 was chosen at the request of the managing forester. After completing a cursory inspection of the woodlot, stands 2 and 10 were chosen because of their usefulness as demonstration sites and because they seemed to provide a wide variety of structural features necessary to test the sampling methods.

According to soil survey documents (Braker 1981), the three stands are on Anderson series soils that are deep, but poorly drained. The documents cite that water availability is moderate, but permeability is slow; less than 15% of the surface is covered by rocks 10 to 24 inches in diameter. This study did not conduct any soil testing to confirm Braker's findings.

Evidence of past management is apparent. The remains of barbed wire fences and rock walls can be found indicating that all three stands were most likely cleared and used for pasture. Subsequently, the area was probably abandoned around 1920 and reverted back to forest. No evidence of recent harvesting in the three stands exists.

All stands are roughly the same age. Stand 5 has the highest site index while stand 2 has the lowest (table 1); predictably, the site index decreases with an increase in elevation. Site index is a measure of a site's suitability for growing trees; the higher the number, the better the site. Site indices were based on two to three trees in each stand. All trees measured for site index were in the dominant or co-dominant crown class, had no noticeable defects, and were equal to or greater than the average stand diameter. Trees were cored at DBH and the rings counted to determine age. Total height was measured using a relaskop[1]. Site index values were determined from appropriate site index tables (Carmean et al. 1989).

Stand 2 (8.04 acres) is large diameter poletimber, consisting of black birch, *Betula lenta* L., on the lower elevations (1300 feet), grading into red oak, *Quercus rubra* L., with scattered hemlock clumps, *Tsuga canadensis* L. The western boundary is formed by a truck road and intermittent stream, the north by a small sapling stand, the east by the private property boundary, and the southern boundary (approximately 1360 feet in elevation) by a larger diameter hardwood stand. The ground is rocky with several wet areas along the bottom. The slope ranges from 10 to 30 percent. Ground layer vegetation is sparse and low with a few clumps of dense shrubs and a moderate midstory made up of suppressed hardwoods and hemlock. Dead and down material is not noticeable except for occasional large (>16" diameter) logs.

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[1] A relaskop is a hand held instrument with numerous measuring capabilities. It functions as a rangefinder (measures distance from an object), clinometer (measuring height or slope), dendrometer (measures tree diameter at any location on the tree), angle gauge (contains several basal area factors for direct measurement of basal area per acre), and provides for slope correction (using both percent and degree tables).

Table 1. Site Index Data For Stands 2, 5, And 10 In The Stewardship Woodlot

	Species	DBH	Tree Age	Total Height	Site Index
Stand 2	Red oak	15	60	80	72
	White pine	16	72	83	65
Stand 5	Red oak	16	60	108	85
	Sugar maple	16	63	111	80
	White ash	16	73	120	95
Stand 10	Red oak	15	65	93	80
	White ash	14	53	88	85
	White pine	16	81	82	85

Stand 5 (3.98 acres) contains primarily large sawtimber, primarily basswood, *Tilia americana* L., and sugar maple, *Acer saccharum* Marsh., with few gaps in the canopy and no indication of recent harvesting activity. It is bounded on the north and west by abandoned cropland, on its east side by an intermittent stream, and on its south by a barbed wire fence. It has a lush ground cover, scattered shrub layer, and no apparent midstory. The stand occupies flat ground (1180 feet in elevation). Site quality appears excellent. Numerous large downed logs are scattered throughout the stand.

Stand 10 (4.38 acres) is similar to stand 2 in diameter and species composition. It is bordered by a clearcut on its western edge, a truck road on its southern and eastern edges, and to the north by a pine stand. The shrub layer is more noticeable along the road and clearcut edges and declines towards the interior. The ground layer grades from sparse to dense and is extremely rocky. Slope is less than 20 percent and elevations run from 1220 to 1300 feet.

Census Procedures

During May, 1993, all woody stems (both live and dead) one inch and larger in diameter at breast height (measured at 4 1/2 feet above the ground) in each stand were counted. Starting in one corner of each stand, the crew would systematically traverse the stand inspecting each applicable stem for timber and vegetative structural information. Each stem was marked with chalk after recording the appropriate information to prevent it from being counted a second time. At the end of the day, metal pins were used to mark the location between marked and unmarked trees in case of rain.

For each counted stem, data were recorded on:

- species,
- diameter at breast height (DBH) - measured to the nearest one inch class,
- quality (definitions are also listed in Appendix B):
  - acceptable growing stock - good quality commercial trees capable of being sold now or in the future as sawtimber,
  - unacceptable growing stock - a commercial tree species that does not have the potential to be sold as sawtimber, may be sold for pulpwood,
  - cull - a tree that cannot be sold as either sawtimber or pulpwood due to an unacceptable proportion of rot, crook, or sweep,
  - not commercial - a tree species that cannot be sold as a merchantable product solely on the basis of its species; i.e., hophornbeam, sassafras,
  - dead - a standing dead tree,
- stem or limb breakage (whether the stem had a broken top or limb),
- perches:
  - high - an overstory tree that clearly towers above all other forest vegetation or where a single tree, or group of trees, stands considerably above the surrounding herbaceous vegetation; can be live or dead trees,

- low - examples are fences, isolated deciduous shrubs, woody sprout clumps, dead stubs less than 10 feet above the ground, or clearcutting residue (DeGraaf et al. 1992); only dead stubs (short snags) were measured during the census,
- cavities[2]:
  - number,
  - size - whether the cavity opening is < 5 inches or ≥ 5 inches,
  - location - whether the cavity is on the main stem, branch, or at the base of the tree,
- snag condition:
  - hard - when hit with an ax, the ax doesn't deeply penetrate the wood,
  - soft - when hit with an ax, the ax readily sinks into the wood,
- vertical height layer position[3]:
  - overstory - vegetation greater than 30 feet tall,
  - midstory - vegetation within the 10 to 30 foot zone beneath the overstory layer,
  - shrub - vegetation within the 2 to 10 foot zone,

After the standing stems were measured, a systematic traverse was conducted to determine the number and amount of downed logs. In each stand every piece of dead and down woody debris (any wooden material ≥ 3 inches in diameter and ≥ 3 feet long) was measured for average diameter (average of small and large end diameters), total length, and decomposition rating (adapted from Thomas 1979). After recording this information, each log was marked with chalk to prevent it from being counted again.

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[2]Cavities were located by visual inspection from the ground of the base, stem, and branches of each tree. Binoculars were used to locate cavities in the upper canopy. This procedure should find the majority, but not all, of the cavities in a stand.

[3]Vertical height of each stem was first determined using a relaskop until the crew was trained to determine height by eye. The relaskop was used at regular intervals to verify crew estimates.

Inventory Methods Evaluated

One of the assumptions for this study was to find one or several methods that can be integrated into a forest inventory (such as SILVAH) used by foresters. The majority of foresters use a 10 BAF plot in connection with a forest inventory. Therefore, the variable radius plot seemed the only logical choice to determine the number, volume, and density of overstory trees. A fixed area plot of a size necessary to determine these characteristics would be too costly and time consuming. For the same reasons, the variable radius plot was the only one chosen to determine the number of snags, cavity trees, and high perches.

Lesser vegetation (herbaceous plants and shrubs) parameters seemed to be more accurately measured by a small fixed area plot (Schreuder et al. 1993). Many of Pennsylvania's foresters already use a 6 foot radius circular plot (1/385 acre) to assess tree regeneration as part of the SILVAH inventory; circular plots with radii of 3.72 feet (1/1000 acre) and 11.75 feet (1/100 acre) are also used. These three circular plots were nested to determine which size was more efficient in determining the species composition in the ground and shrub layers, sapling density, percent cover (ocularly estimated), and the volume of dead and down material. Dead and down material was also measured using the line intersect. This method was selected because of its simplicity and because foresters already determine distance between plots, a necessary parameter with the line intersect method.

The point-centered quarter method, which can determine density and cover of plants and species composition, was selected based on recommendations from Chris Nowak, Forest Service researcher at the Northeastern Forest Experiment Station, Warren, Pennsylvania (personal communication, 1993).

Two instruments, the ocular tube (modified from James and Shugart 1970) and a grid (modified from Garrison 1949) were used to sample cover in the ground, shrub, midstory, and overstory layers in conjunction with the nested circular plots. Percent overstory and midstory cover were also determined from tables relating crown cover to basal area, DBH, and species (Leak and Tubbs 1983); relative density measurements attained from SILVAH guidelines (Marquis et al. 1992) were also compared with overstory cover.

Sampling Procedures

Sampling was conducted in July, 1993. From a subjective starting location along the stand boundary, the first sample point (the center location of plot 1) was located so that the entire sample area would be within the delineated stand. Subsequent sample points were located systematically every 100 feet (site maps in Appendix A). This pattern allowed 16 sample points to be placed in stands 5 and 10 and 32 sample points in stand 2. All sample points were marked by flagged and numbered metal stakes.

Vegetative information was recorded using point-centered quarter plots, nested fixed area circular plots, variable radius plot (called prism plot hereafter), and line intersect plots. Table 2 lists which methods sampled the different vegetative features. The procedure at each sample point was to establish circular plots of 3.72 feet (1/1000 acre), 6.0 feet (1/385 acre), and 11.75 feet (1/100 acre) radii with flagged metal stakes placed on a north-south and east-west axis (see figure 2). In this way the flags not only showed the three circular plot outlines, but also divided the plot into quarters for the point-centered quarter plots.

The point-centered quarter method was used first to collect information on the ground layer (table 2). In each quarter the ground layer species (herb/grass/fern) closest to the sample point (measured from sample point to the center of the plant's stem) was

Table 2. Methods Used To Sample Vegetative Features

Vertical Height Layer	Vegetative Feature	Sampling Method
Ground 0 to 2 feet	Volume of dead and down material	1. Line intersect 2. Nested circular plots
	Percent cover	1. Point centered quarter 2. Nested circular plots (using ocular, tube, and grid methods)
	Species composition	1. Point centered quarter 2. Nested circular plots
Shrub > 2 to ≤ 10 feet	Percent cover	1. Point centered quarter 2. Nested circular plots (using ocular, tube, and grid methods)
	Species composition	1. Point centered quarter 2. Nested circular plots
Midstory > 10 to ≤ 30 feet	Percent cover	1. Point centered quarter 2. Nested circular plots (using tube and grid methods)
	Number of saplings	1. Point centered quarter, 2. Nested circular, 3. Prism plots
	Cavity, snag, and live tree characteristics (DBH, BA, etc.)	1. Prism plots
Overstory >30 feet	Percent cover	1. Nested circular (using tube and grid methods) 2. Prism plots (using relative density and basal area-diameter relationships)
	Cavity, snag, and live tree characteristics	1. Prism plot

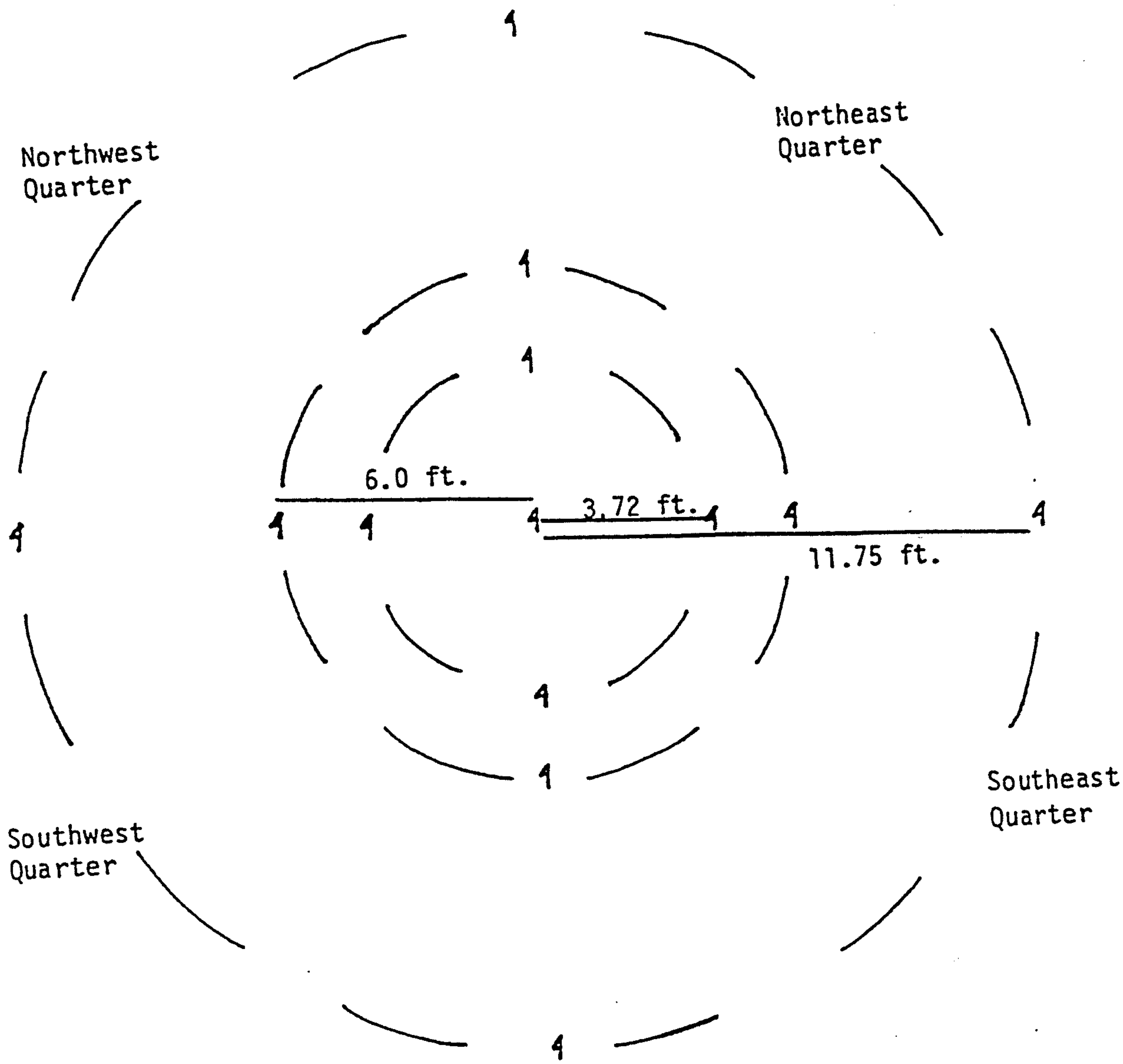

Figure 2. Drawing of ground and shrub layer circular and point-centered quarter plots. (4 = flag locations; ‿ = circular plot outline)

recorded for species, distance to the sample point, and the total area covered by the plant (to later determine percent cover). Similar information was then collected on tree seedlings (those within the ground layer), vegetation in the shrub layer, and saplings (midstory layer) in each quarter. DBH was also recorded for sapling species.

After collecting the point-centered quarter plot data, similar data were collected using the nested circular plots. In stand 5, data were collected starting from the smallest circular plot (1/1000 acre) and working to the largest; in stands 2 and 10 the order was determined by a random number table. In each circular plot the crew:

- identified ground and shrub layer plant species;
- ocularly estimated total percent vegetative cover in the ground and shrub layers by 10% classes (i.e., 0%, 10%, 20%, etc.; cover charts used to estimate percent cover are included in Appendix C);
- ocularly estimated percent rock cover by 10% classes,
- measured dead and down material using the average diameter (average of the smallest and largest diameters of the piece within the circular plot) and length within the circular plot, and recorded decomposition class[4];
- assigned a qualitative plant dispersion index number (how clumped or random plants are) for ground and shrub layer plants using Noon's (1981) method;
- recorded the number, species, and DBH of saplings (1.0" to 5.5" DBH).

If possible herbaceous species were identified in the field, otherwise plants were listed by numbers on the tally sheet and specimens were collected for later identification. See Appendix D for a list of all species identified in the ground and shrub layers.

Two other methods of determining percent vegetative cover for all four layers were used in conjunction with the circular plots: the ocular tube and the grid. James and Shugart (1970) originally used the tube in conjunction with a 1/10 acre circular plot

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[4]Although decomposition class was recorded during the census and sampling process no further analysis was conducted. It is mentioned here only to inform the reader.

where 20 readings indicating presence or absence of vegetation at the crosshair were systematically taken (figure 3). Since the largest plot in this study was 1/100 acre the number of cover readings was reduced. A total of thirteen readings could be taken at approximately six foot intervals (the interval used by James and Shugart) using the circumferences of the 1/385 and 1/100 acre (6.0 foot and 11.75 foot radii respectively) and the plot center. Figure 4 shows the location of the 13 points.

Using a grid (modification of Garrison 1949), cover estimates were taken at 5 points using the 1/100 acre plot circumference and the plot center (figure 4). The number of squares covered by vegetation at each point was recorded (figure 5) and the recordings averaged. Only five readings were taken because the grid covers a larger area than does the tube.

A 10 basal area factor prism was used to determine percent cover (using basal area/crown cover relationships) and tree characteristics of interest (table 2). For live and dead sampled trees species, DBH, cavity size and location, snag condition, vertical height layer, high or low perch potential, and broken tops or branches were recorded.

Finally, the line intersect method (Van Wagner 1968) was used to measure dead and down material. Along the 100-foot lines between plot centers the diameter of any dead and downed log was recorded at the point of intersection (where the line crossed the log). Line A always went between plot centers (i.e., from the center of plot 1 to the center of plot 2, from the center of plot 2 to the center of plot 3, etc.) (figure 6). The midpoint of each line A was marked by a flagged stake and used as the midpoint for the other two lines, lines B and C, which were run at 60 degree angles to line A. Van Wagner (1968) suggested that sampling error due to nonrandom orientation of logs could be reduced by having three sample lines at 60 degree angles.

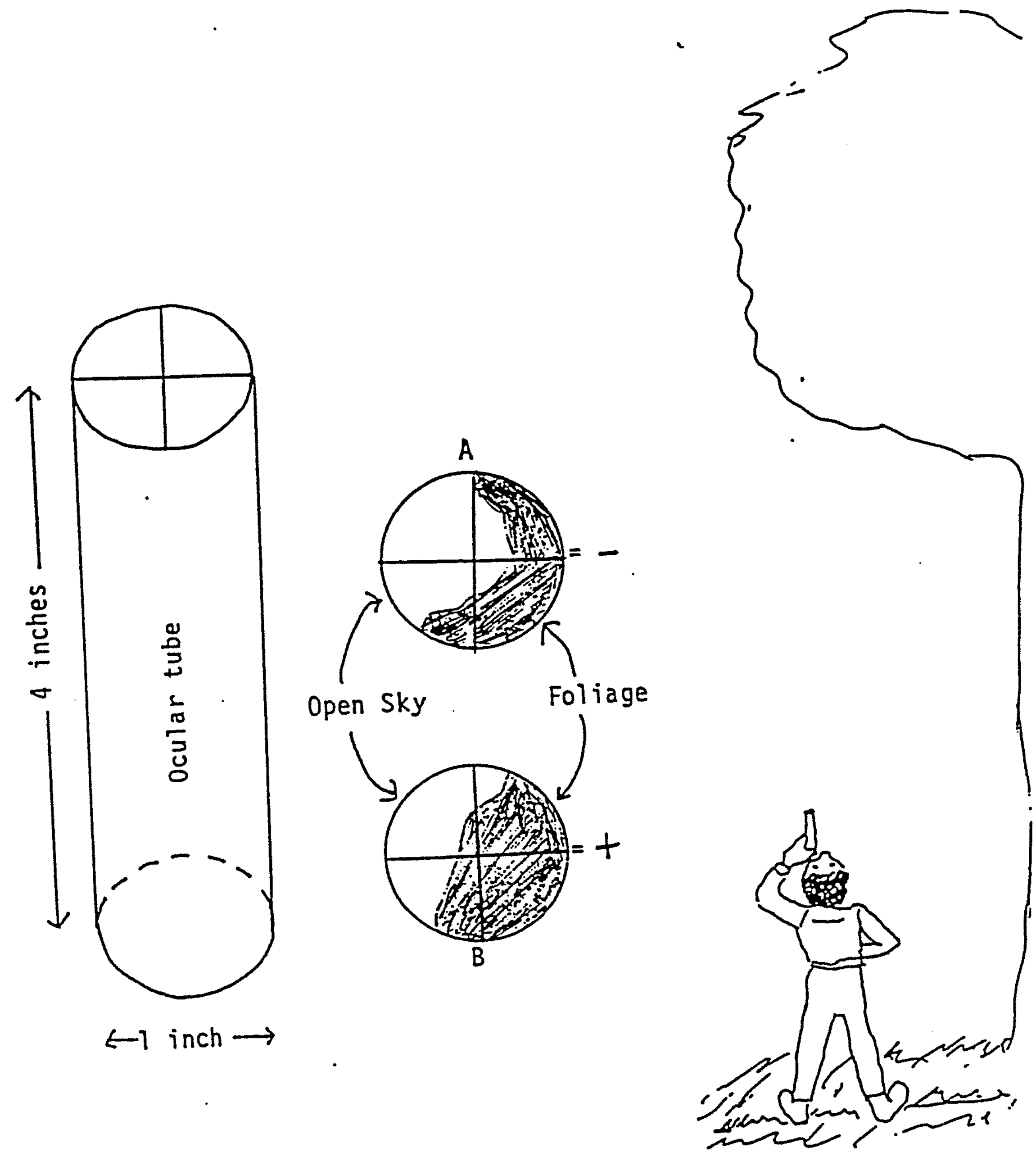


Figure 3. The ocular tube. Drawing A is a siting without foliage present. Drawing B is a siting with foliage present.

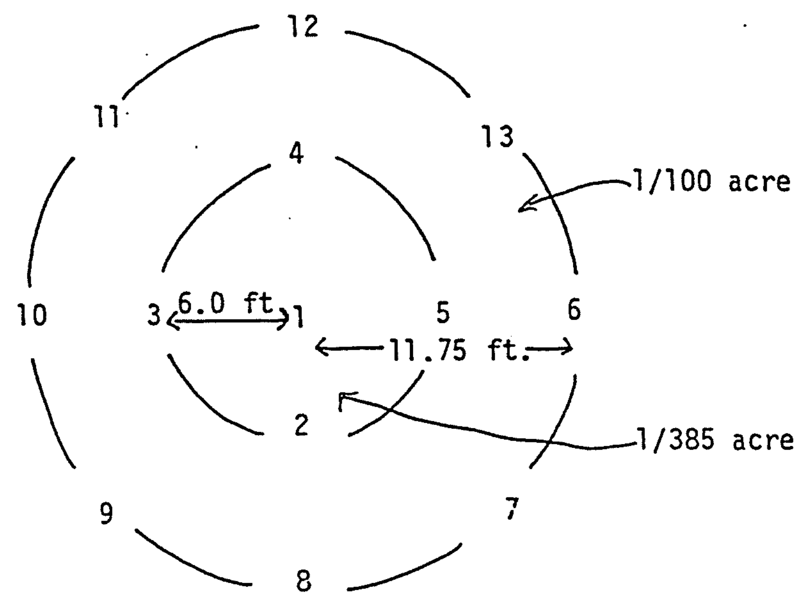
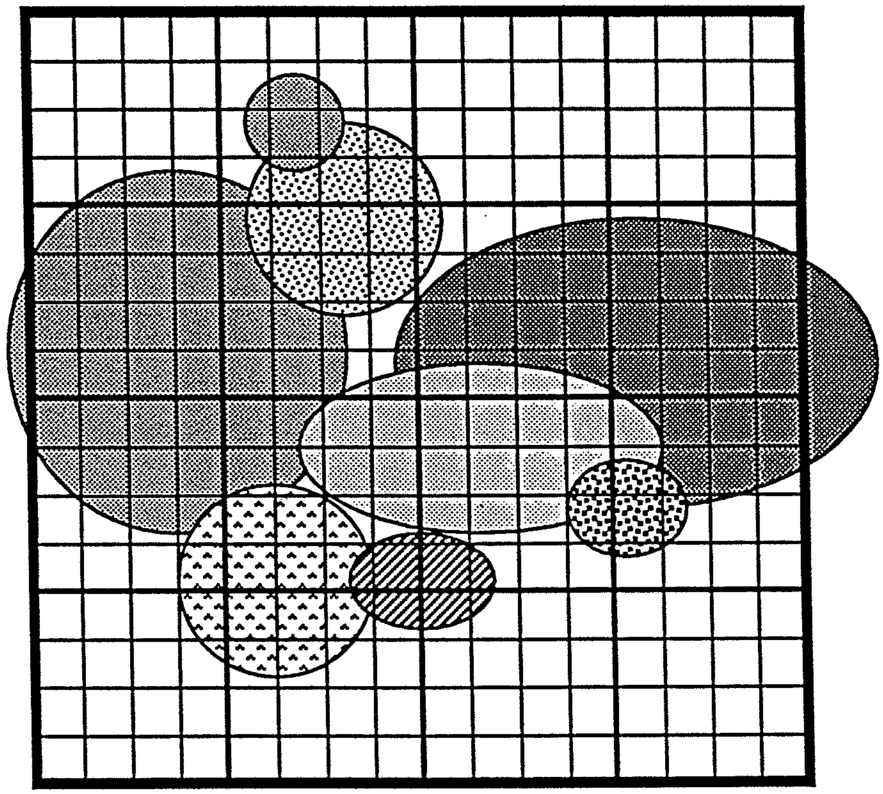


Figure 4. Outline of 6.0 foot and 11.75 foot radii circular plots with numbered positions used for determining percent cover of all vertical layers using the tube and grid methods. All points are used with the tube; points 1, 6, 8, 10, and 12 are used with the grid. (◡ = circular plot outline.)



Percent cover = $\frac{\text{number of large squares covered by vegetation}}{\text{16 squares}}$ X 100

Figure 5. Example of using the grid to determine percent cover. Approximately half of the large squares are covered by vegetation (the shaded areas); this plot has 50% cover.

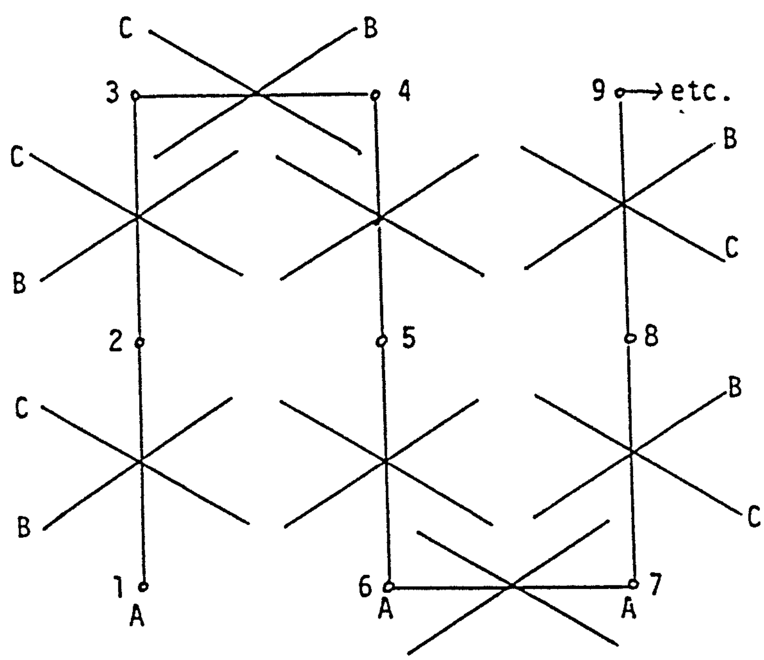


Figure 6. Line intersect pattern showing 100-foot line segments and plot numbers. A, B, and C represent different line orientations.

The sampling procedure just discussed was the same in all stands except that in stands 2 and 10 a random number table was used to pick the order in which the three nested circular plots would be sampled (i.e., which of the six combinations was chosen) and the length of time needed to complete all measurements within each circular plot was recorded. Stand 5 was the first stand sampled and time was not recorded nor was the order of the plots varied.

Analysis Of Sample Data

Percent Cover

Percent cover was estimated with different methods in the various vertical height layers (table 2). Estimates of percent cover were determined ocularly on the three nested circular plots for the ground and shrub layers and measured in all four vertical height layers using the grid and tube methods, and calculated in the ground, shrub, and midstory layers by the point-centered quarter method. In addition, an estimate of percent cover for the overstory and midstory was determined from tables estimating residual crown cover (Leak and Tubbs 1983). The tables, originally designed for use in New England, are based on the relationship between tree crown diameters, DBH, basal area, and tree species.

Relative density for each plot was determined using the SILVAH program (Marquis et al. 1992) and used as an estimate for overstory percent cover. Relative density measures the degree of crowding in a stand based on species composition. Each forest type has its own average maximum density that is usually shown on stocking charts as average maximum basal area. Each forest type's average maximum density can be considered 100% relative density. The SILVAH program determines the average area covered by a tree based on its DBH and species and should provide a reasonable cover estimate.

Point-centered quarter estimates of cover for midstory, shrub, and ground layers were calculated by multiplying the average number of plants per acre ($\bar{x}$) by the average area covered per plant ($\bar{a}$) in each sample, and dividing by 43,560 square feet per acre (see table 3), thus allowing a variance to be estimated.

Table 3. Example Of Percent Cover Estimate Calculations Using The Point-Centered Quarter Method

plot number	average number of plants per acre = $\bar{x}$	average square foot area covered per plant per plot = $\bar{a}$	Percent cover per plot = $\frac{(\bar{x} \cdot \bar{a})}{43560} \times 100$
1	60	100	14
2	60	150	21
.	.	.	.
.	.	.	.
.	.	.	.
16	60	75	10

Percent cover was assumed to be normally distributed in order to use a fixed effects analysis of variance test that compares means of the different methods (Minitab AOVONEWAY procedure; Ryan et al. 1985). Before running the analysis of variance, Hartley's Test for equality of variances was computed for each of the layers (Neter et al. 1990). Hartley's test determines whether substantial differences exist between the largest and smallest treatment variances. Unequal variances were found in at least one stand for the overstory, midstory, and shrub layers. However, the fixed effects analysis of variance is quite robust against unequal variances between populations, or treatments, as well as departures in normality if all treatment levels (i.e., methods) have the same sample size. Since within each stand and each vertical height layer treatment sample sizes were equal, the fixed effects analysis of variance can be validly used.

Minitab's AOVONEWAY procedure (Ryan et al. 1985) was used to calculate 95% confidence intervals for all treatments to determine if treatment means differ. If a p-value of less than .05 was calculated, indicating a significant difference between treatment means, a Tukey multiple pair comparison (separation of means) test with a family error rate of .05 was conducted. Tukey's method simultaneously constructs confidence intervals for all differences of treatment pair means (i.e., $\mu_i - \mu_j$); for example, if there are four treatments, or methods, there will be six confidence intervals for the six treatment pair means (pairs 1 and 2, 1 and 3, 1 and 4, 2 and 3, 2 and 4, and 3 and 4). An error rate of alpha = .05 refers to the confidence interval of the whole experiment (the family of confidence intervals for all pairs) and not to a particular pair's individual confidence interval. "Because the confidence interval for the entire set of comparison of means is 95%, the confidence interval for any particular comparison is larger than 95% and increases as the number of comparisons (that is, treatment means) increases" (DeVore 1991, p. 384).

Dead And Down Woody Material

Estimates of the cubic foot volume of dead and down woody debris were determined by measuring the average diameter and length of all logs within the three circular plots and then calculating the volume to an acre basis and by the line intersect method of Van Wagner (1968). Minitab's TTEST procedure (Ryan et al. 1985) tested the null hypothesis that the sample mean did not equal the population mean (H_a: $\bar{x}_i \neq \mu$). A p-value of less than 0.05 would indicate the sample mean was significantly different from the population mean.

In order to analyze differences among sample estimates a fixed effects analysis of variance was used. It was conducted twice, once on the three circular plots and again for the line intersect method; the two methods could not be compared in the analysis of variance due to different sample sizes. Although the circular plots were nested, independence of samples was assumed in order to use this analysis procedure.

Basal Area Parameters

Minitab's TTEST procedure (Ryan et al. 1985) provided a methodology to test the null hypothesis that the sample mean equaled the population mean.

The number of perches, snags, and cavity trees per acre was calculated from the formula:

$$\text{Number per acre} = 43{,}560/(\pi\ D^2\ C^2)$$

where: D = diameter at breast height, and

C = the plot radius factor; for D expressed in inches, C = 2.75.

For example, one six-inch DBH tree sampled in a 10 BAF plot [$43560/(\pi\ 6^2\ 2.75^2)$] equals 51 six-inch DBH trees per acre (Myers and Shelton 1980).

Number Of Saplings

A fixed effects analysis of variance was used to determine differences between sample mean estimates of the number of saplings per acre with the nested circular plots and the prism plot. Estimates from the point-center quarter method were not included since its variance cannot be calculated.

Species Composition

A fixed effects analysis of variance was used to determine differences between the number of new species per plot by evaluation method in the ground and shrub layers. To evaluate the plots on the number of species found per square foot, the number of new species found in the circular plots was divided by the appropriate plot size and an analysis of variance was calculated for these figures.

Time

In stands 2 and 10 the amount of time needed to complete all of the measurements associated with the different size circular plots was recorded; stand 5 was used to establish procedures and thus was not represented in this analysis. The measurements included identifying ground and shrub layer species, estimating percent cover in the ground and shrub layers, and measuring the average diameter and length of downed logs within the appropriate circular plot. A fixed effects analysis of variance was used to determine whether differences existed between the size of the plot, the data acquired, and the amount of time needed to complete the associated measurements.

Sample Size Determinination

A criterion for determining whether one method is more efficient than another is the number of samples needed to evaluate a particular structural feature. Simply, inventory cost varies directly with the number of samples. DeVries (1986) suggested calculating sample size (after conducting a pilot survey) from the following formula:

$$n = (ts)^2/D^2 \qquad \text{(equation 3.1)}$$

where: n = sample size,

t = Student's t value at the 95% confidence level with n-1 degrees of freedom,

s = the sample standard deviation,

D = the allowable error, such as ± 15 square feet of basal area or ± 50 cubic feet of dead and down material.

The degrees of freedom are first estimated since 'n' is not known. The process is repeated until a final sample size is determined. For example, how many tube readings are needed in stand 5 to be 95% confident of being within ± 10 percentage points of mean overstory cover? Using 15 degrees of freedom the answer is 5.07 or 6 samples $\{[(2.131)^2 (10.57)^2]/100\}$. The process is then repeated using 6-1 degrees of freedom and continues until the sample size does not change. The final sample size is 7.

Thus, methods with smaller variances would require fewer samples and be more cost-effective.

Sample size can also be determined using the coefficient of variation. The coefficient of variation (the sample standard deviation divided by the sample mean) compares the relative variability in means produced by different methods. It is used quite often because it is easier to estimate a parameter's coefficient of variation (whether it has higher or lower relative variability compared to another method) than it is to exactly determine what the particular standard deviation is. For example, it is easier to determine if basal area, or any other parameter, will have the same variability from each method, i.e., 100% coefficient of variation, than it is to say it varies by 15 square feet.

The formula (DeVries 1986) used to compute sample size with the coefficient of variation is:

$$n = (tCV)^2/E^2 \qquad \text{equation (3.2)}$$

where: n = sample size

t = Student's t value at the 95% confidence level with n-1 degrees of freedom,

CV = the coefficient of variation, expressed as a percent,

E = the relative allowable error, expressed as a percent.

Equation 3.2 is a variation of equation 3.1. Both equations, in theory, will produce equal sample sizes (DeVries 1986); in practice, using the coefficient of variation (equation 3.2) produces a higher sample size.

Acquisition Of Wildlife Habitat Requirements

The species habitat tables developed by DeGraaf et al. (1992) and Hassinger et al. (1993 a/b) provide a great deal of information, but lack sufficient quantitative values. Each habitat feature is presented as a dichotomous variable; needed or not needed by the species of interest. This begged the question of whether thresholds could be developed for various structural features. In attempting to establish thresholds it is important to recognize that the threshold values are not absolute and that they do not adequately represent the interplay with other features in the ecosystem, but represent a starting point.

Unfortunately the literature does not provide sufficient information on most species to establish even rudimentary threshold data. Individual researchers and scientists may have measured and quantified habitat features, but these values are often not reported in the literature. Believing that experts do have opinions about the relative amounts of various habitat features required by wildlife species, the Delphi method of consensus building was used to elicit input. The panel consisted of members of the Pennsylvania Biological Survey technical committees and other selected experts.

The Delphi method is one of a group of consensus building or information sharing techniques that has effectively been used with natural resource related problems

(Baughman 1989; Durham et al. 1985; Zuboy 1981). The general model for Delphi consensus building uses an iterative review of responses from panel members. Initially, questions, opinions, or information is mailed to panel members for their reactions. Their responses are summarized and reported back to the panel. The process is considered complete when the majority of experts agree with the results or when the investigator determines that any additional information is not worth the added expense (Fink et al. 1991).

The Pennsylvania Biological Survey technical committees represent expertise in amphibians and reptiles, mammals, and birds. The survey instrument submitted to the panel was a modification of the species/habitat feature table developed by DeGraaf et al. (1992). Modifications to the table included deletions of species not found in Pennsylvania, addition of species found in Pennsylvania, but not in New England, and information on habitat requirements gleaned from the literature. Panel members were asked to:

- quantify amounts of vegetative or physical structural features listed as being required;
- suggest additional required features;
- recommend modifications to the species list.

In October, 1993, a questionnaire (see appendix E) was sent to 46 experts. The questionnaire contained two tables; one containing species from DeGraaf et al. (1992) and another table of Pennsylvania species not listed in their report. Each panel member was asked to supply their 'best estimate' on the amounts of specific structural features needed by the species (i.e., how many dead and down logs or what percent shrub cover would species 'x' need).

Responses were consolidated in early December. Another iteration listing all responses was then sent to all panel members, even those who did not reply to the first round. The panelists were asked to comment on the first round results and to add any additional information. Second round responses were consolidated in January, 1994.

The end product of the Delphi effort was a new species table that characterized some of the habitat structural features into various quantitative scales. Information obtained from the Delphi questionnaires was used in this table if a consensus was reached on a required quantity or feature. If no consensus was reached, information from DeGraaf et al.'s (1992) report was used. However, many of the habitat features by necessity remained dichotomous, that is, the feature was listed as only being required with no quantity noted.

This species table was used to design another presence/absence matrix listing species found in Pennsylvania with their associated habitat structural features. This matrix was used as the basis to establish functional groups, species that function similarly way within similar habitat structures. Structural features needed by species were coded as 1 (the feature is required) or 0 (the feature is not required); the entire matrix is found in Appendix F. A cluster analysis was run on this matrix (SAS CLUSTER procedure, SAS Institute Inc., 1989). The objective of the cluster analysis was to group species so that all species within a group would have common characteristics and be dissimilar to species in other groups.

Because each method of cluster analysis has advantages and disadvantages, several methods were used to compare how clusters were formed (SAS Institute Inc., 1989). The cluster analysis methods used in this study were the centroid, average linking, and Ward's method. All methods used a distance matrix to determine similarity, but varied in how the distances were formed.

The information used in the cluster analysis was not weighted; all features were assumed to be of equal importance. However, in reality, the importance of a feature probably depends on the species involved. Also, the information is limited in its scope since there is insufficient information on most species habitat requirements.

Chapter 4

RESULTS AND DISCUSSION

Census Results

When all live stems ≥ 1 inch DBH were considered, stand 2 had an average diameter of 7 inches and a basal area of 122 square feet per acre (table 4). Based on the number of stems per acre (table 5), stand 2 was composed mainly of black birch (37%), red maple, *Acer rubrum* L. (12%), hophornbeam, *Ostrya virginiana* Scop. (10%), white pine, *Pinus strobus* L. (8%), and spicebush, *Lindera benzoin* L. (5%). When species composition was based on total basal area per acre, a species shift occurred. Black birch remains the major species with 38 square feet per acre followed by chestnut oak, *Quercus prinus* L. (17 sq. ft.), red oak (15 sq. ft.), white pine (14 sq. ft.), and red maple (13 sq. ft.). These five species accounted for 80 percent of the basal area. (Note: Because every stem in the population was measured, variances or standard errors cannot be given for these parameters.)

Table 4. Basal Area Per Acre By Vertical Height Layer For Live Stems ≥1" DBH In Stands 2, 5, And 10 In The Study Area

	Overstory	Midstory	Shrub	Total
Stand 2*	113.58	8.35	0.45	122.38
Stand 5	153.56	11.21	0.63	165.40
Stand 10	120.88	9.09	0.91	130.88

*Stand 2 = 8.04 acres; stand 5 = 3.98 acres; and stand 10 = 4.38 acres.

Table 5. Species Composition Of All Live Stems ≥ 1" DBH In Study Area

Common Name*	STAND 2 Trees/ Acre	STAND 2 %	STAND 5 Trees/ Acre	STAND 5 %	STAND 10 Trees/ Acre	STAND 10 %
Basswood	5.8	2.0	63.6	27.4	8.7	2.9
Bigtooth aspen	0.2	0.1	—	—	—	—
Bitternut hickory	0.6	0.2	1.3	0.5	1.8	0.6
Black birch	109.3	37.0	6.7	3.0	9.6	23.0
Black cherry	1.0	0.3	3.5	1.5	0.9	0.3
Black gum	6.0	2.0	—	—	12.8	4.2
Butternut	0.5	0.1	—	—	0.7	0.2
Chestnut oak	11.4	3.9	—	—	3.4	1.1
Choke cherry	—	—	0.5	0.2	—	—
Cucumbertree	—	—	0.8	0.3	—	—
Dogwood	11.1	3.8	1.0	0.4	2.5	0.8
Eastern hemlock	6.0	2.0	0.3	0.1	10.7	3.6
Elm	2.0	0.7	4.8	2.1	3.4	1.1
Hawthorn	0.2	0.1	4.8	2.1	2.0	0.6
Hophornbeam	28.8	9.7	1.8	0.8	41.1	13.6
Mockernut hickory	3.0	1.0	5.8	2.5	3.0	1.0
Mountain laurel	0.1	0.0	—	—	—	—
Musclewood	—	—	0.5	0.2	—	—
Pin cherry	0.1	0.0	—	—	0.2	0.1
Pitch pine	0.5	0.1	—	—	0.2	0.1
Red maple	35.1	11.9	8.8	3.8	34.5	11.4
Red oak	10.4	3.5	6.3	2.7	8.2	2.7
Shadbush	0.6	0.2	—	—	—	—
Shagbark hickory	2.4	0.8	2.0	0.9	10.5	3.5
Spicebush	14.7	5.0	—	—	20.3	6.7
Striped maple	0.1	0.0	—	—	1.6	0.5
Sugar maple	0.5	0.1	91.6	39.6	2.1	0.7
Sumac	—	—	0.5	0.2	—	—
Viburnum	1.0	0.3	7.8	3.3	2.5	0.8
White ash	6.1	2.1	16.6	7.2	22.4	7.4
White oak	1.4	0.5	1.5	0.7	1.6	0.5
White pine	24.9	8.4	0.2	0.1	30.7	10.2
Witch hazel	11.4	3.9	1.0	0.4	7.3	2.4
	295.2	100.0	231.7	100.0	302.7	100.0

*See Appendix D for scientific nomenclature.

Stand 5 had an average diameter of 10 inches, a basal area of 165 square feet per acre (table 4), and was composed mainly of sugar maple (40%), basswood (27%), white ash, *Fraxinus americanus* L. (7%), red maple (4%), and viburnum, *Viburnum spp*. L. (3%) (table 5). Basswood and sugar maple contained 67% of the stand's basal area (41% and 26% respectively).

Stand 10 had an average diameter of 7 inches, 131 square feet of basal area per acre (table 4), and was composed mainly of black birch (23%), hophornbeam (14%), red maple (11%), white pine (10%), and white ash (7%) (table 5). However, white pine had the highest basal area per acre (22 sq. ft.) followed by black birch (21 sq. ft.), red oak (16 sq. ft.), red maple (14 sq. ft.), and shagbark hickory, *Carya ovata* (Mill.) K. Koch (9 sq. ft.). These five species comprised 62% of the basal area.

When only trees in the overstory layer (main canopy) were considered a different stand structure appeared: average diameter was greater, basal area was slightly less, and species composition, based on number of trees per acre, shifted. The average diameter in stand 2 increased 43% to 10 inches and basal area decreased 7% to 114 square feet per acre (table 4). Black birch and red maple remained the top two species based on the number of stems per acre, white pine moved from fourth to third in dominance followed by chestnut oak and red oak. The two lower layer species, hophornbeam and spicebush, dropped out.

The average diameter in stand 5 increased by 40% to 14 inches, basal area decreased 7% to 154 square feet per acre (table 4), basswood became the dominant tree species followed by sugar maple (indicating that a large part of sugar maple stems were below the main canopy), and white ash remained third. Red maple and viburnum were replaced by black birch and red oak.

The average diameter of stand 10 increased 57% to 11 inches and basal area decreased 8% to 121 square feet per acre (table 4). Black birch remained the dominant species, white pine moved from fourth to second place, red maple remained third, white ash moved up one notch to fourth followed by shagbark hickory. Hophornbeam which had the second highest number of stems per acre (total) dropped out of the top five since most of its stems were not in the overstory.

The number of live stems ≥ 1 inch DBH per acre in the overstory and midstory did not greatly differ between stands 2 and 10; stand 10 had 41% more stems in the shrub layer than stand 2 (table 6). Stand 5 contained approximately 25% fewer stems per acre (total); this was expected since the average diameter of the stand was greater. The fewest number of dead stems per acre was found in stand 5 while stand 10 contained four times as many. In all stands the majority of snags were found in the midstory layer.

Table 6. Number Of Stems Per Acre ≥ 1" DBH By Vertical Height Layer In Stands 2, 5, And 10 In The Study Area

		Overstory	Midstory	Shrub	Total
Stand 2*	DEAD	8.33	18.66	5.35	32.34
	LIVE	166.04	89.30	39.80	295.15
Stand 5	DEAD	3.27	5.02	3.77	12.06
	LIVE	136.43	70.85	24.37	231.66
Stand 10	DEAD	11.87	29.68	8.66	50.22
	LIVE	152.28	94.29	56.16	302.74

*Stand 2 = 8.04 acres; stand 5 = 3.98 acres; and stand 10 = 4.38 acres.

The census revealed that stands 2 and 10 contained the same number of saplings per acre (129 saplings; trees between 1" to 5.5" DBH in any height layer). Stand 5 had only 60% as many saplings per acre (79 saplings per acre), probably due to the age and increased stand diameter.

Only one high perch was found during the census located in stand 2. This high perch was a 19 inch DBH white pine; none of the other trees met the definition of a high perch. Low perches consisted of short snags, those snags greater than 4.5 feet tall to less than 10 feet. The census did not include measurement of other low perches such as fences or isolated shrubs. Stand 10 had a somewhat higher number of low perches per acre than the other two stands (table 7).

Table 7. The Number And Basal Area Per Acre Of Low Perches In Stands 2, 5, And 10

	Number of low perches per acre	Basal area per acre of low perches
Stand 2*	2.9	.7
Stand 5	2.3	.7
Stand 10	4.8	.9

*Stand 2 = 8.04 acres; stand 5 = 3.98 acres; and stand 10 = 4.38 acres.

Although stand 10 had more snags than the other two stands, all stands had a similar number of cavities per acre, number of trees per acre with cavities, and basal area per acre of trees with cavities when considering all live and dead trees ≥ 4 inches DBH (table 8). Cavities in trees smaller than four inches DBH are not usually used by cavity nesting birds (Thomas 1979).

Table 8. Cavity Data For All Stems (Live And Dead) ≥ 4" DBH In The Study Area

	Number of cavities per acre	Number of trees per acre with cavities	BA per acre of trees with cavities
Stand 2*	21.64	9.58	12.88
Stand 5	20.35	12.81	14.14
Stand 10	23.06	11.19	13.01

*Stand 2 = 8.04 acres; stand 5 = 3.98 acres; and stand 10 = 4.38 acres.

The number of dead and downed logs did not differ between stands 2 and 5, but stand 5 had 50% more volume (table 9). Stand 10 contained the greatest number of logs, but the least volume.

Table 9. The Number And Cubic Foot Volume Per Acre Of Dead And Downed Woody Debris In The Study Area

	Number of Logs per acre	Cubic foot Volume per acre
Stand 2*	110.57	349.99
Stand 5	100.00	536.59
Stand 10	179.22	251.86

*Stand 2 = 8.04 acres; stand 5 = 3.98 acres; and stand 10 = 4.38 acres.

The census showed that stand 5 differed from stands 2 and 10 in species composition and had fewer numbers of live trees and saplings, a larger average diameter, higher total and overstory basal area, fewer numbers of snags, and a greater volume of dead and downed logs. Stand 10 differed from stand 2 by having slightly more basal area per acre, 41% more shrubs, 62% more downed logs, but 28% less volume of downed logs. Stands 2 and 10 had similar average diameters and species composition whether based on number of trees or basal area.

Results Of Sample Data

Overstory Percent Cover

Estimates of overstory percent cover were compared using the tube, grid, basal area-cover tables, and relative density methods (table 2). In stands 2, 5, and 10 there were significant differences between treatment means for overstory percent cover (F=21.33, p=0.000; F=15.21, p=0.000; and F=4.16, p=0.010 respectively). In stands 2 and 5, multiple pair comparisons revealed a significantly higher estimate for overstory percent cover using the basal area-cover tables of Leak and Tubbs (1983), noted as ba-chart on figures 7 to 12, compared to the other methods (figures 7 and 8).

In stand 10, the basal area-cover relationship had a significantly higher estimate than relative density (figure 9). There was also a nonsignificant increase in estimating percent cover with the basal area-cover relationship compared with the tube and grid methods.

Percent cover estimated from basal area-cover tables were consistently higher because of the nature of the table; these tables were developed to determine percent cover of residual trees with few overlapping crowns. Used in an unharvested stand, with overlapping crowns, values well over 100% cover can be obtained. However, the tube and grid methods can never be over 100% and relative density rarely goes over.

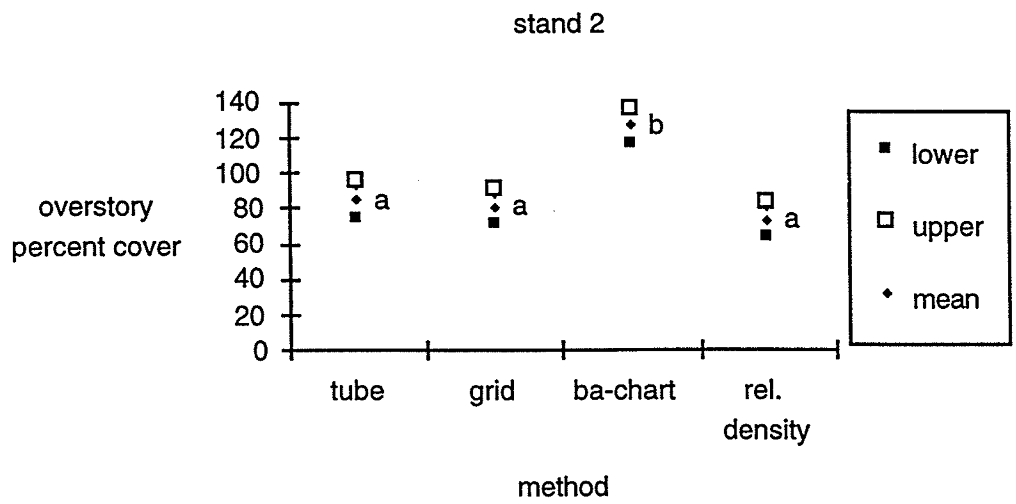


Figure 7. 95% confidence intervals for overstory percent cover by evaluation method in stand 2. Means with the same letter are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

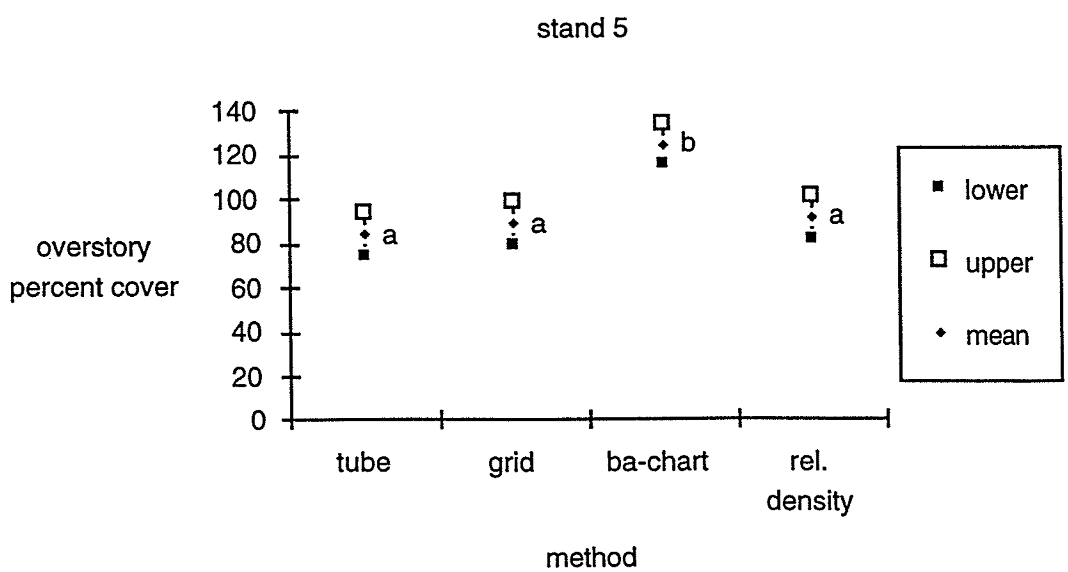


Figure 8. 95% confidence intervals for overstory percent cover by evaluation method in stand 5. Means with the same letter are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

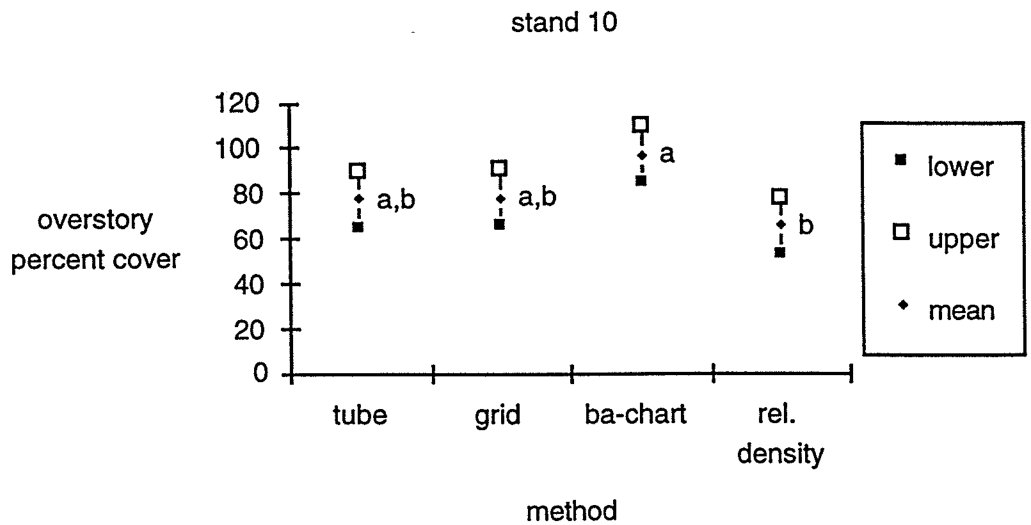


Figure 9. 95% confidence intervals for overstory percent cover by evaluation method in stand 10. Means with the same letter are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

The tube, grid, and relative density means did not exhibit any pattern, none of these three methods had consistently higher or lower estimates than the others (table 10). However, the tube and grid estimates were always closer to each other than to relative density estimates and their variances were smaller.

Table 10. Overstory Percent Cover Estimates

stand 2

method	n	mean	standard deviation	std. error of the mean
tube	32	85.12	9.47	1.67
grid	32	81.25	9.77	1.73
ba-chart	32	126.97	53.49	9.46
rel. density	32	73.59	20.05	3.54

pooled standard deviation = 29.36, degrees of freedom = 124

stand 5

method	n	mean	standard deviation	std. error of the mean
tube	16	84.19	10.57	2.64
grid	16	89.06	6.80	1.70
ba-chart	16	124.81	27.69	6.92
rel. density	16	92.00	22.64	5.66

pooled standard deviation = 18.96, degrees of freedom = 60

stand 10

method	n	mean	standard deviation	std. error of the mean
tube	16	77.50	14.65	3.66
grid	16	78.31	15.04	3.76
ba-chart	16	97.25	37.08	9.27
rel. density	16	66.00	27.54	6.88

pooled standard deviation = 25.37, degrees of freedom = 60

Midstory Percent Cover

Midstory percent cover was estimated using the tube, grid, basal area-cover tables, and the point-centered quarter methods (table 2). For midstory cover, significant differences in treatment means occurred in stand 2 (F=14.46, p=0.000) and stand 5 (F=3.51, p=0.02). In stand 2 multiple pair comparisons revealed a significantly lower cover estimate using the basal area-cover relationship than those obtained with the tube and grid methods (figure 10). The estimate of percent cover from the point-centered quarter method (noted as "pcq" in the following figures) was significantly lower than the estimate obtained using the tube.

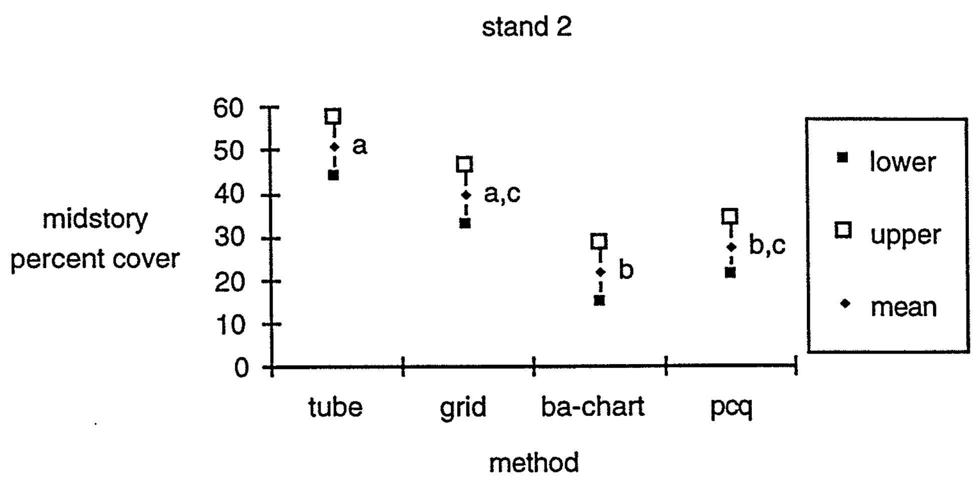


Figure 10. 95% confidence intervals for midstory percent cover by evaluation method in stand 2. Means with the same letter are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

Multiple pair comparisons did not reveal any significant differences between treatment means in stand 5 (figure 11). Recall that the analysis of variance calculated individual 95% confidence intervals to determine if treatment means differed. Whereas, in the Tukey multiple pair comparison test the 95% confidence interval referred to all pairs of confidence intervals; the individual confidence intervals would be at approximately the 99% level.

No significant differences were found between treatment means in stand 10 (F=2.23, p=0.94; figure 12).

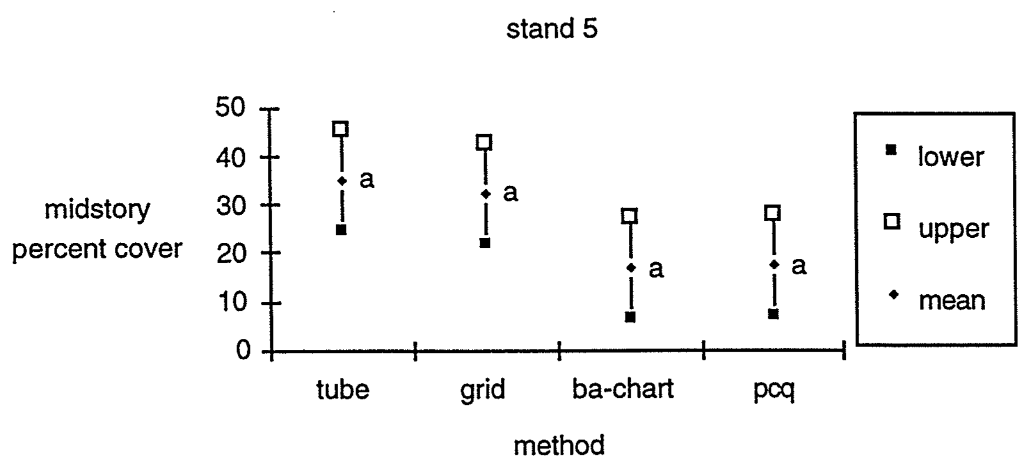


Figure 11. 95% confidence intervals for midstory percent cover by evaluation method in stand 5. There are no significant differences between evaluation methods (Tukey's multiple comparison test, family error rate alpha = 0.05).

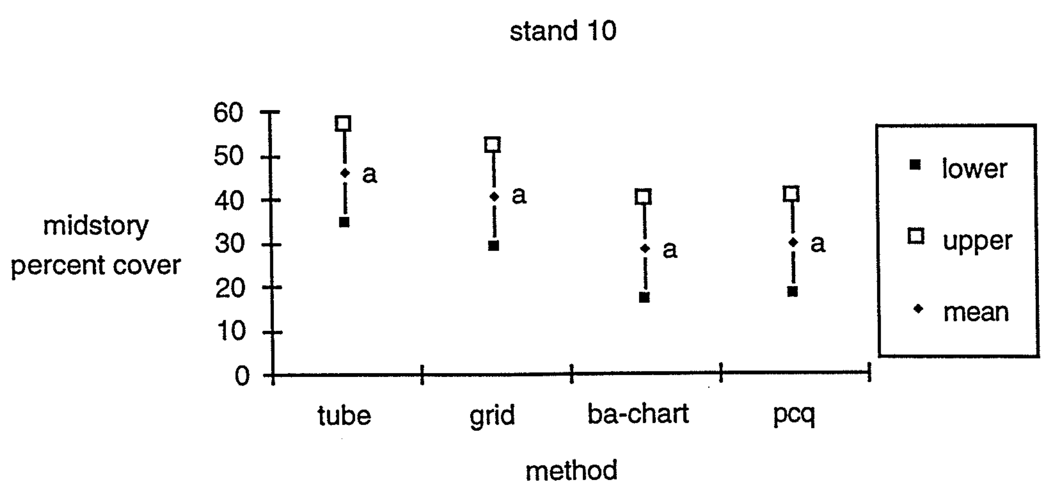


Figure 12. 95% confidence intervals for midstory percent cover by evaluation method in stand 10. There are no significant differences between evaluation methods (Tukey's multiple comparison test, family error rate alpha = 0.05).

In all three stands, the tube and grid methods consistently had the highest and second highest estimates of percent midstory cover and basal area-cover method had the lowest (table 11). Tube and grid estimates were closer to each other than they were to the estimates of the other methods. Variance for the point-centered quarter method was the smallest, probably due to the method of calculation, and variances for the tube and grid were almost identical.

Table 11. Midstory Percent Cover Estimates

	method	n	mean	standard deviation	std. error of the mean
stand 2	tube	32	50.84	17.48	3.09
	grid	32	39.75	17.84	3.15
	ba-chart	32	21.91	27.60	4.88
	pcq	32	27.62	9.38	1.66

pooled standard deviation = 19.19, degrees of freedom = 124

	method	n	mean	standard deviation	std. error of the mean
stand 5	tube	16	35.19	25.90	6.47
	grid	16	32.56	26.90	6.72
	ba-chart	16	16.69	17.67	4.42
	pcq	16	17.37	6.29	1.57

pooled standard deviation = 20.89, degrees of freedom = 60

	method	n	mean	standard deviation	std. error of the mean
stand 10	tube	16	46.06	21.83	5.46
	grid	16	40.94	23.15	5.79
	ba-chart	16	28.69	30.56	7.64
	pcq	16	29.69	11.97	2.99

pooled standard deviation = 22.86 degrees of freedom = 60

Shrub Percent Cover

Shrub percent cover was estimated from six methods: the tube, grid, point-centered quarter, 1/1000 acre plot, 1/385 acre plot, and the 1/100 acre plot (table 2). For shrub cover, significant differences between treatment means occurred in stand 2 (F=4.75, p=0.000) and 10 (F=3.34, p=0.008). In stand 2, estimates from the point-centered quarter, the 1/1000 acre circular plot, and the 1/385 acre circular plot were all significantly lower than the tube estimate (figure 13). In stand 10, the point-centered quarter and the 1/1000 acre circular plot estimates were significantly lower than the tube estimate (figure 14). No significant differences were found in stand 5 (F=0.98, p= 0.437; figure 15).

Table 12 shows that in stands 2 and 10, the tube had the highest estimate of cover; in stand 5 the grid was highest. In all stands the point-centered quarter had the smallest estimate of cover and the 1/1000 acre the next smallest. The point-centered quarter had the smallest variance.

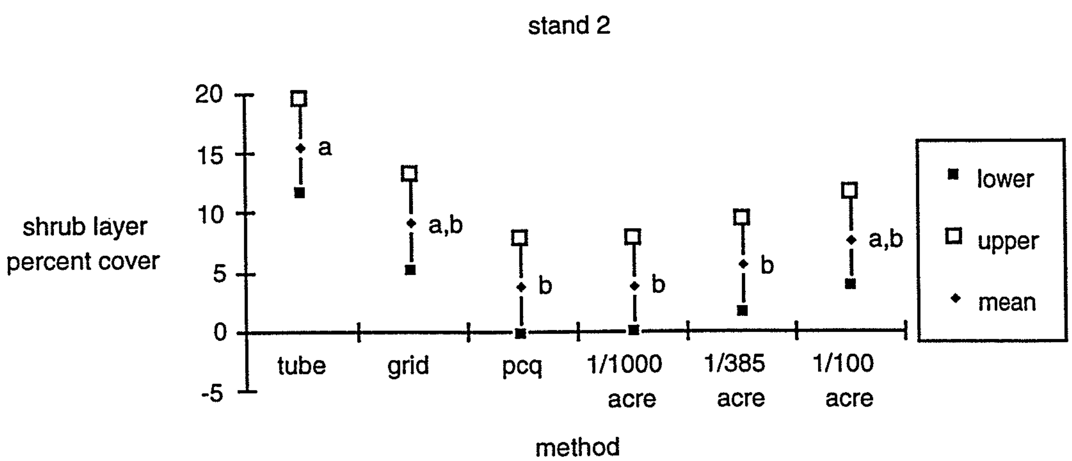


Figure 13. 95% confidence intervals for shrub layer percent cover by evaluation method in stand 2. Means with the same letter are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

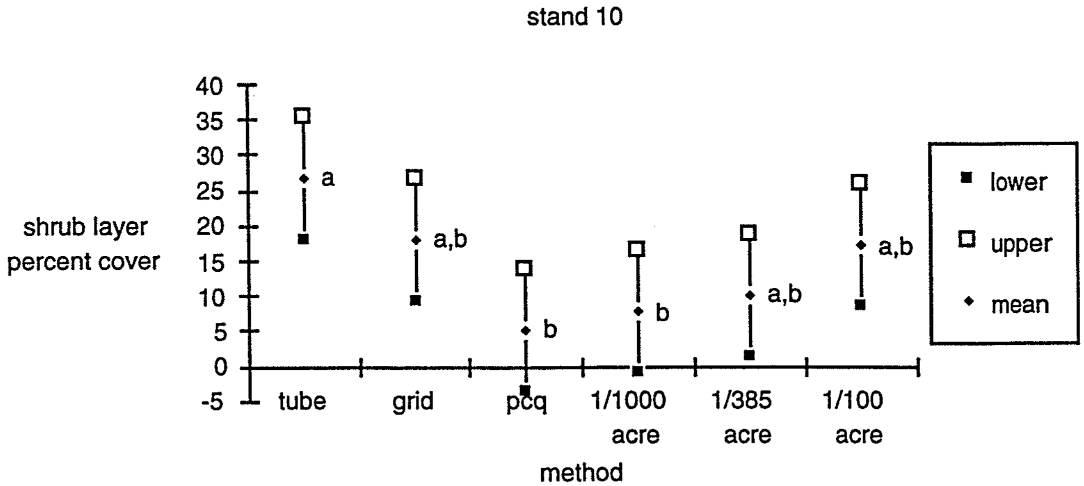


Figure 14. 95% confidence intervals for shrub layer percent cover by evaluation method in stand 10. Means with the same letter are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

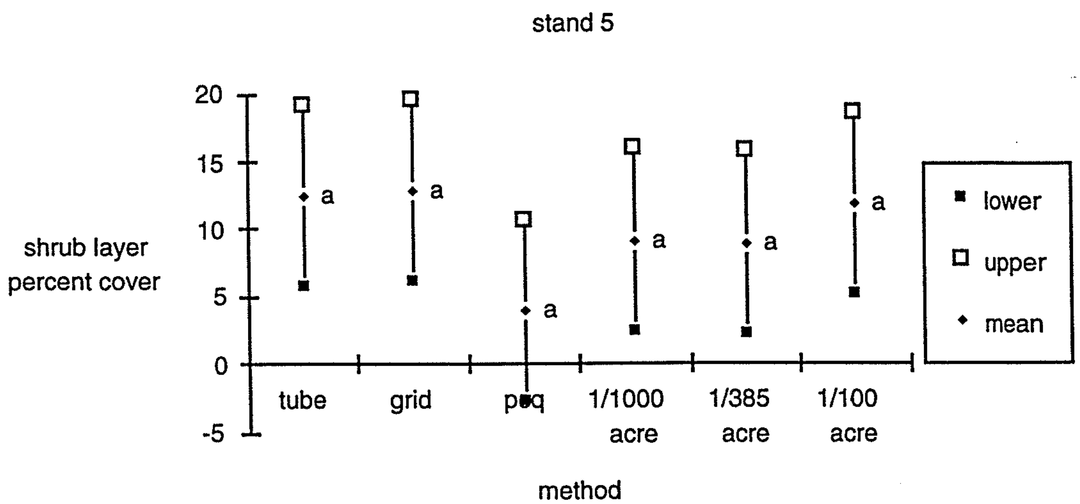


Figure 15. 95% confidence intervals for shrub layer percent cover by evaluation method in stand 5. There are no significant differences between evaluation methods (Tukey's multiple comparison test, family error rate alpha = 0.05).

Table 12. Shrub layer percent cover estimates

stand 2

method	n	mean	standard deviation	std. error of the mean
tube	32	15.56	15.57	2.75
grid	32	9.16	11.09	1.96
pcq	32	3.78	3.71	0.66
1/1000 acre	32	3.87	10.22	1.81
1/385 acre	32	5.50	10.66	1.89
1/100 acre	32	7.69	14.15	2.50

pooled standard deviation = 11.53, degrees of freedom = 186

stand 5

method	n	mean	standard deviation	std. error of the mean
tube	16	12.50	12.45	3.11
grid	16	12.88	17.92	4.48
pcq	16	4.00	2.25	0.56
1/1000 acre	16	9.19	13.09	3.27
1/385 acre	16	9.00	15.41	3.85
1/100 acre	16	11.87	14.34	3.59

pooled standard deviation = 13.51, degrees of freedom = 90

stand 10

method	n	mean	standard deviation	std. error of the mean
tube	16	26.87	22.72	5.68
grid	16	18.13	20.24	5.06
pcq	16	5.31	3.59	0.89
1/1000 acre	16	7.81	14.26	3.56
1/385 acre	16	10.19	16.81	4.20
1/100 acre	16	17.19	20.46	5.11

pooled standard deviation = 17.53, degrees of freedom = 90

Ground Percent Cover

Ground percent cover was estimated from the six methods used to determine shrub percent cover: the tube, grid, point-centered quarter, 1/1000 acre plot, 1/385 acre plot, and the 1/100 acre plot (table 2). For percent ground cover, a significant difference occurred between treatment means for stands 2 (F=5.02, p=0.000) and 5 (F=4.48, p=0.001). In stand 2, multiple comparison of treatment pairs revealed that the point-centered quarter estimate was significantly lower than estimates obtained from the tube, the 1/385 acre circular plot, and the 1/100 acre circular plot methods (figure 16).

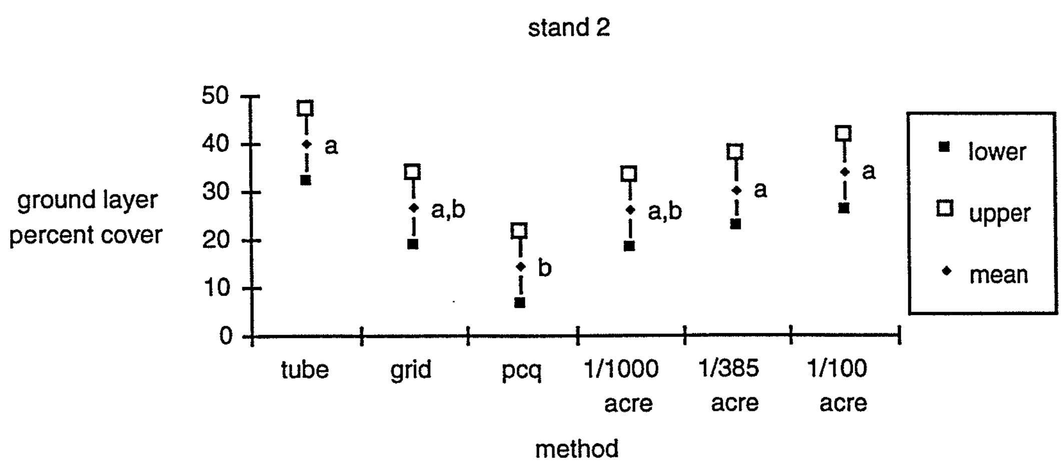


Figure 16. 95% confidence intervals for ground layer percent cover by evaluation method in stand 2. Means with the same letter are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

In stand 5, the point-centered quarter estimate was significantly lower than the estimates obtained from the tube and grid methods (figure17). The estimate from the 1/1000 acre circular plot was significantly lower than the tube estimate.

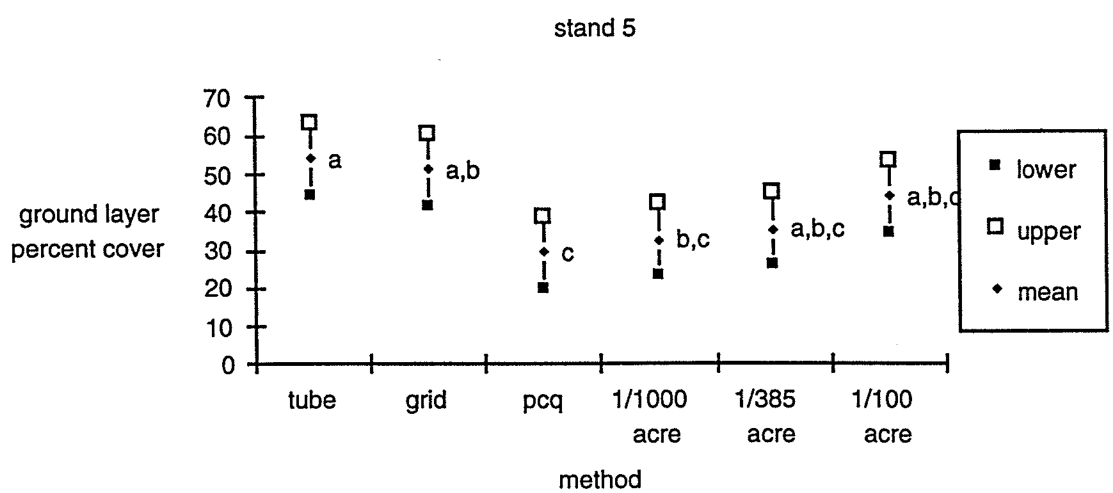


Figure 17. 95% confidence intervals for ground layer percent cover by evaluation method in stand 5. Means with the same letter are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

No significant differences were found between treatment means in stand 10 ($F=1.38$, $p=0.24$; figure18).

There was no pattern to the variances although the tube consistently had the highest mean estimate among the evaluation methods (table 13).

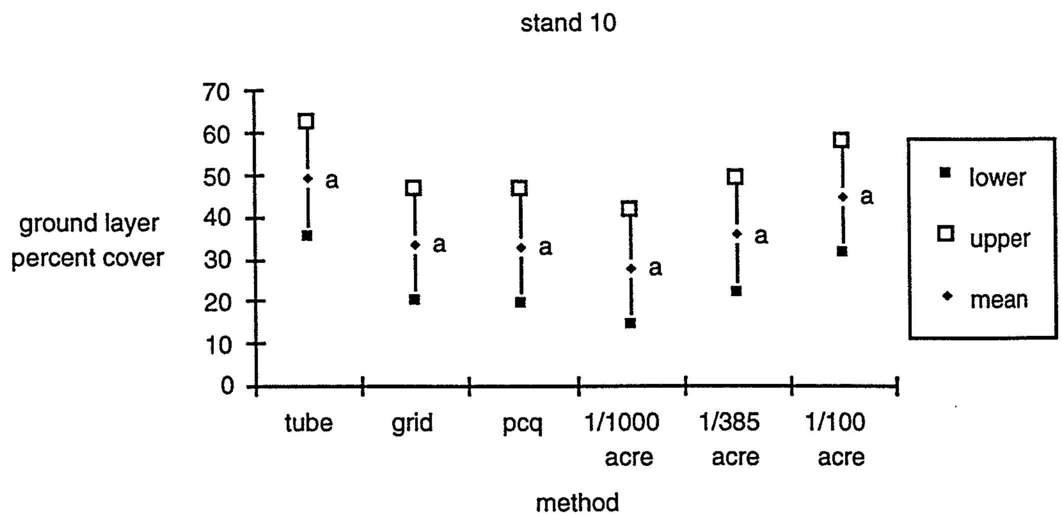


Figure 18. 95% confidence intervals for ground layer percent cover by evaluation method in stand 10. There are no significant differences between evaluation methods (Tukey's multiple comparison test, family error rate alpha = 0.05).

Table 13. Ground Layer Percent Cover Estimates

stand 2

method	n	mean	standard deviation	std. error of the mean
tube	32	39.66	23.98	4.24
grid	32	26.25	23.05	4.07
pcq	32	14.13	21.11	3.73
1/1000 acre	32	25.84	20.04	3.54
1/385 acre	32	30.09	22.05	3.90
1/100 acre	32	33.75	20.28	3.59

pooled standard deviation = 21.80, degrees of freedom = 186

stand 5

method	n	mean	standard deviation	std. error of the mean
tube	16	53.88	16.37	4.09
grid	16	51.12	21.50	5.38
pcq	16	29.50	23.24	5.81
1/1000 acre	16	32.81	17.03	4.26
1/385 acre	16	35.63	16.72	4.18
1/100 acre	16	44.38	18.25	4.56

pooled standard deviation = 19.03, degrees of freedom = 90

stand 10

method	n	mean	standard deviation	std. error of the mean
tube	16	49.13	24.64	6.16
grid	16	33.62	26.40	6.60
pcq	16	33.20	40.80	10.20
1/1000 acre	16	28.12	19.14	4.78
1/385 acre	16	35.94	20.59	5.15
1/100 acre	16	45.00	25.03	6.26

pooled standard deviation = 27.05, degrees of freedom = 90

Dead And Down

Estimates obtained from the three circular plots and the line intersect method were compared to actual population figures. Only stand 5 had sample estimates significantly different from the population mean (table 14).

In comparing the volume of dead and down woody debris in the circular plots, the largest plot consistently had the largest estimate and the smallest plot the smallest estimate (table 14). However, the differences were not significant. The 1/100 acre plot was closest to the actual mean in stands 2 and 5 and had the smallest variance in stands 2 and 5. The 1/1000 acre plot was closest (although twice as much) to the actual mean in stand 10.

When compared to the circular plots, the line intersect method more accurately reflected the true mean with equal or smaller variances. The higher variances in stand 5 for lines A and C were due to a few plots crossing large piles of debris. The smaller variances in stand 2 were probably due to the increased sample size.

A fixed effects analysis of variance revealed no difference between the means of the three line orientations (estimates from the average were not included).

Table 14. Comparison Of Cubic Foot Volume Per Acre Of Dead And Down Material By Sampling Methods To Population Data

Stand # 2 (μ = 350 cu. ft./acre)

	# of plots	Vol/acre	Std. error of mean	% of Actual μ	95% Confidence interval	contains μ
Line intersect						
Line A	31	266	46.6	76	171.3, 361.5	yes
Line B	31	361	61.3	103	235.7, 486.1	yes
Line C	31	247	51.6	70	141.3, 352.2	yes
Average of lines A+B+C	31x3	291	33.7	83	222.5, 360.2	yes
circular plots						
1/1000ac	32	165	106.3	47	-51.4, 382.1	yes
1/385 ac	32	244	121.8	70	-4.9, 491.9	yes
1/100 ac	32	370	101.1	105	163.2, 575.6	yes

Stand # 5 (μ = 537 cu. ft./acre)

	# of plots	Vol/acre	Std. error of mean	% of Actual μ	95% Confidence interval	contains μ
Line intersect						
Line A	15	493	165.7	92	137.6, 848.4	yes
Line B	15	322	71.5	60	168.6, 475.3	no
Line C	15	390	169.7	72	25.4, 753.4	yes
Average of lines A+B+C	15x3	402	117.8	75	148.8, 654.1	yes
circular plots						
1/1000ac	16	231	117.9	43	-20.3, 428.8	no
1/385 ac	16	278	124.7	52	12.6, 544.3	yes
1/100 ac	16	342	90.3	64	149.7, 534.9	no

Stand # 10 (μ = 252 cu. ft. /acre)

	# of plots	Vol/acre	Std. error of mean	% of Actual μ	95% Confidence interval	contains μ
Line intersect						
Line A	15	268	76.1	106	105.0, 431.5	yes
Line B	15	371	122.0	147	108.8, 633.1	yes
Line C	15	269	90.7	107	74.7, 463.7	yes
Average of lines A+B+C	15x3	303	68.1	120	156.8, 448.8	yes
circular plots						
1/1000ac	16	554	254.2	219	12.1, 1096.6	yes
1/385 ac	16	574	200.8	228	146.1, 1002.2	yes
1/100 ac	16	680	274.0	270	95.8, 1264.1	yes

Basal Area Parameters

Table 15 shows the comparison between per acre sample and population means for the various parameters. Per acre sample means of total basal area, overstory basal area, and snag basal area were accurately estimated using the prism. However, cavity tree basal area per acre (the basal area of all trees ≥ 4 inches DBH, live or dead, that contain cavities) was significantly underestimated by the prism in all three stands.

The number of snags ≥ 4 inches DBH per acre were accurately estimated by the prism in all stands. The number of live and dead trees cavity trees was estimated accurately in stands 2 and 10. In stand 5, however, the sample mean underestimated the population mean by 53%.

Confidence intervals for the numbers of low perches per acre included the population means in stands 5 and 10; no low perches were found using the prism plot in stand 2. However, population means were extremely low on a per acre basis.

The prism plot did not find any high perches in any of the stands.

Table 15. Comparison Of Per Acre Sample And Population Means Of Basal Area Dependent Parameters Using Prism Sampling

	Stand #	# of plots	sample mean	actual μ	% of actual μ	Std. error of mean	95% confidence interval	contains μ?
Total live BA per acre	2 5 10	32 16 16	116 154 128	122 165 131	95 93 98	4.9 8.4 10.2	106.2, 126.3 136.4, 172.3 105.7, 149.3	yes yes yes
Overstory live BA per acre	2 5 10	32 16 16	104 145 111	114 153 121	91 95 92	5.4 8.2 8.9	92.6, 114.8 127.6, 162.4 92.3, 130.2	yes yes yes
Snag BA per acre	2 5 10	32 16 16	8.4 3.8 11.9	11 4 16	73 95 74	1.9 1.2 3.8	4.5, 12.3 1.1, 6.4 3.8, 19.9	yes yes yes
Cavity tree BA per acre	2 5 10	32 16 16	5.9 4.4 4.4	13 14 13	46 31 34	1.1 1.3 1.8	3.7, 8.1 1.6, 7.1 0.5, 8.2	no no no
Number of cavity trees per acre	2 5 10	32 16 16	8.6 6.1 6.2	10 13 11	90 47 56	4.1 1.8 3.0	0.2, 16.9 2.1, 10.0 -0.2, 12.5	yes no yes
Number of snags per acre	2 5 10	32 16 16	35.9 8.2 53.6	31 9 47	116 91 114	11.9 3.1 19.3	11.7, 60.2 1.7, 14.7 12.5, 94.8	yes yes yes
Number of low perches per acre	2 5 10	32 16 16	0 1.8 5.2	2.9 2.3 4.8	0 78 108	— 1.8 5.2	— -2.0, 5.7 -5.9, 16.2	 yes yes

Number of saplings

Circular plots, prism plots, and the point-center quarter method were used to provide estimates of the number of saplings. A fixed effects analysis of variance conducted on estimates obtained by the three circular plots and the prism plot found no significant differences between the means of these methods (stand 2: F=0.09, p=0.964; stand 5: F=0.11, p=0.955; and stand 10: F=1.77, p=0.162). Because the point-centered quarter method used the overall average distance to determine the number of saplings (i.e., number of saplings = 43,560 sq. ft. per acre/average distance^2), a variance and thus a confidence interval could not be calculated; its estimate could not be included in the analysis of variance. In this instance the point-centered quarter estimate was on a per area basis; in the percent cover estimates a variance was determined on the area covered per plant, not on the number of plants. Sample means for the point-centered quarter method were comparable to the prism and 1/100 acre plot results (table 16).

No discernible pattern to the circular plots was detected; that is, the 1/1000 acre plot had the smallest estimate of saplings in stand 2, the middle estimate in stand 5, and the largest estimate of saplings in stand 10. The 1/100 acre plot had the smallest variance in each stand since larger plots at equal sample sizes usually have smaller variances.

Table 16. Comparison Of Sample And Population Means For Number Of Saplings Per Acre By Sampling Methods

Stand #: 2 (μ = 129 saplings/acre)

Plot size or method	# of plots	sample mean	% of Actual μ	Std. Error of mean	95% Confidence interval	contains μ?
1/1000ac	32	62	48	43.5	-26.2, 151.2	yes
1/385 ac	32	84	65	33.4	16.1, 152.4	yes
1/100 ac	32	75	58	19.6	35.1, 114.9	no
Prism	32	80	62	23.2	24.1, 127.1	no
PCQ	32	81	63			

Stand #: 5 (μ = 71 saplings/acre)

Plot size or method	# of plots	sample mean	% of Actual μ	Std. Error of mean	95% Confidence interval	contains μ?
1/1000ac	16	62	88	62.5	-70.7, 195.7	yes
1/385 ac	16	72	102	52.3	-39.4, 183.8	yes
1/100 ac	16	38	53	22.1	-9.7, 84.7	yes
Prism	16	51	72	34.0	-21.0, 126.8	yes
PCQ	16	41	58			

Stand #: 10 (μ = 129 saplings/acre)

Plot size or method	# of plots	sample mean	% of Actual μ	Std. Error of mean	95% Confidence interval	contains μ?
1/1000ac	16	312	242	119.7	57.3, 567.6	yes
1/385 ac	16	168	130	49.3	63.3, 273.6	yes
1/100 ac	16	138	106	41.7	48.6, 226.4	yes
Prism	16	95	74	39.1	12.1, 178.7	yes
PCQ	16	104	81			

Species Composition

Ground Layer Species Composition

The point-centered quarter method and the three circular plots sampled species composition in the ground layer (any plant species within the 0 to 2 foot vertical height layer). Circular plots included a greater number of plant species, but 44% of all species found in the three stands were also found by the point-centered quarter plot. Figure 19 shows the cumulative number of species found by evaluation method for stand 10; stands 2 and 5 showed similar patterns.

A total of 92 plants identified to at least genus were found in the three stands from the sum of the circular plot samples (a list of identified plants is included in Appendix D). A pink lady's slipper, *Cypripedium acaule*, found in stand 2, was the only uncommon species identified. Another 25 herbaceous plants were found in these circular plots, but could not be identified due to either the lack of flowers or other vegetative parts.

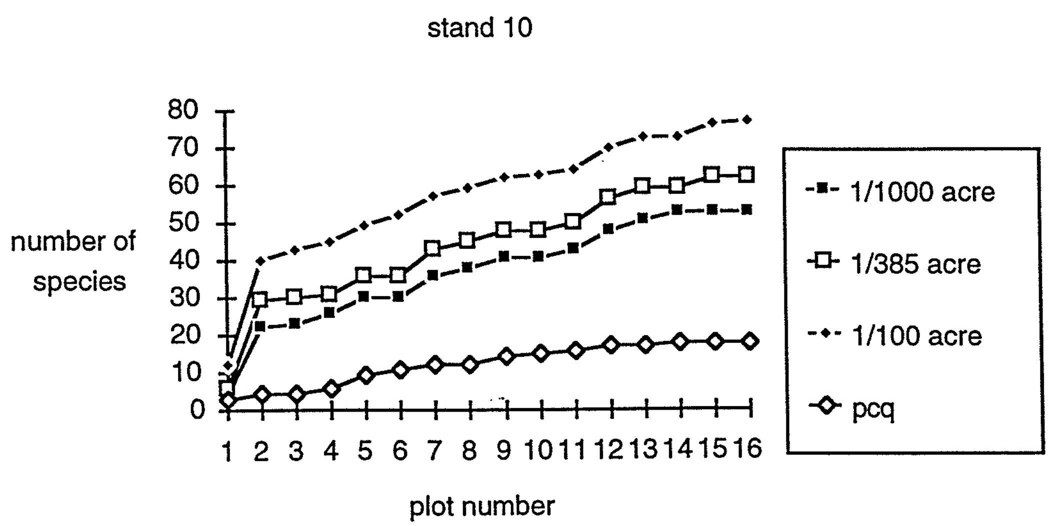


Figure 19. Cumulative number of species per plot by evaluation method in stand 10.

Table 17 lists those species found most frequently in the circular plots. As plot size increased so did the probability of a plant being present in that plot (Myers and Shelton 1980).

Table 17. Species Most Frequently Found In The Ground Layer Circular Plots

	1/1000 acre		1/385 acre		1/100 acre	
Stand 2	red maple	91%	red maple	97%	hickory sp.	100%
	partridgeberry	59%	partridgeberry	75%	hophornbeam	100%
	white ash	56%	white ash	75%	red maple	97%
	hickory sp.	53%	white pine	75%	partridgeberry	88%
	hophornbeam	47%	hophornbeam	75%	white ash	88%
Stand 5	sugar maple	100%	sugar maple	100%	sugar maple	100%
	elm sp.	88%	elm sp.	100%	elm	100%
	black cohosh	81%	black cohosh	100%	black cohosh	100%
	violet sp.	81%	violet sp.	94%	white ash	100%
	white ash	75%	white ash	88%	violet sp.	94%
Stand 10	Christmas fern	69%	Christmas fern	88%	Christmas fern	100%
	red maple	69%	greenbriar	81%	red maple	94%
	spicebush	56%	red maple	75%	spicebush	88%
	white ash	50%	spicebush	69%	greenbriar	81%
	greenbriar	50%	white ash	62%	white ash	81%
	partridgeberry	50%	partridgeberry	62%	virginia creeper	81%

Significant differences occurred among treatment means in the number of new species found per plot in stand 5 (F=3.61, p=0.018). Multiple pair comparisons revealed that the point-centered quarter method contained significantly fewer new species per plot than the 1/100 acre plot (figure 20). No significant differences were found between circular plot sizes.

No significant differences in the number of new species per plot were found in stand 2 (F=1.80, p=0.15; figure 21) or stand 10 (F=1.61, p=0.196; figure 22).

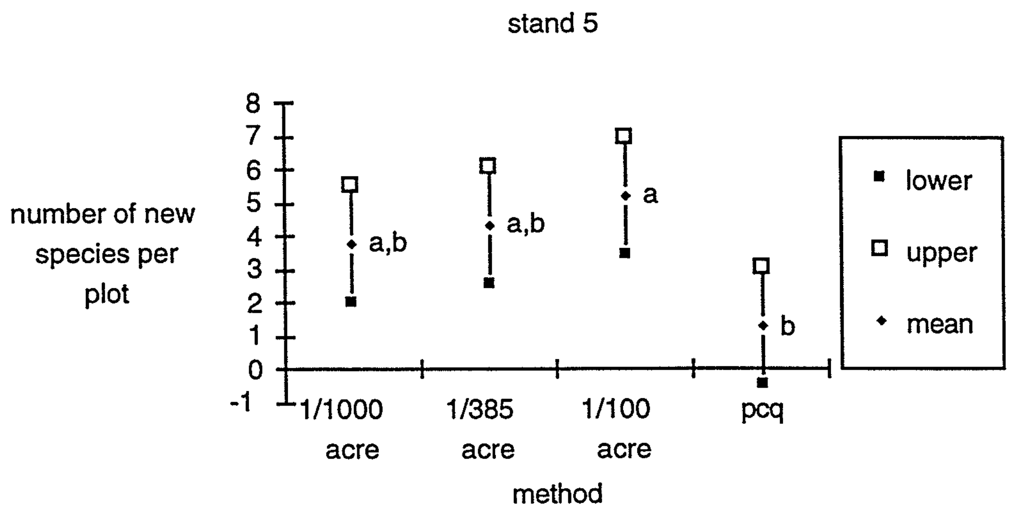


Figure 20. 95% confidence intervals for the number of new species found per plot by evaluation method in the ground layer in stand 5. Means with the same letter are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

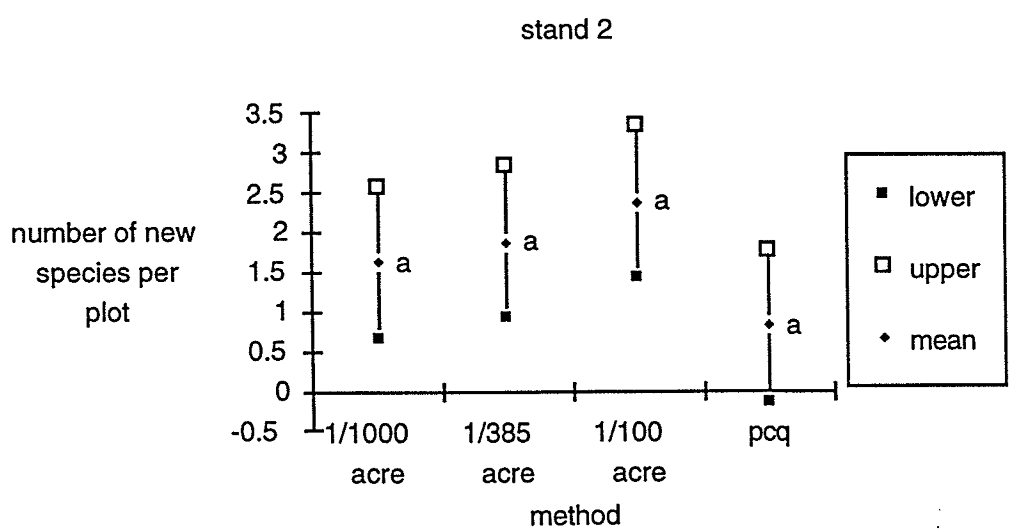


Figure 21. 95% confidence intervals for the number of new species found per plot by evaluation method in the ground layer in stand 2. Means with the same letter are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

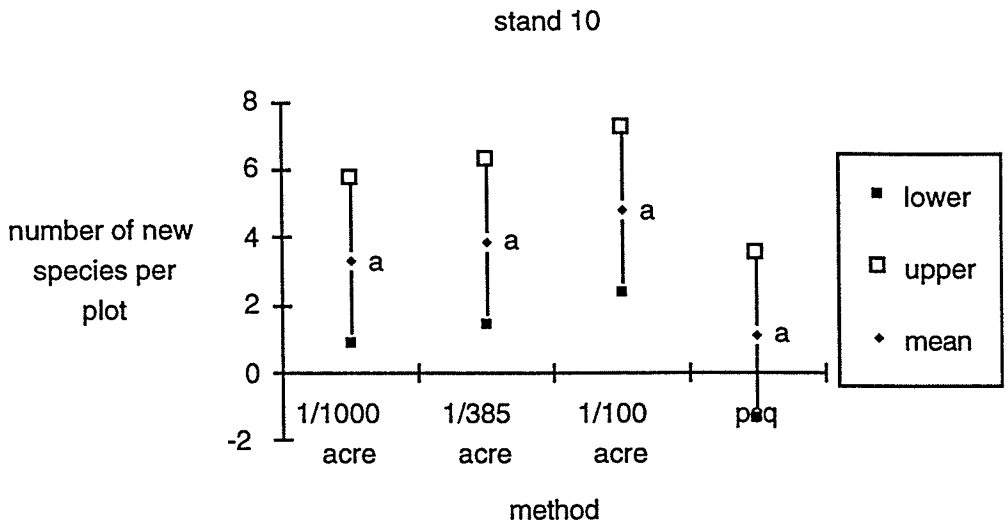


Figure 22. 95% confidence intervals for the number of new species found per plot by evaluation method in the ground layer in stand 10. Means with the same letter are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

To evaluate the plots on a per unit basis (in this case per square foot), a fixed effects analysis of variance was calculated for the number of new species found in the circular plots divided by plot size. The point-centered quarter estimates could not be used since it had no plot area. Significant differences were found between treatment means in all stands (stand 2: $F=8.48$, $p=0.000$; stand 5: $F=11.90$, $p=0.000$; stand 10: $F=4.14$, $p=0.022$).

Multiple pair comparisons revealed that in all stands the 1/1000 acre plot had a significantly higher number of species per square foot than the 1/100 acre plot (figures 23 to 25). In stand 2 and stand 5 the 1/1000 acre plot also found a significantly higher number of species per square foot than the 1/385 acre plot (figures 23 and 24 respectively).

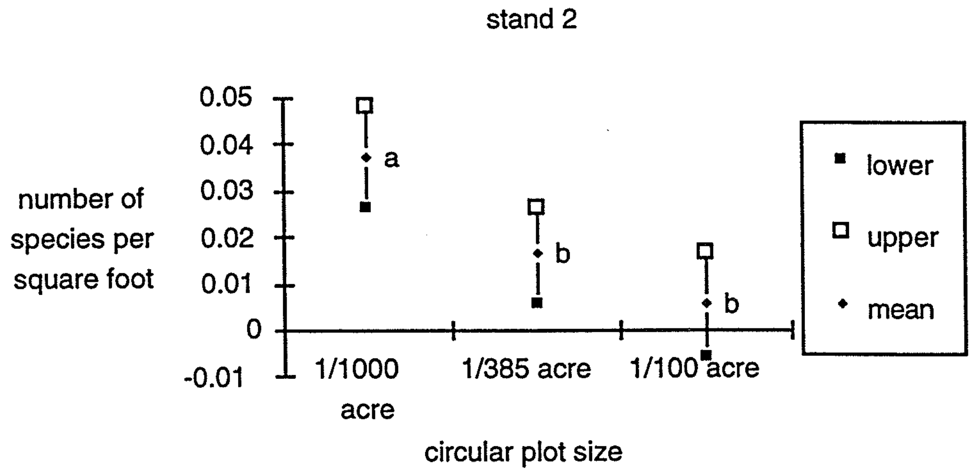


Figure 23. 95% confidence intervals for the number of species per square foot in all circular plots in the ground layer in stand 2. Means with the same letters are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

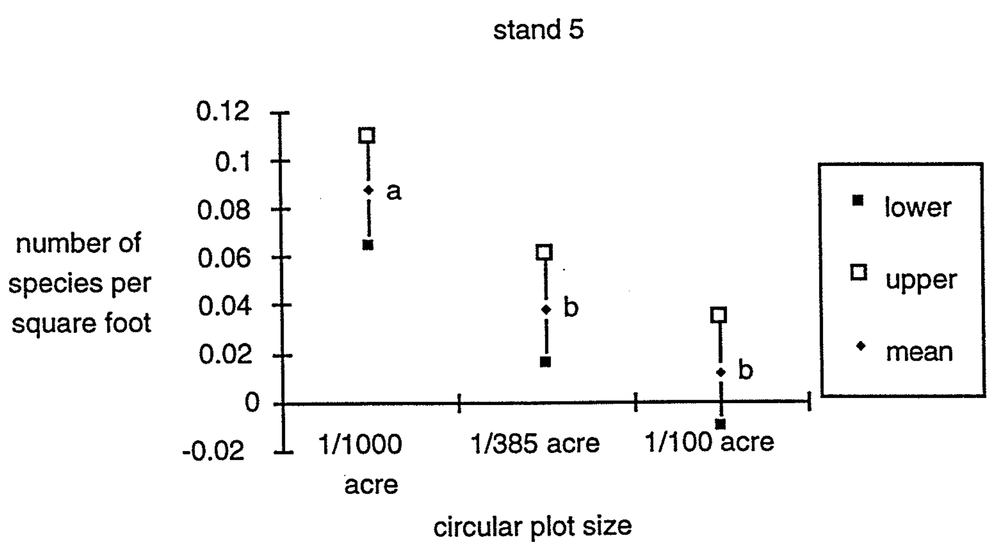


Figure 24. 95% confidence intervals for the number of species per square foot in all circular plots in the ground layer in stand 5. Means with the same letters are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

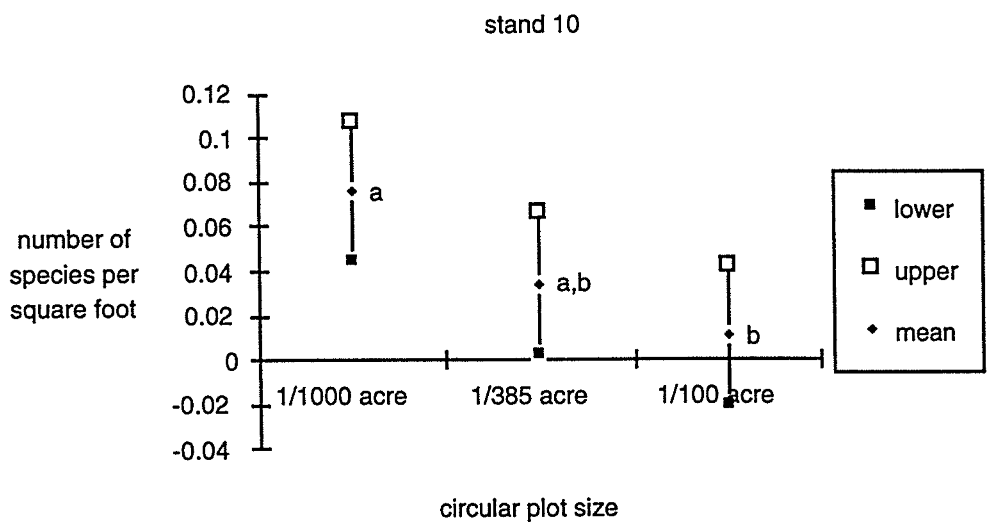


Figure 25. 95% confidence intervals for the number of species per square foot in all circular plots in the ground layer in stand 10. Means with the same letters are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

Shrub Layer Species Composition

Species composition in the shrub layer (all plants found within the 2 to 10 foot vertical height layer) was sampled by the point-centered quarter method and the three circular plots. Seventeen plants, identified to at least genus, were found in the shrub layer (Appendix D). Within stand 2, the point-centered quarter method found all shrub species identified in the circular plots as well as three additional species; all methods found the same species in stand 5; and in stand 10, point-centered quarter plots located 8 of the 13 species found in the circular plots.

Spicebush had the highest frequency rate in both the circular plots and point-centered quarter plots in stands 5 and 10; in stand 2, white pine was the most frequently found species.

A fixed effects analysis of variance conducted on the number of new species per plot indicated no significant differences in the mean number of new species per plot between the circular and point-centered quarter methods (stand 2, F=0.16, p=0.924; stand 5, F=0.00, p=1.00; and stand 10, F=0.05, p=0.985; table 18).

Table 18. Mean (± Standard Error) Number Of New Species Per Plot In The Shrub Layer. Means are not significantly different (p > 0.05).

	Stand 2	Stand 5	Stand 10
1/000 acre	0.25 ± 0.10	0.12 ± 0.08	0.69 ± 0.43
1/385 acre	0.25 ± 0.11	0.12 ± 0.08	0.94 ± 0.57
1/100 acre	0.25 ± 0.11	0.12 ± 0.08	0.81 ± 0.43
PCQ	0.35 ± 0.15	0.12 ± 0.08	0.88 ± 0.44
pooled SE	± 0.12	± 0.08	± 0.47

A fixed effects analysis of variance conducted on the number of new species per unit area (the number of new species found in each plot divided by the appropriate plot area) did not include the point-centered quarter estimates since it was a plotless method. The analysis of variance found significant differences between circular plots sizes in stand 2 (F=3.31, p=0.041). Multiple pair comparisons revealed that the 1/1000 acre plot had a significantly higher number of species per square foot than the 1/100 acre plot (figure 26).

No significant differences were found in the number of species per square foot in stand 5 (F=1.17, p=0.318; figure 27) or stand 10 (F=1.15, p=0.325; figure 28).

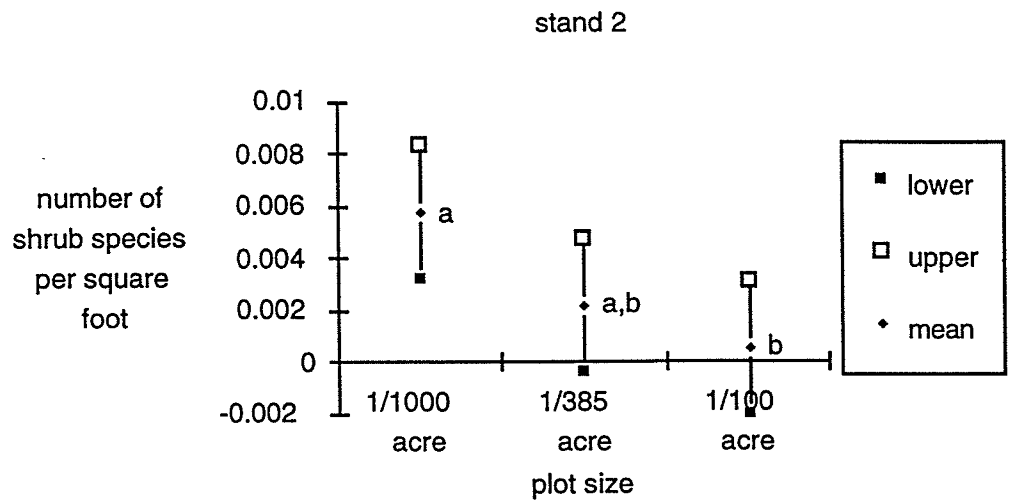


Figure 26. 95% confidence intervals for the mean number of species found per square foot in all circular plots in the shrub layer in stand 2. Means with the same letters are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

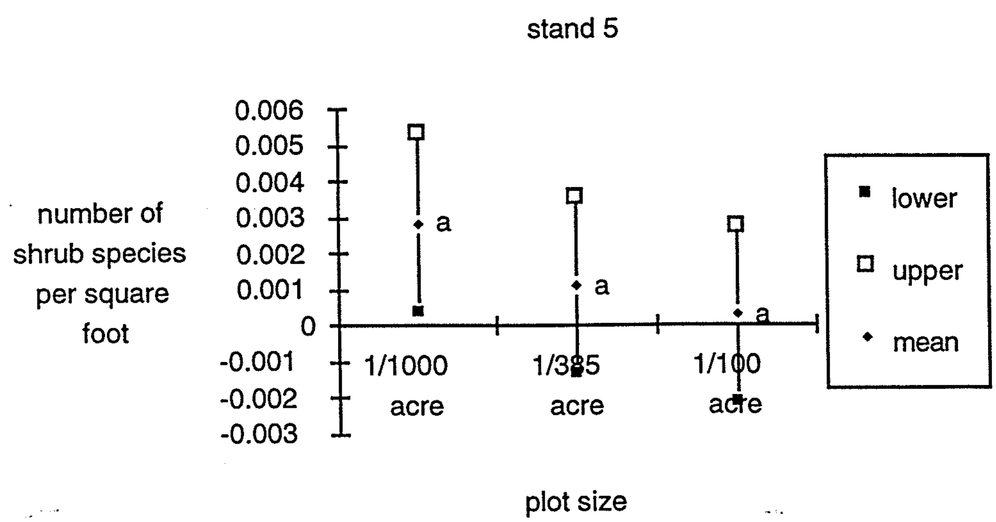


Figure 27. 95% confidence intervals for the mean number of species found per square foot in all circular plots in the shrub layer in stand 5. Means with the same letters are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

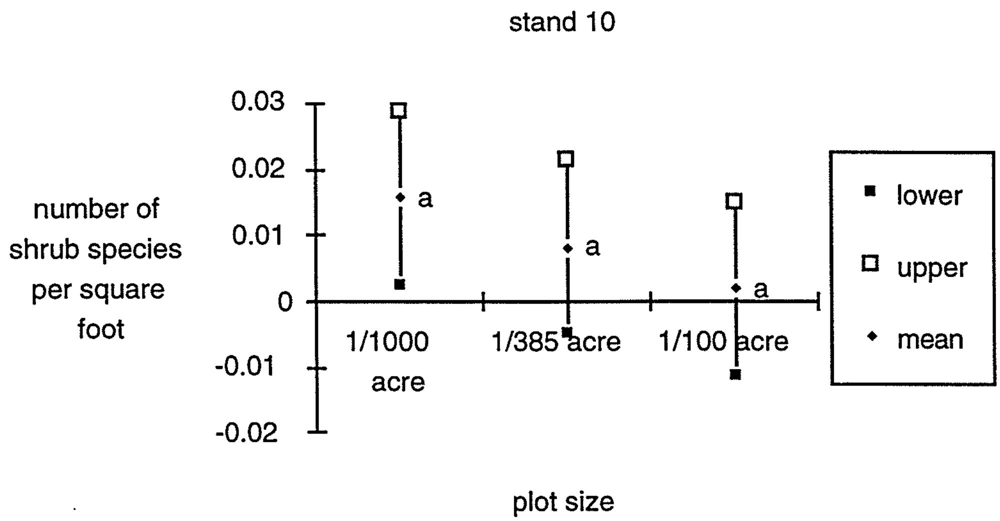


Figure 28. 95% confidence intervals for the mean number of species found per square foot in all circular plots in the shrub layer in stand 10. Means with the same letters are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

Time

An analysis of variance conducted on time per plot indicated significant differences in stand 2 (F=146.60, p=0.000) and stand 10 (F=24.60, p=0.000). In both stands it took significantly longer to complete the 1/100 acre plot than the other sized plots (figures 29 and 30). In stand 2, the 1/385 acre plot was also significantly higher than the 1/1000 acre plot.

When time per plot was divided by the appropriate plot area and an analysis of variance conducted, significant differences were found in both stands, but with reverse results (stand 2, F=65.62, p=0.000: and stand 10, F=23.03, p=0.000). In both stands the 1/1000 acre plot took a significantly longer time per square foot than the other sized plots (figures 31 and 32). In stand 2, the 1/385 acre plot was also significantly higher than the 1/100 acre plot.

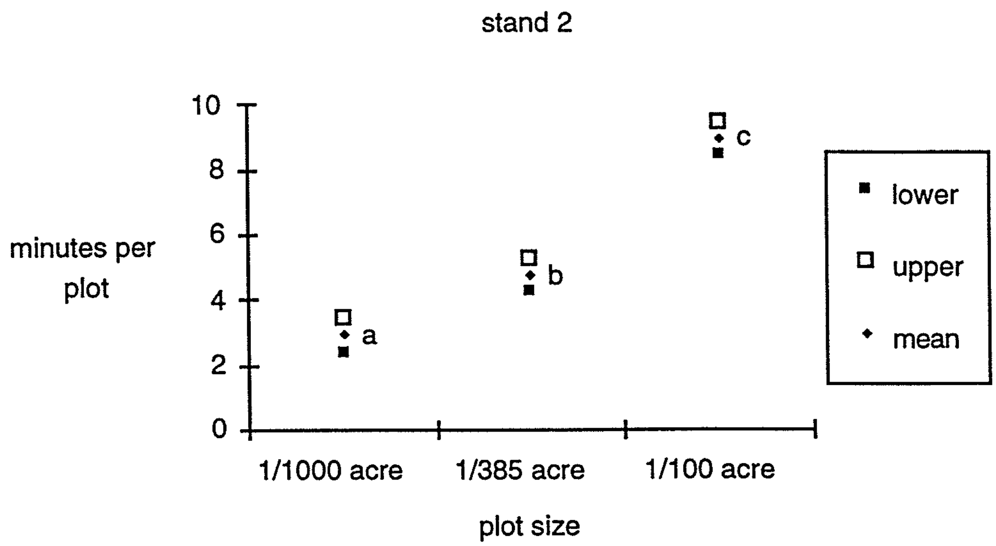


Figure 29. 95% confidence intervals for the mean time spent taking measurements per plot size in stand 2. Means with the same letters are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

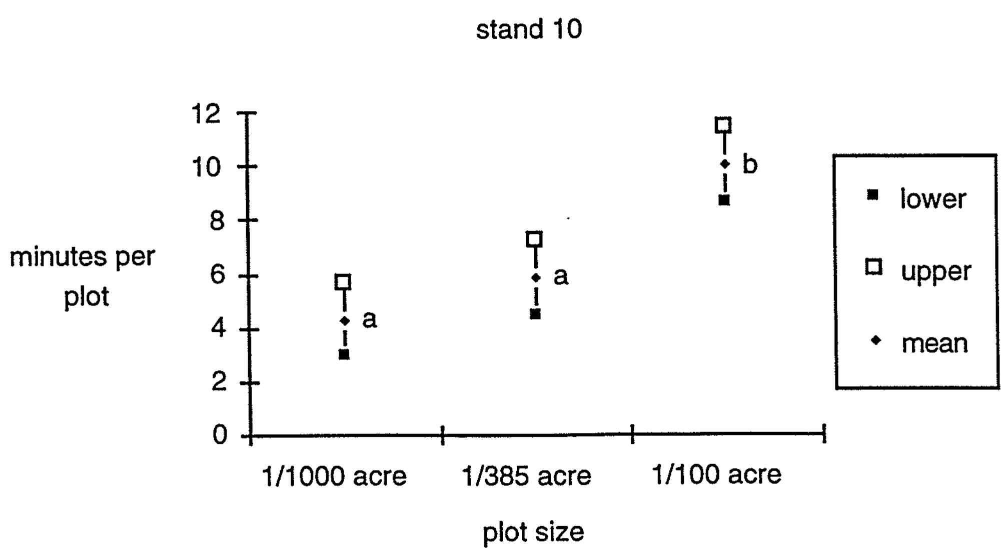


Figure 30. 95% confidence intervals for the mean time spent taking measurements per plot size in stand 10. Means with the same letters are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

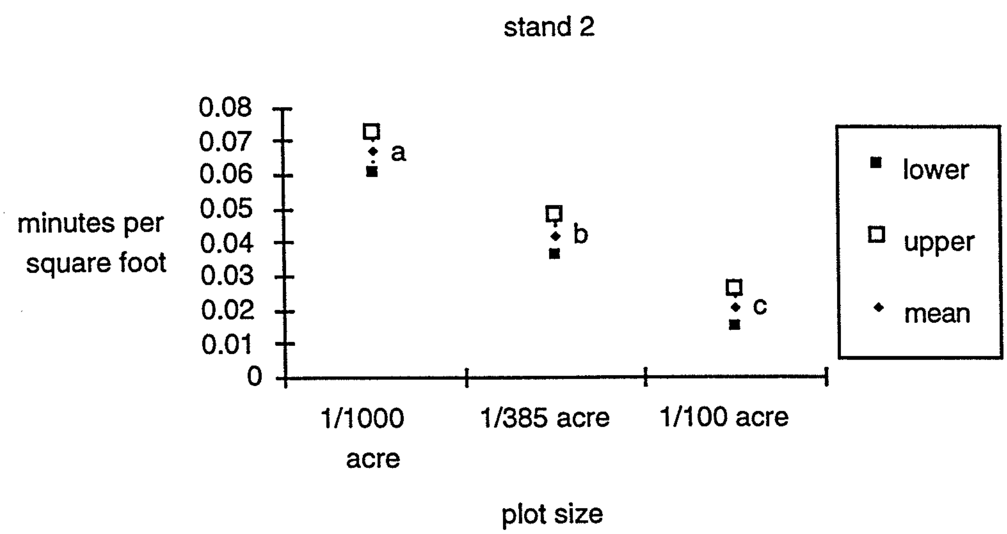


Figure 31. 95% confidence intervals for the mean time spent taking measurements per square foot in stand 2. Means with the same letters are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

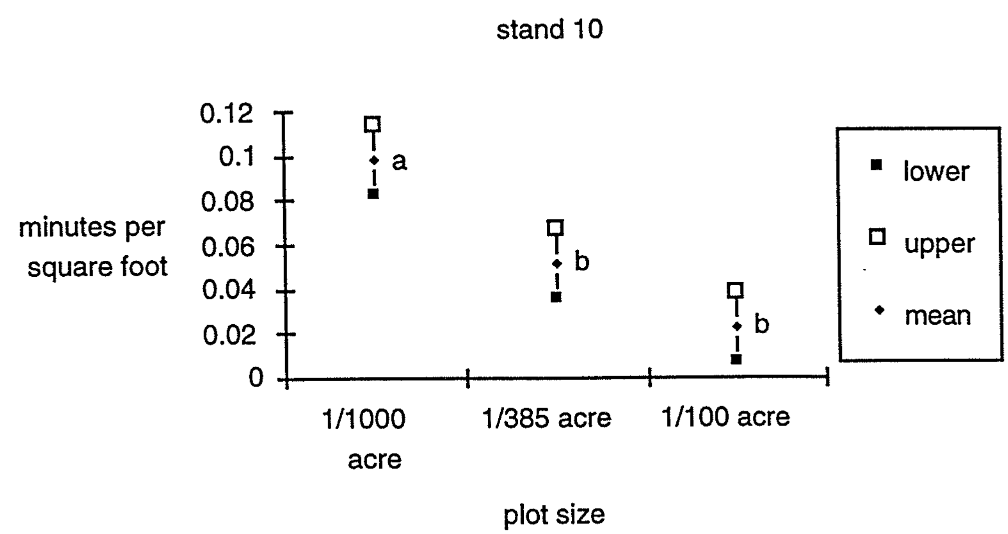


Figure 32. 95% confidence intervals for the mean time spent taking measurements per square foot in stand 10. Means with the same letters are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

An analysis of variance conducted on the number of species found per minute (to determine plot size efficiency) had mixed results. No significant differences were found in stand 10 (F=0.65, p=0.526) although the 1/1000 acre plot had the highest mean estimate and the 1/100 acre plot had the lowest (figure 33).

In stand 2 significant differences were found in the number of species found per minute (F=4.01, p=0.021). The 1/1000 acre plot found a significantly higher number of species per minute than the 1/100 acre plot (figure 34).

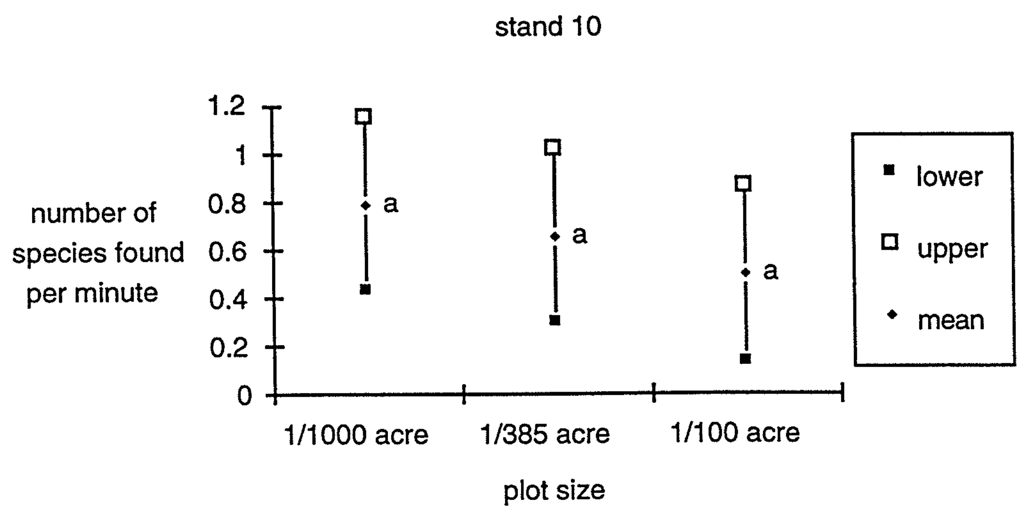


Figure 33. 95% confidence intervals for the number of species found per minute in stand 10. Means with the same letters are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

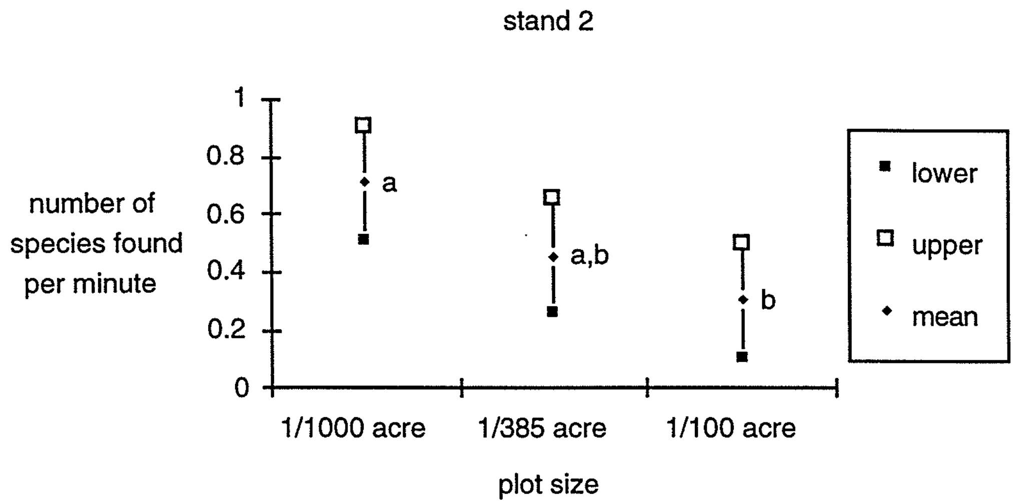


Figure 34. 95% confidence intervals for the number of species found per minute in stand 2. Means with the same letters are not significantly different (Tukey's multiple comparison test, family error rate alpha = 0.05).

Sample Size

Statistically, the 'best' sampling method is the method whose sample estimates have the smallest variance and are closest to the population mean. This, of course, requires that the true population be known. For some of the variables a complete census was done; see Methods chapter, census procedures section. However, percent cover for all vertical height layers and the number and composition of the ground and shrub layers were habitat structural features that could not be censused easily. Therefore, sample estimates cannot be compared directly to the actual population. Instead, other criteria, such as sample size, must be considered in determining the 'best' sampling method.

Table 19 lists the approximate number of samples to determine percent cover by evaluation method and vertical height layer; equation 3.1 was used to calculate sample size.

Table 19. Approximate Number Of Samples Needed By Evaluation Method To Be 95% Confident Of Being Within ± 10 Percentage Points Of The Mean Percent Cover

overstory

	tube	grid	BA-chart*	rel. density
stand 2	6	6	115	18
stand 5	7	5	33	23
stand 10	11	11	58	34

midstory

	tube	grid	BA-chart	PCQ
stand 2	14	14	32	8
stand 5	30	31	15	3
stand 10	22	24	40	9

shrub

	tube	grid	PCQ	1/1000 acre	1/385 acre	1/100 acre
stand 2	12	8	1 or 22	7	8	10
stand 5	9	15	1 or 9	9	12	11
stand 10	23	19	1 or 21	11	13	18

ground

	tube	grid	PCQ	1/1000 acre	1/385 acre	1/100 acre
stand 2	12	22	19	17	20	17
stand 5	13	21	24	14	13	16
stand 10	27	30	66	17	19	27

*BA-chart refers to estimates from Leak and Tubbs' (1983) crown cover tables.

Table 20 shows the number of 100-foot line segments needed with the line intersect method to meet various degrees of precision at the 95% confidence level for each of the stands using plot to plot line estimates (line orientation A). The coefficient of variation for stand 2 is 97%, 130% for stand 5, and 110% for stand 10; equation 3.2 was used to calculate sample size. The coefficient of variation method was also used in calculating the sample size needed to determine the number of saplings per acre (table 21).

Table 20. Sample* Sizes Required For The Line Intersect Method Using The Coefficient Of Variation

	Degree of precision							
	± 10%	± 20%	± 25%	± 30%	± 35%	± 40%	± 45%	± 50%
stand 2	364	91	60	42	32	25	20	16
stand 5	650	163	105	74	54	43	35	28
stand 10	465	116	76	53	40	31	25	21

*One sample equals a 100-foot line segment using the line intersect method.

Table 21. Approximate Number Of Samples Needed By Evaluation Method To Be 95% Confident Of Being Within ± 10% Of The Mean Number Of Saplings

	1/1000 acre	1/385 acre	1/100 acre	Prism
stand 2	5,945	1,935	837	1,042
stand 5	6,144	3,231	2,140	2,689
stand 10	906	527	565	1,032

Cluster Analysis Results

Information obtained from the Delphi process and DeGraaf et al. (1992) served as the basis for the cluster analysis. In the first round of questionnaires, habitat structural information was obtained on 146 species from 12 panel members: 63 bird species from three panelists, 40 mammal species from six panelists, and on 43 species of amphibians and reptiles from three panelists. In the second round of questionnaires, information was obtained on 152 species from 21 panel members: 64 bird species from five panelists, 41 mammal species from 12 panelists, and on 47 amphibian and reptile species from four panelists.

Cluster analysis was chosen to assist in assembling wildlife species functional groups. Initial analysis of the R^2 values (the square of the correlation coefficients) of the 226 species using the average linkage method suggested that three cluster sizes adequately represented the functional groups. Ward's method was subsequently used to form clusters of 11, 20, and 35. Ward's method was selected because it usually performs better than the centroid or average linkage methods and can accommodate outliers (SAS Institute Inc., 1989).

After observing the species breakdown in each cluster size (the 11, 20, and 35 clusters options), the 35 cluster grouping was chosen as the 'best' solution. The 11 and 20 cluster groupings lumped too many species together with dissimilar habitat requirements.

The original species matrix had a group requiring both temporary and permanent water. In reality, the species within the group could use either temporary or permanent water and thus required a new group to reflect this. Another group in the original species matrix required both a shrub layer of between 20% to 50% and also greater than 50%. In reality, they could use any percent shrub cover greater than 20% and so formed another group. The end result was that 37 functional groups were defined (table 22).

Table 22. Master List Of Functional Groups And Associated Species

Group Number & Features	Species	
#1 **T***	eastern American toad Fowler's toad spring peeper gray treefrog	green frog northern leopard frog bog turtle
#2 **T, DD, & L**	marbled salamander Jefferson salamander spotted salamander	red-spotted newt four-toed salamander wood frog
#3 **P**	eastern American toad Fowler's toad spring peeper gray treefrog green frog northern leopard frog	pickerel frog bullfrog common grackle beaver raccoon river otter
#4 **P, S, Slg, & L**	wood turtle northern short-tailed shrew star-nosed mole southern red-backed vole	woodland vole southern bog lemming mink
#5 **P, DD, R, & L**	marbled salamander spotted salamander red-spotted newt northern dusky salamander mountain dusky salamander	four-toed salamander wood frog Jefferson salamander northern two-lined salamander northern water snake
#6 **P & R**	northern coal skink Queen snake seal salamander	northern spring salamander eastern ribbon snake rock vole
#7 **P, G<30, & L**	northern waterthrush	Louisiana waterthrush
#8 **S**	hairy-tailed mole eastern mole	coyote

(Continued next page; *codes found on page 96)

(Continued) Table 22. Master List Of Functional Groups And Associated Species

Group Number & Features	Species	
#9 S, DD, & M*	black bear striped skunk	eastern chipmunk
#10 DD & R	five-lined skink northern brown snake northern black racer woodland jumping mouse	eastern milk snake northern copperhead long-tailed shrew
#11 DD & L	Maryland shrew redback salamander black rat snake pygmy shrew	least shrew masked shrew smoky shrew
#12 DD, ShD, Up4, & L	hermit thrush worm-eating warbler Canada warbler Wehrle's salamander	ermine bobcat ravine salamander slimy salamander
#13 DD & Snag	broad-headed skink winter wren house wren	Virginia opossum long-tailed weasel gray fox
#14 R	northern ringneck snake timber rattlesnake	northern redbelly snake
#15 G>75	eastern smooth green snake barn swallow	eastern garter snake
#16 G>75, ShD, & Slg	eastern box turtle Carolina wren blue-winged warbler golden-winged warbler hooded warbler	mourning warbler chipping sparrow Lincoln's sparrow white-tailed deer
#17 G>75, ShD, ShE Up1, & Low	eastern kingbird northern shrike yellow warbler	indigo bunting song sparrow American goldfinch

(Continued next page; *codes found on page 96)

(Continued) Table 22. Master List Of Functional Groups And Associated Species

Group Number	Species	
#18 **G>75, ShC, & ShE***	Wilson's warbler white-throated sparrow dark-eyed junco Nashville warbler	rusty blackbird snowshoe hare common redpoll Tennessee warbler
#19 **G>75 & Snag**	tree swallow European starling	purple martin
#20 **G>75, Up2, & M**	ruffed grouse wild turkey	deer mouse white-footed mouse
#221 **ShD, ShE, & Slg**	yellow-billed cuckoo alder flycatcher willow flycatcher gray catbird	black-throated blue warbler yellow-breasted chat New England cottontail
#22 **ShD, ShC, ShE, Up1, & M**	northern cardinal rufous-sided towhee	brown thrasher cedar waxwing
#23 **ShD, ShE, Up3**	black-billed cuckoo whip-poor-will ruby-throated hummingbird chestnut-sided warbler	American tree sparrow fox sparrow eastern woodrat
#24 **ShD & MD**	acadian flycatcher veery wood thrush American robin Kentucky warbler	white-eyed vireo Philadelphia vireo American redstart rose-breasted grosbeak
#25 **ShC & MC**	gray-cheeked thrush Swainson's thrush yellow-rumped warbler	blackpoll warbler white-winged crossbill
#26 **MD & M**	raven northern mockingbird	blue jay American crow
#27 **MC & Up4**	solitary vireo northern parula magnolia warbler	pine grosbeak pine siskin

(Continued next page; *codes found on page 96)

(Continued) Table 22. Master List Of Functional Groups And Associated Species

Group Number & Features	Species	
#28 Snag*	eastern fox squirrel barred owl yellow-bellied sapsucker red-breasted nuthatch prothonotary warbler great crested flycatcher	little brown myotis northern myotis Indiana myotis silver-haired myotis big brown bat
#29 Snag & Up2	turkey vulture eastern screech owl northern saw-whet owl downy woodpecker	northern flicker pileated woodpecker eastern bluebird
#30 Snag & M	Carolina chickadee red-bellied woodpecker hairy woodpecker black-capped chickadee tufted titmouse white-breasted nuthatch red-headed woodpecker	brown creeper gray squirrel red squirrel southern flying squirrel northern flying squirrel porcupine
#31 Up1 & Hi	Cooper's hawk red-tailed hawk golden eagle	American kestrel northern oriole
#32 Up2	red-shouldered hawk golden eagle American woodcock	mourning dove warbling vireo orchard oriole
#33 Up3	eastern pipistrelle Cooper's hawk northern goshawk	blue-gray gnatcatcher yellow-throated vireo pine warbler

(Continued next page; *codes found on page 96)

(Continued) Table 22. Master List Of Functional Groups And Associated Species

Group Number & Features	Species	
#34 Up4*	summer tanager	Cape May warbler
	sharp-shinned hawk	black-throated green warbler
	northern goshawk	Blackburnian warbler
	red-shouldered hawk	pine warbler
	broad-winged hawk	bay-breasted warbler
	red-tailed hawk	black & white warbler
	great horned owl	cerulean warbler
	least flycatcher	scarlet tanager
	golden-crowned kinglet	red bat
	ruby-crowned kinglet	hoary bat
	red-eyed vireo	ovenbird
#35 Hi & Low	olive-sided flycatcher	brown-headed cowbird
#36 Low	eastern phoebe	eastern wood-pewee
#37 None	purple finch	evening grosbeak
	house finch	small-footed myotis

FEATURES CODES:

T	Temporary ponds.
P	Permanent water.
S	Subterranean habitat.
DD	Dead & down woody debris and slash piles.
G<30	Percent ground cover less than 30%.
G>75	Percent ground cover greater than 75%.
ShD	Deciduous shrubs.
ShC	Coniferous shrubs.
ShE	Ericaceous shrubs.
Slg	Percent shrub cover greater than 50%.
MD	Deciduous midstory.
MC	Coniferous midstory.
Snag	Snags and/or cavity trees.
Up1	Overstory percent cover less than 15%.
Up2	Overstory percent cover from 16% to 30%.
Up3	Overstory percent cover from 31% to 70%.
Up4	Overstory percent cover greater than 70%.
R	Rocks.
L	Forest and leaf litter.
M	Mast.
Hi	Hi perches.
Low	Low perches.
None	No required habitat structural features.

Discussion

Percent Cover

Overstory Cover

In this study, percent overstory cover was measured using two instruments, the ocular tube and the grid, and two indicators of percent cover, one determined from cover tables developed by Leak and Tubbs (1983) and the other, relative density, determined from the SILVAH program of Marquis et al. (1992).

Results showed that using Leak and Tubbs' (1983) cover tables gave the highest estimates of overstory percent cover, significantly higher than all other methods in stands 2 and 5, and significantly higher than relative density estimates in stand 10 (see figures 7 to 9). Were the estimates too high? Estimates were typically over 100% probably due to overlapping crowns. Thus, this method provided an estimate of absolute cover (which can be greater than 100%) and not relative cover (which cannot exceed 100%). It was compared to the tube and grid methods that cannot exceed 100% and relative density that rarely exceeds 100% except in overstocked stands. If these tables could be revised to reflect crown cover in unharvested stands it would permit estimates of percent overstory cover at no increase in field costs since basal area and diameter information are collected in most forest inventories.

High variances produced by sampling methods will be reflected in the number of samples that are needed. Variances from the cover tables were the highest of any method reflecting that measurements can be greater than 100%. In addition, this method required the highest number of samples to obtain the desired level of confidence (table 19). Relative density, the proportion of the stand covered by trees compared to the amount that could be covered under ideal conditions, provided estimates comparable to the tube and grid. However, its variance was almost twice as high as those methods. This higher variance was reflected in the larger computed sample size (table 19).

Marquis et al. (1992) reported that 10 to 25 plots per stand will accurately estimate relative density. The number of plots listed in table 19 seems rather large for the acreages involved which would increase inventory costs. The SILVAH program (Marquis et al. 1992) estimated relative density from those trees intersected in a 10 basal area factor plot based on their species and DBH; relative density can also be determined from fixed area plots. Relative density represents a desirable alternative because no additional cover measurements are required during a stand inventory. While relative density appears to offer several advantages and has the desired accuracy, although with high variability, the relationship between relative density and percent overstory cover should be applied in lower density stands before general acceptance.

The tube and grid methods produced similar mean estimates of overstory percent cover and variances. This was not surprising since both deal with the presence or absence of vegetation in a particular area. The tube or grid offers advantages for those who do not use SILVAH. Because of similar variances, sample sizes were almost identical (table 20), requiring the fewest number of plots of all methods tested. The tube's estimate depended on 13 presence or absence readings; a number selected to fit with the circular plot design. The grid's estimate depended on five readings; a number chosen to cover the same area as the tube. Fewer readings per plot by either method may provide a sufficient estimate of percent overstory cover. If the same information can be obtained from fewer readings, time per plot, and subsequently cost, will decrease. Calculation of percent cover with the tube would also be easier if the number of readings were reduced to ten.

The tube provided quick and easy readings; its disadvantage was that a series of readings was required. The grid required fewer readings per plot, but it took more time to count the squares. Both methods caused some physical discomfort (a stiff neck from looking up) and dense lower layer vegetation occasionally obscured the overstory possibly causing inaccurate readings.

Midstory Cover

Estimates of midstory percent cover were obtained from the tube, grid, crown cover tables (Leak and Tubbs 1983) and the point-centered quarter methods. In contrast to overstory cover estimates, midstory cover estimates from crown cover tables (Leak and Tubbs 1983) gave the lowest estimate of cover (significantly lower than the tube and grid in stand 2), but usually with the highest variance. Estimates of sample sizes for 95% confidence reflected the higher variances in stands 2 and 10 (table 19).

Midstory trees are usually suppressed or intermediate trees with narrower crowns than dominant or codominant trees. Leak and Tubbs (1983) noted that their charts may overestimate percent cover of suppressed and intermediate trees; if true, the mean estimates in this study should be even lower. This method failed to account for overstory trees which have part of their live crown in the midstory.

The point-centered quarter method produced mean estimates similar to the other methods except in stand 2 where it was significantly lower than the tube's estimate. The point-centered quarter method had lower variances and thus a lower sample size (table 19). The lower variances indicated that saplings were evenly dispersed.

In even-aged stands, saplings generally constitute the majority of trees in the midstory; in stand 2 saplings accounted for 88% of midstory trees, 72% in stand 5, and 85% in stand 10. The point-centered quarter method, as used in this study, underestimated the number of saplings in all stands. In stand 2, the point-centered quarter method found 63% of the population total, 58% in stand 5, and 81% in stand 10 (table 16). Thus midstory percent cover was underestimated.

If the actual population figures for the number of saplings are used instead of the sample estimates, percent midstory cover by the point-centered quarter method increases and the estimates come closer to those of the tube and grid (stand 2: $\bar{x}$ = 44%, s = 15%; stand 5: $\bar{x}$ = 30%, s = 11%; and stand 10: $\bar{x}$ = 38%, s = 14% (where $\bar{x}$ = sample mean and s = sample standard deviation). Therefore, if the point-centered quarter method could accurately determine the number of saplings per acre (which happens in a truly random population), it would produce estimates as accurate as either the tube or grid methods.

Several disadvantages were noted using the point-centered quarter method. It did not account for larger diameter trees in the midstory or for overstory trees with live crown in the midstory layer. Also, a practical disadvantage of the point-centered quarter method was that it worked better with two people taking measurements. Although one person was sufficient, measurement was awkward since one end of the tape was secured at the plot center to determine distance to the closest sapling in each quarter (which can be a good distance away), then unsecured in order to measure that sapling's crown area.

The tube and grid consistently gave the highest and next highest estimate of midstory cover and, as was the case with overstory percent cover, their estimates were nearer to each other than to the other methods. Due to almost equal variances, sample size was almost identical in each stand (table 19). The sample variances were larger than those obtained for the overstory possibly indicating that the midstory layer was more variable than the overstory. More samples are required in the midstory layer to obtain the same precision using the tube and grid. Advantages and disadvantages of the tube and grid methods are the same as for the overstory layer.

<u>Shrub Cover</u>

Shrub cover was estimated by the tube, grid, point-centered quarter methods, and also estimated by eye on three different sized circular plots.

The point-centered quarter method consistently gave the lowest mean estimate of percent shrub cover and was significantly lower than the tube estimate in stands 2 and 10. The low estimate may be from underestimating the shrub population. Shrubs were clumped and the point-centered quarter method tends to underestimate clumped populations (Schemnitz 1980). Without actual population figures it was impossible to analyze the amount of underestimation. Variance of the point-centered quarter was always lowest and indicated that most shrubs were evenly dispersed. Because of the low variance estimates, the calculation of sample size showed an oddity of the formula (table 19). In this case, sample size was either one or had an upper number that was higher than other methods that have larger variances than the point-centered quarter method. As with the midstory, measurements taken using the point-centered quarter method were awkward with one person.

Mean estimates of percent shrub cover from the different size circular plots were similar to each other although slight increases occurred as plots increased in size. Estimates from the 1/1000 acre plot were significantly lower than the tube in stands 2 and 10, and the 1/385 acre plot was significantly lower than the tube in stand 2. Only slight differences existed among the circular plot variances and were comparable with variances from the tube and grid methods.

Although Marquis et al. (1992) advocated using a 1/20 acre plot to determine cover of interfering plants, Daubenmire (1959) suggested that smaller plots reduce observer error and that increasing the number of smaller plots was better than increasing the size of the plot. Daubenmire (p. 57) also felt that estimating cover by eye "becomes awkward as plants begin to exceed waist height."

The tube usually gave the highest estimate, but there was no significant difference between the tube and grid estimates. Trying to measure percent shrub cover with the tube or grid was awkward because the vegetation was closer to the instrument in this layer;

often one branch would cover the instrument's focal point. Although James and Shugart (1970) suggested holding the tube at arms length and focusing 4 feet away for ground cover, they did not suggest any format for shrub cover. Using instruments to estimate percent cover proved more awkward in the shrub layer than in any other layer. In reviewing ways to measure cover, Guilkey et al. (1958) concluded that instruments used for determining percent cover were inadequate below head height.

Ground Cover

Ground cover was estimated using the same methods as for shrub cover. Estimates from the point-centered quarter method were consistently lower than the other methods and significantly lower in two stands. As with the shrub layer, ground vegetation is often clumped and the point-centered quarter method probably underestimated the number of ground plants and thus underestimated cover. Since ground layer plants are usually more numerous than plants in the shrub layer, no difficulties arose in measuring them with only one person.

As circular plot size increased so did the estimate of ground cover, but with no significant differences between circular plots. Variances are similar between the three circular plots and similar to variances obtained from the other methods. Thus, sample sizes (table 19) are similar for all methods except for the point-centered quarter in stand 10 due to an extremely high variance.

Percent cover in the ground layer was the most variable of all the height layers because a majority of the cover was composed of herbaceous species that change during the growing season. Estimates in early May probably will not be the same as estimates taken in late July. This is in contrast to the other vertical height layers that are composed of woody species; once the woody plants are fully leafed, percent cover will not drastically change barring an insect or disease outbreak.

Summary of Percent Cover Methods

Numerous methods and instruments are available to measure cover. "Any and all of the gadgets and methods have yielded results that have pleased the inventors and displeased the critics. A critic is any worker who uses a different one" (Guilkey 1958, p. 101). In this study, the tube and grid were the only methods used in each of the vertical height layers. The tube and/or grid seemed to work better at measuring the overstory and midstory layers. Both the tube and grid proved awkward to use when they were closer to vegetation because a single branch, and sometimes a single leaf, covered the entire measurement area of the instrument.

The 1/1000 acre plot seemed sufficient for estimating percent cover in the shrub and ground layers since no significant differences were found and sample sizes for the shrub and ground layers were similar among the circular size plots. Research has shown cover can be estimated to within ± 10% with training (Hatton et al. 1986) eliminating the need for instruments and smaller plots reduce observer error (Daubenmire 1959).

The overstory appeared less variable than the other layers, which is not surprising since stands are usually defined by dominant tree layer characteristics such as a uniform canopy (Avery 1975). To account for the increased variability, more samples are needed in the lower vertical height layers to reach the same precision as for the overstory.

Volume Of Dead And Down Material

Cubic foot volume per acre of dead and down material was estimated by measuring the average diameter and length of the log contained within each of the circular plots and with the line intersect method between plot centers. These sample estimates were compared to actual population figures.

Because of the large variances involved, analysis of variance did not reveal any differences between the means of the different size circular plots. However, none of the circular plots were consistent in estimating the volume of downed logs, that is, they do not consistently under or overestimate the true mean although in most cases the 95% confidence intervals do include the true mean (table 14). In stand 2 the 1/100 acre plot was 105% of the actual mean, 64% in stand 5, but in stand 10 it was twice as large as the mean. Stand 10 had the least volume and it should be reflected in the sample estimate. In stand 5, which had the highest volume of dead and down material, estimates were barely 50% of the actual mean.

Compared to the circular plots, estimates from the line intersect method were more accurate and had lower or equal variances. Three line orientations were originally tested because Van Wagner (1964) suggested that running three lines at 60 degree angles to each other would account for non-random orientations of downed logs (where the majority of logs lay in one direction). The line intersect method was originally designed for and tested in harvested stands where trees are usually felled or bunched in a certain direction. Uncut debris should have a more random pattern, but on steeper slopes may exhibit a direction bias--downhill.

A fixed effects analysis of variance revealed no difference between the means of the three line orientations (estimates from the average are not included) which suggests the logs are randomly distributed. However, some confidence intervals of the three line orientations barely include the actual mean indicating a possible log orientation bias.

Howard and Ward (1972) noted that precise measurements (to be within ± 20% of the mean 95% of the time) would require an inordinate number of sample lines. This study agrees with their conclusions (table 20). The number of sample lines required to be within ± 25% would not be cost effective nor is the precision necessary for a general wildlife habitat survey. It is interesting to note that this study required far fewer line segments to be within ± 30% of the mean than table 20 indicates.

Since the line intersect method more accurately reflects the true population mean volume of dead and down logs, has smaller variances, thus requiring fewer samples, it should be used to determine the volume of dead and down material instead of the circular size plots tested in this study. Since it is unlikely that all logs would be oriented in the same direction in unmanaged stands, sample lines should go in at least 2 directions to prevent severe bias (DeVries 1979 p.38). On flat ground, one of the two directions should be oriented perpendicular to the prevailing wind. On steeper ground, one of the lines should go perpendicular to the slope (with the contour).

Prism Plot Parameters

Total, overstory, and snag basal areas per acre were accurately estimated in this study using the prism plot. Basal area per acre of cavity trees (live or dead trees ≥ 4 inches DBH that contain a cavity) was underestimated. Although the actual cavity tree basal area per acre was low for the stands in this study, it was similar to snag basal area per acre.

Considering that both snag basal area and cavity basal area were roughly the same proportion of the total basal area and sample variances were similar it would be expected that both parameters would be accurately estimated. One explanation of why cavity basal area was not accurately estimated could be that the populations were censused just at the start of leaf-out, while sampling took place with the trees fully leafed. The leaves could have hidden some of the upper cavities on branches. Snags are more prominent than cavities.

More plots will be needed to accurately reflect cavity tree basal area per acre. However, the number of plots needed to be statistically sound would probably not be cost effective. Basal area of snags and cavity trees is not a frequently used parameter by foresters. The number of snags per acre or cavity trees per acre is the usual measure; the number of trees per acre is based on the proper conversion equation (Myers and Shelton 1980). The number of snags per acre was accurately estimated in all stands. The number of cavity trees per acre was accurately estimated in stands 2 and 10 but underestimated by 50% in stand 5. This indicates the need for a better sampling method to determine the number of trees with cavities. Perhaps calculating the number of cavity trees from basal area plots plus treating cavity trees as a within-stand-feature (noting the presence of all cavity trees during the entire forest inventory) would work.

The number of low perches was estimated accurately in stands 5 and 10, but no low perches were sampled in stand 2 even though several existed in the stand. The prism plot only measured the number of short snags, those snags within the shrub layer, that could be used as low perches. This method was not used to inventory other low perches such as exposed shrubs or fences. Using the prism plot will underestimate the number of low perches.

Some structural features, such as high and low perches, have extremely low numbers in the population. Only one high perch was censused in stand 2 and the prism plot did not record this feature. Another method needs to be tested to acquire accurate information on high perches or it should be treated as a within-stand-feature and simply noted on a tally sheet as they are encountered during a forest inventory.

SILVAH guidelines (Marquis et al. 1992) suggested taking 10 to 25 plots in a stand to estimate total basal area (and other critical overstory indicators) to within 10% standard error with a 95% confidence. Although SILVAH did not list any guidelines for determining the number of snags or cavity trees (both live and dead trees), it is assumed that the number of plots needed for the overstory parameters would also be sufficient to estimate snags and cavities. Results from this study agree with the number of plots suggested for overstory parameters. More samples should be taken to estimate either cavity tree basal area per acre or the number of cavity trees per acre.

Number Of Saplings

At the start of this project, the number of saplings was investigated as a possible vegetation parameter to quantify the midstory since most saplings are in the midstory layer. It was not decided until all the questionnaires from the Delphi survey were examined that percent midstory cover and not the number of saplings was the preferred parameter. Information is listed here to document the results of the study.

Estimates of the number of saplings came from the three circular plots, prism plots, and the point-centered quarter plots. No single method produced extremely accurate results with a correspondingly small variance. Estimates from the 1/1000 acre had the widest range and highest variation.

Variances of all methods (a variance could not be computed for the point-centered quarter method) were quite large probably because saplings are not evenly distributed in the stands. The large variances are reflected in the large sample sizes calculated in table 21.

Although Schreuder et al. (1993) advocated the use of fixed area plots to determine density, this study found that estimating the number of saplings by the point-centered quarter and the prism methods were just as accurate as the three circular plots.

Species Composition

Shrub Layer

Species in the shrub layer (any plant 2 to 10 feet high) were sampled using the three circular plots and the point-centered quarter method. Each method produced similar results although the smallest circular plot usually included more species per plot area. Although a similar number of plant species were measured using the point-centered quarter method, it did have a practical disadvantage. When measuring distance to the nearest shrub, the point-centered quarter method worked best with two people.

Ground Layer

The ground layer usually contains more species than the shrub layer due to the wide variety of herbaceous plants. Species in the ground layer (any plant from ground level to 2 feet in height) were sampled by the same methods as for the shrub layer -- the three circular plots and the point-centered quarter method. The point-centered quarter method can include, at most, four new species at each sampling point as only one plant in each quarter is sampled. By using circular plots, by virtue of the area they cover, the examiner should encounter more species. More species per plot size were encountered using the smallest circular plot than the other circular plots.

This study did not address in which month ground species composition should be taken. The ground layer is more variable in species composition (and cover) than the shrub layer due to the larger number of herbaceous species. Since species composition changes from snow melt to snowfall, only intensive repeated surveys could determine the actual range of ground species. This seasonal issue of ground vegetation was beyond the scope of this project.

Summary of Species Composition

In areas of low species composition, all methods produced similar results although a greater number of species in the ground layer were found in the three circular plots tested when compared to the point-centered quarter method. The 1/1000 acre plot has the advantage in this study of including more species on a unit basis and is preferred over the two larger size plots.

Circular Plot Size And Time

In order to determine which circular plot was more efficient (i.e., acquired the most information in the least amount of time), the time to complete all measurements in each circular plot was recorded in stands 2 and 10 ; stand 5 was used to establish sampling procedures and is not represented in this discussion.

Intuitively it seems that the larger the plot, the longer the amount of time needed to complete the measurements, but also more information is acquired. But what information is acquired for the time spent? The 1/1000 acre plot was actually the most efficient method for a greater number of species was found in less time. There is little added benefit from taking a larger size plot to determine species composition in the ground and shrub layers.

Cluster Analysis and Information Gathering

The wildlife habitat models and assessment process are only as good as the assumptions that led to their creation. This study assumed that if a wildlife species' required habitat structural features existed in a stand, then that species can reasonably be expected to be there. It is true that "a species can exist only in habitats where these specific requirements are fulfilled," but the simple presence of a feature does not guarantee the presence of the species that uses it (Balda 1975, p. 60). The species presence may depend on combinations of habitats rather than some mean condition (Hooper & Crawford, 1969; MacArthur et al. 1962). However, for the intended purpose of the assessment model, that is to get forest managers sensitized on how their management activities affect structural features, the assumption that habitat features and species presence are correlated is still reasonable.

Another of the assumptions was that quantified descriptions of structural features required by wildlife species could be obtained. Since the investigator did not have a wildlife background, information had to be obtained through other sources. DeGraaf et al. (1992) and the Delphi process provided some data that supported this assumption. However, the accuracy of habitat structural feature information required by wildlife species varied for each species. Certain species habitat requirements were well documented, while for others, only limited data was available. Information obtained in this study is treated as a working hypothesis that requires testing. Therefore, table 22, the so-called master list of functional groups, and the assessment tools, should also be treated as hypotheses.

Cluster analysis speeded the process of grouping species with similar habitat structural requirements. However, once the clusters were formed it was necessary to determine if the clusters actually made biological sense. Several changes were made after the clusters were formed. For example, the barred owl was put in cluster 30 (group 30 in table 22) by the computer program; this cluster contains species needing mast and snags. The barred owl's requirements are snags and a dense overstory; however, no cluster was formed with these two requirements. So the barred owl was subjectively put into cluster 28 whose species required only snags. Therefore, each group may not reflect all of the structural features necessary for each individual species in the group.

The cluster analysis did not include any information on forest type, tree size-class, or species ranges. This was accomplished manually. Table 22 was refined to reflect species that require a particular forest type and/or size-class as noted in DeGraaf et al. (1992) or by one of the contacted experts. Tables of functional groups by forest type and size class and a process for eliminating species outside of their documented physiographic province will be in the completed manual format. Copies can be obtained from Penn State Extension, 110 Ferguson Building, University Park, PA, 16802. The sample manual format found in Appendix G contains only the functional group table for the northern hardwood forest type and small sawtimber size-class.

As listed in DeGraaf et al. (1992), a number of wildlife species do not appear in the sapling/pole size-class. This is probably due to the loss of a required vegetative structural feature (e.g., no dead and down material). However, this provides an opportunity to actively plan for structural features in size classes that normally lack them, such as leaving snags or cutting trees to provide for dead and down material. This may allow some species to expand their use of size-classes.

The Delphi information gathering process met with limited success. The majority of those polled were concerned about attempting to place values on structural features with no research data which, they believed, would then lead to inaccurate results in the assessment process. However, several experts from each committee were quite willing to hypothesize on amounts of structural features needed even though no 'hard' research had actually occurred. The strengths and weaknesses of the assessment models, and the underlying data, will have to be made perfectly clear to all users.

Future questionnaires should be specifically focused to the research area of the expert, that is, raptor species should only be sent to the raptor experts, not to all ornithologists. This would alleviate the feeling of being 'put upon' by a large number of questions. Narrowing the focus of the questionnaire would entail more work on the investigator's part, but may increase the overall amount of data acquired from the experts. In addition, in any questionnaire, species should be placed in taxonomic order instead of by structural feature order. Finally, a literature review should be conducted before soliciting panel input.

Chapter 5

CONCLUSIONS

The objectives of this study were to: 1) Analyze different sampling methods and efficiencies to provide a methodology to rapidly assess the nature and quality of habitat structural features; 2) Provide wildlife habitat assessment techniques; 3) Obtain information on the habitat structural features required by wildlife species common to Pennsylvania forests through a Delphi process; and 4) Develop wildlife functional groups based on information obtained from DeGraaf et al. (1992) and the Delphi process.

Through evaluations of the line intersect plot, nested circular plot, point-centered quarter plot, and the variable radius plot (using a 10 BAF prism) the following conclusions are made.

- The line intersect method more accurately determined the cubic foot volume of dead and down material than any of the nested circular plots tested in this study.
- Ground and shrub layer percent cover were easily calculated from ocular estimates on a 1/1000 acre plot.
- Overstory and midstory layer percent cover were easily estimated using either the ocular tube or the grid.
- More information about species composition in the ground and shrub layers can be obtained in less time using the 1/1000 acre circular plot.
- No significant differences were found in the methods tested to determine the number of saplings per acre. However, the largest circular plot tested (1/100 acre) produced similar estimates with lower variances.
- Total, overstory, and snag basal area per acre and the number of snags per acre were accurately estimated using a 10 BAF plot.

- The number of low perch trees per acre were accurately estimated using a 10 BAF plot, but this plot only included one type of low perch--short snags (<10 feet tall). Other low perches, such as fences, brush piles, and individual shrubs, were not tallied with this method. These other low perches should be counted as they are encountered in the stand.
- Basal area per acre of live and dead cavity trees was not estimated accurately using a 10 BAF plot, possibly because cavities were harder to see during leaf out. The number per acre of live and dead trees containing cavities provided a more accurately estimated parameter.

The appropriate sample size depends on the variability of the parameter. As a minimum, the examiner should use the same number (n) of plots as suggested in SILVAH guidelines (Marquis et al. 1992); the number of plots for the line intersect method will be one less than the total (n-1) since this method is used between plots. If a high degree of precision is sought, the number of plots should be increased. In describing the number of plots necessary in a survey, G. P. Patil, Professor of Statistics, The Pennsylvania State University, often replies that "what is convincing is not affordable, and what is affordable is not convincing" (personal communication 1994).

A wildlife habitat assessment technique is provided in a manual and computer format; prototype sample formats are found in Appendix G and H respectively. Both formats provide the user the opportunity to determine present wildlife habitat composition from measurements obtained through the habitat structural features inventory. By predicting changes to structural features from recommended forest management activities, the 'future' wildlife habitat composition can be obtained. By evaluating the changes, the user can decide whether the changes are compatible with the landowner's objectives.

Wildlife functional groups were developed from cluster analyses calculated from a species matrix indicating the possible habitat structural features required by each species. Information used in developing the species matrix was obtained from the following sources: DeGraaf et al. (1992), Pennsylvania Game Commission reports (Hassinger et al. 1993a and 1993b), and the Delphi survey of committee members of the Pennsylvania Biological Survey and other experts. A master list of wildlife functional groups is found in table 22.

Limitations

The accuracy of habitat structural feature information required by wildlife species varies for each species. Certain species habitat requirements are well documented, while for others only limited data is available. Information used in developing the species/structural feature matrix is treated as a working hypothesis that requires testing. Through use, the assessment model and the species structural feature requirements will be refined. However, this model represents a test of the methodology; any subsequent modifications are the responsibility of future researchers.

The models are quick and useful assessment tools for predicting shifts in wildlife species due to silvicultural management activities that modify structural features. The models also yield information that give managers and landowners the opportunity to decide whether they are increasing or eliminating certain habitats. The user should be aware that:

1. Information about structural features for some species is limited and assessment outcomes should be treated as hypotheses.
2. In order to make the manual format manageable, species were clustered and these groups may not reflect all of the required structural features for individual

species in the group. For example, the least flycatcher was placed into a group whose 'main' structural feature is dense (>70%) overstory cover. The least flycatcher also requires percent ground cover between 30-75%. However, because no group was formed in the cluster analysis with these two features (dense overstory cover and partial ground cover), the least flycatcher was placed in this overstory users' group.

The proposed inventory method will be tested to determine if users can produce similar results in the same stand; this will be accomplished in a series of workshops under the direction of the extension forester at Penn State. However, the true test is determined by how well habitat predictions actually reflect species habitat selection (Lancia et al. 1978). It would be interesting to have a vertebrate survey to see what species actually use the study site.

This study does not include any information on vegetative structural features needed by invertebrates, a major factor in biological diversity. Murphy and Wilcox (1986) suggested that managing a variety of habitats for vertebrates will successfully provide the majority of habitats needed by invertebrates. However, while local habitat alterations may not affect vertebrate species, alterations could cause invertebrate decline through the loss of needed structural components, such as the loss of nectar producing plants (Beattie 1993). Information about vegetative structural features needed by invertebrates should be compiled and made available to interested parties.

Two problems arise when inventorying herbaceous species. First, most natural resource professionals can only identify a fraction of the total number; this was also identified by Durham et al. (1985) as a stumbling block. A pocket guide of uncommon and rare plants and one on identifying herbaceous species by their leaf structure instead of by their flowers should be created for field use. In addition, workshops on using existing herbaceous plant keys and herbaceous plant identification should be conducted.

Although it is impossible for any one person to recognize the thousands of herbaceous plants occurring in Pennsylvania, education has to start somewhere.

Second, herbaceous plants change in species composition and percent cover throughout the growing season. Any species list acquired through this inventory will only consist of a portion of the actual composition on a site. It is also difficult to estimate percent cover in the ground layer during the winter since most of the vegetation decays rapidly or is covered by snow. Estimating percent cover in the other vertical height layers during leaf-off is not that difficult since estimates can be made from the area covered by the woody portion of the stems.

Recommendations

The following recommendations are suggested for future study.

1) Another Delphi panel should be convened to further refine the composition of functional groups and their associated habitat structural features.
2) Workshop participants should be interviewed after a time to determine if the inventory process and associated wildlife habitat assessment changed either their management activities or increased their awareness of biological diversity.
3) Most forest landowners want a visually pleasing landscape. The correlation between the number and kind of structural features and the landowner's objectives for having a forest that 'looks good' should be investigated.

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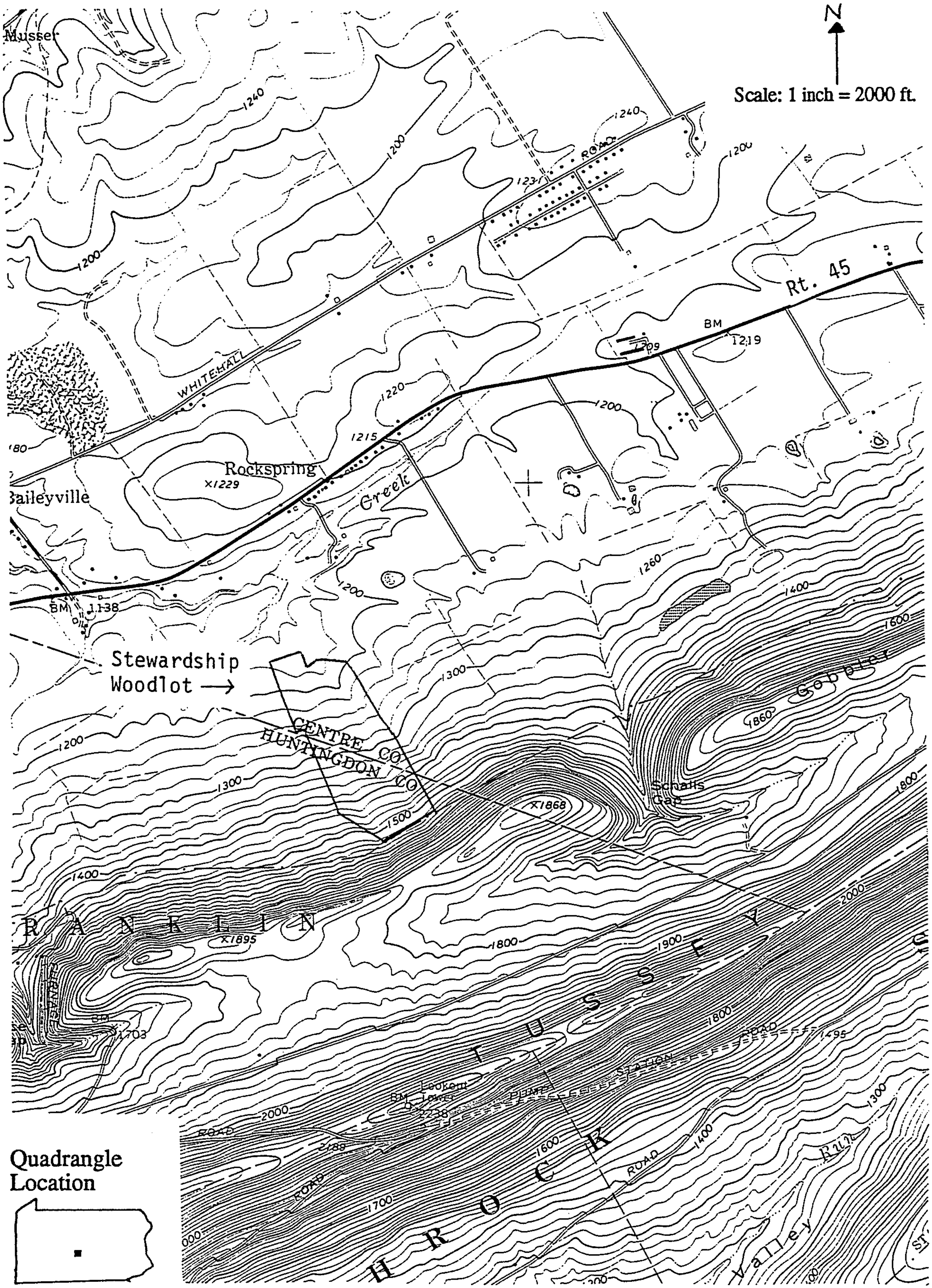
APPENDIX A

AREA AND STAND MAPS

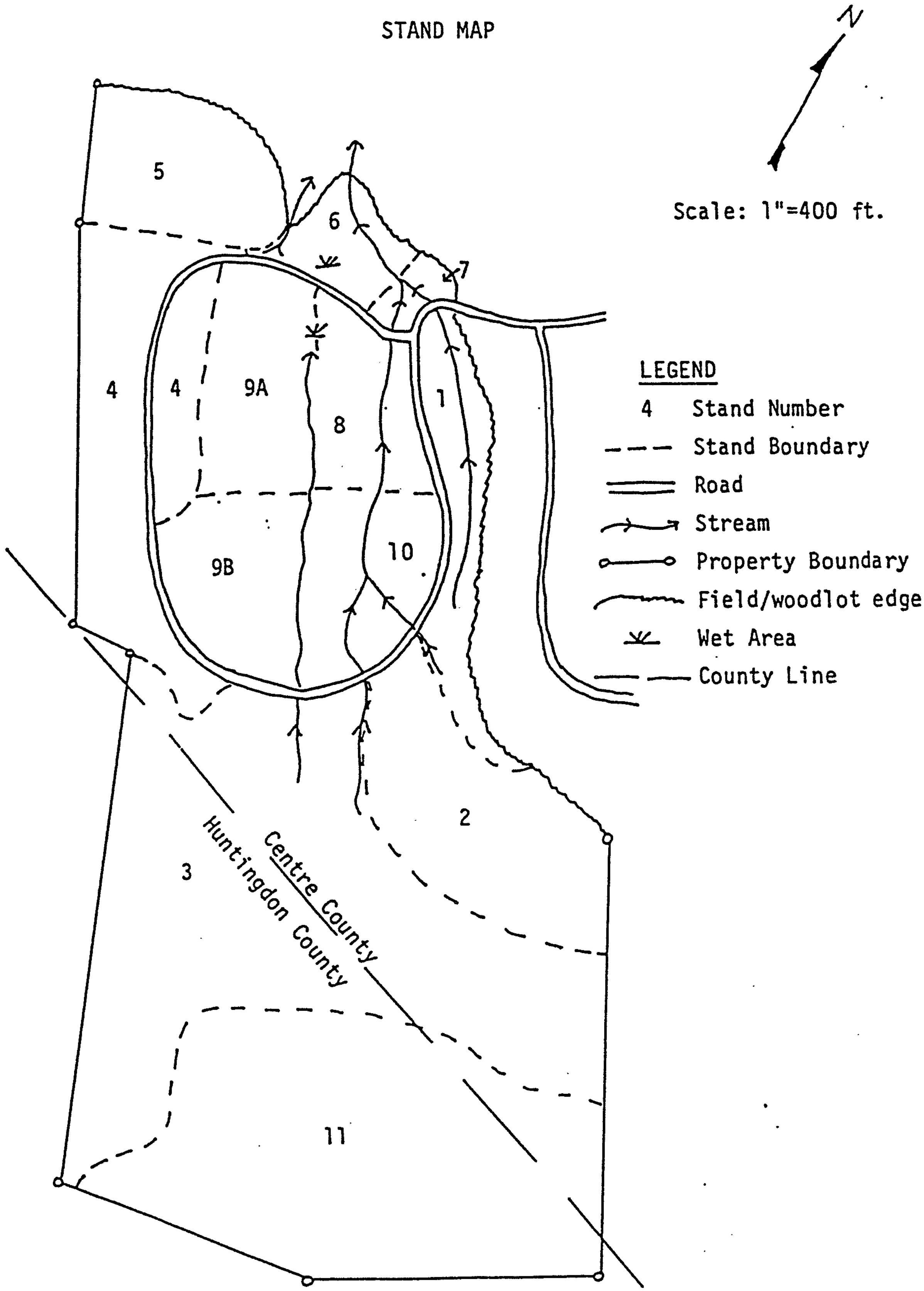
Pine Grove Mills, PA
Quadrangle

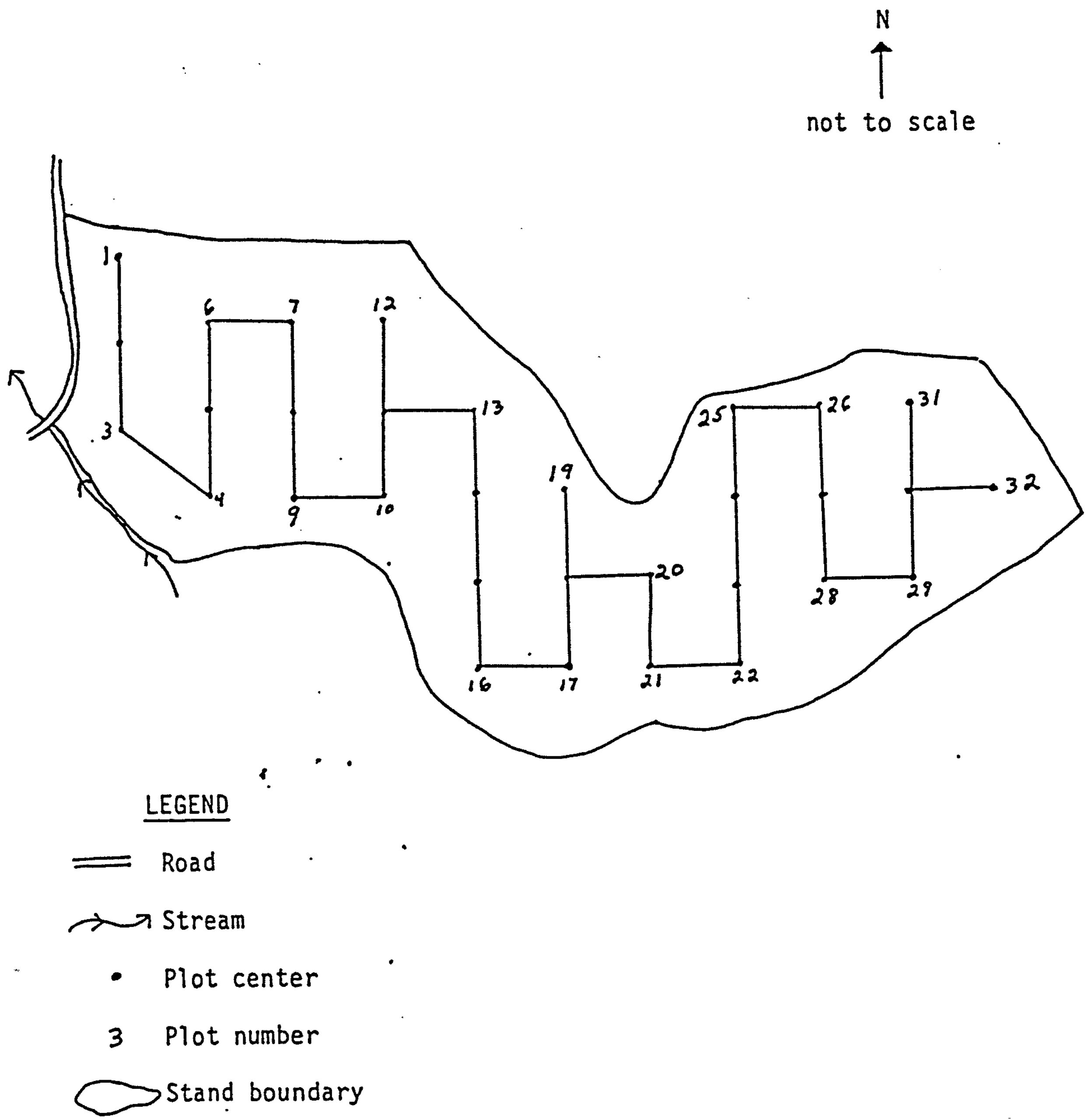


Quadrangle
Location

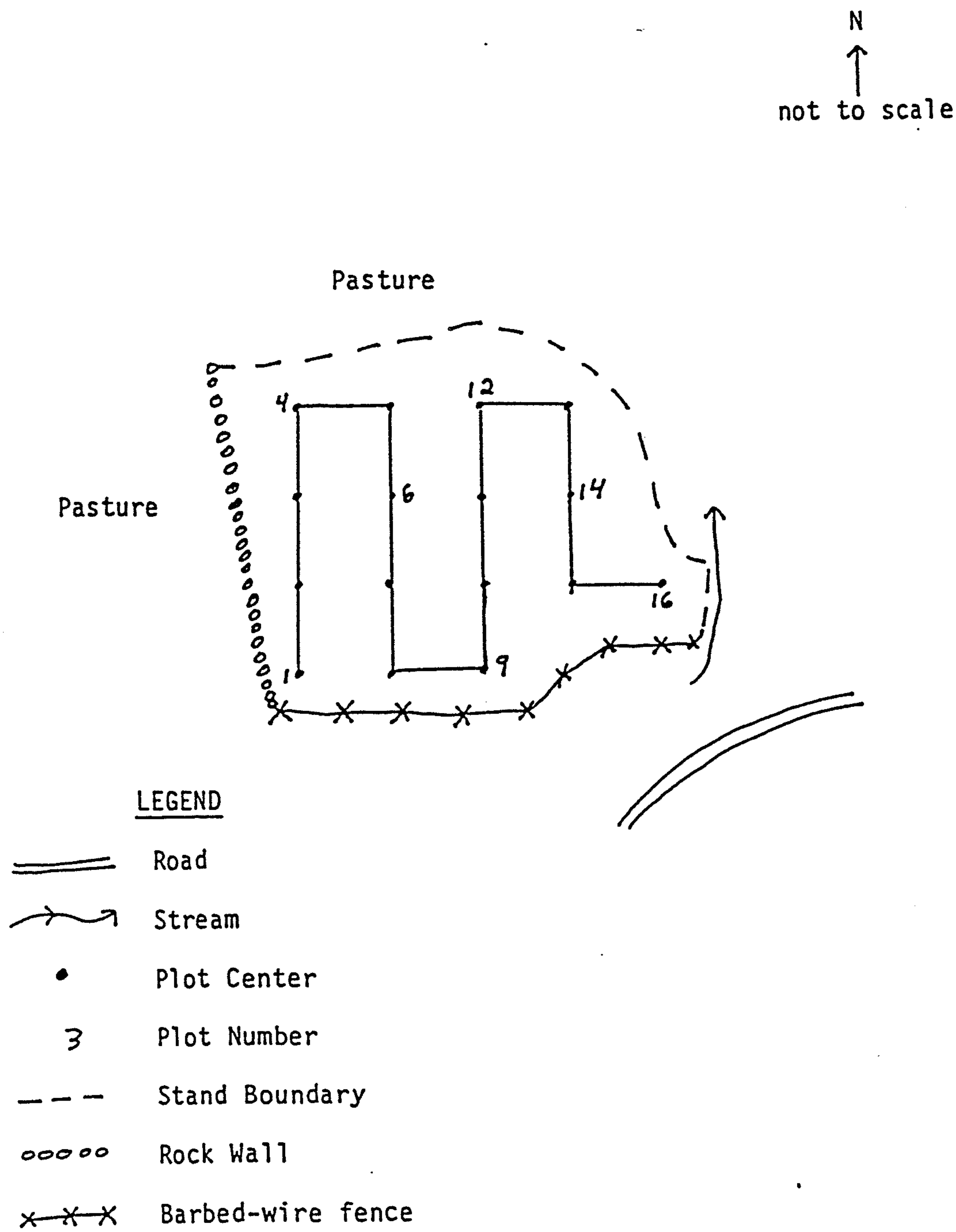
STEWARDSHIP WOODLOT

STAND MAP

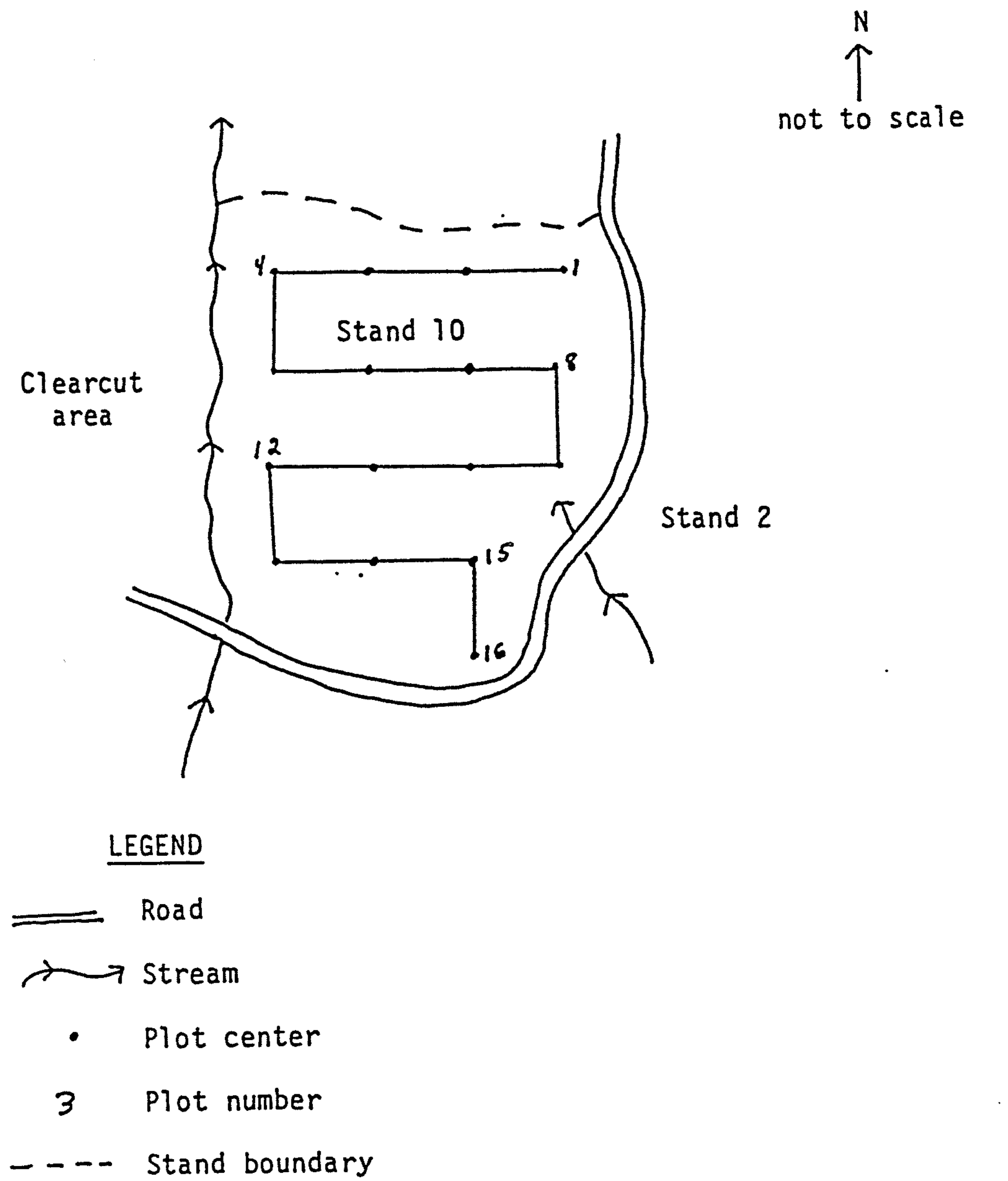




SITE MAP OF STAND 2 IN THE STEWARDSHIP WOODLOT SHOWING SAMPLE PLOT LOCATIONS



SITE MAP OF STAND 5 IN THE STEWARDSHIP WOODLOT SHOWING SAMPLE PLOT LOCATIONS



SITE MAP OF STAND 10 IN THE STEWARDSHIP WOODLOT SHOWING
SAMPLE PLOT LOCATIONS

APPENDIX B

GLOSSARY

Definitions Used In This Thesis

Acceptable growing stock (AGS) - good quality commercial trees capable of being sold now or in the future as sawtimber.

Cull - a tree which cannot be sold as either sawtimber or pulpwood due to an unacceptable proportion of rot, crook, or sweep.

Dead - standing dead trees.

Dead and down material - all woody material that is dead and lying on the ground that is at least 3 inches in diameter and at least 3 feet long.

Forest litter - the surface layer of the florest floor consisting of freshly fallen leaves, needles, stems, twigs, bark, and fruits.

Friable soil - crumbly, relatively soft, well-aerated soil suitable for burrowing.

Functional group - a group of species that respond in a similar way to a variety of changes likely to affect their environment.

Generalist - a species that doesn't require a single specific forest habitat or structural feature, but is very flexible and can successfully shift from one forest condition to another.

Ground layer - forbs, grasses, and woody seedlings that occur in the 0 to 2 foot vertical height zone in forest and nonforest cover types.

High perch - an overstory tree that clearly towers above all other forest vegetation or where a single tree, or group of trees, stands considerably above the surrounding herbaceous ground vegetation; can be live or dead trees.

Low perch - examples are fences, utility lines, isolated deciduous shrubs, woody sprout clumps, dead stubs less than 10 feet high, or clearcutting residue.

Midstory layer - deciduous and coniferous saplings and poles that occur within the 10 to 30 foot zone beneath the overstory canopy.

Noncommercial (NC) - a tree species which cannot be sold for either sawtimber or pulpwood solely on the basis of its species; i.e. hophornbeam, black gum.

Nonforest species - a species that requires only nonforest habitats to complete its life cycle.

Overstory crown closure -
- minimal - forested stands or nonforested cover type with less than 15% closure.
- partial - forested stands with overstory closure between 15 to 70%.
- closed - forested stands with overstory closure greater than 70%.

(Continued Next Page)

Overstory inclusions - isolated patches of conifer stems in hardwood stands, or hardwood stems in conifer stands (can be just a group of several stems or patches 1/4 to 2 acres in size depending on stand size).

Overstory layer - vegetation greater than 30 feet tall.

Percent cover - the percentage of ground 'covered' by foliage. Within each vertical height layer, relative percent cover has a maximum of 100%, absolute cover can be over 100%.

Sapling - any tree species ≥ 0.5" DBH, but ≤ 5.5" DBH.

Seedling- any tree species < 0.5" DBH.

Seep - a small spring usually found at the base of a hill, associated with lush ground vegetation.

Shrub layer - deciduous, coniferous, and ericaceous shrubs and seedlings that occur within the 2 to 10 foot zone in forested and nonforested cover types, usually, but not always, with an overstory canopy present.

Slash piles - piled brush.

Snag - any dead tree at least 4 inches in diameter at breast height and at least 6 feet tall.

Specialist - a species that requires a special combination of habitat/structural features to survive and reproduce, such as a cavity nester.

Unacceptable growing stock (UGS) - a commercial tree species which does not have the potential to be sold as sawtimber.

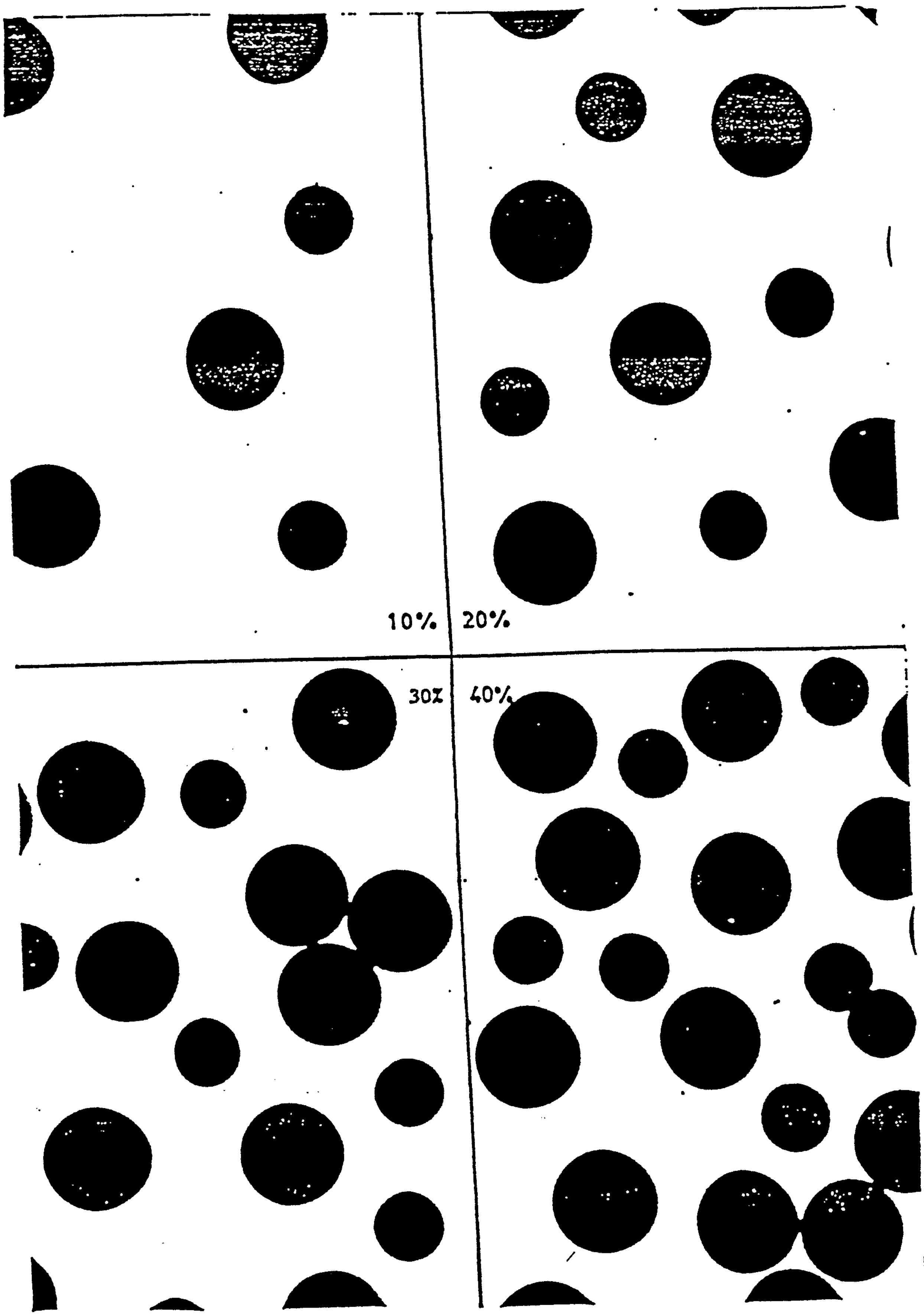
Vegetation structure - the vertical and horizontal layers of leafy and woody vegetation in a forested area.

Wildlife habitat - the specific combinations of food, cover, water, and space required by each species to survive and reproduce.

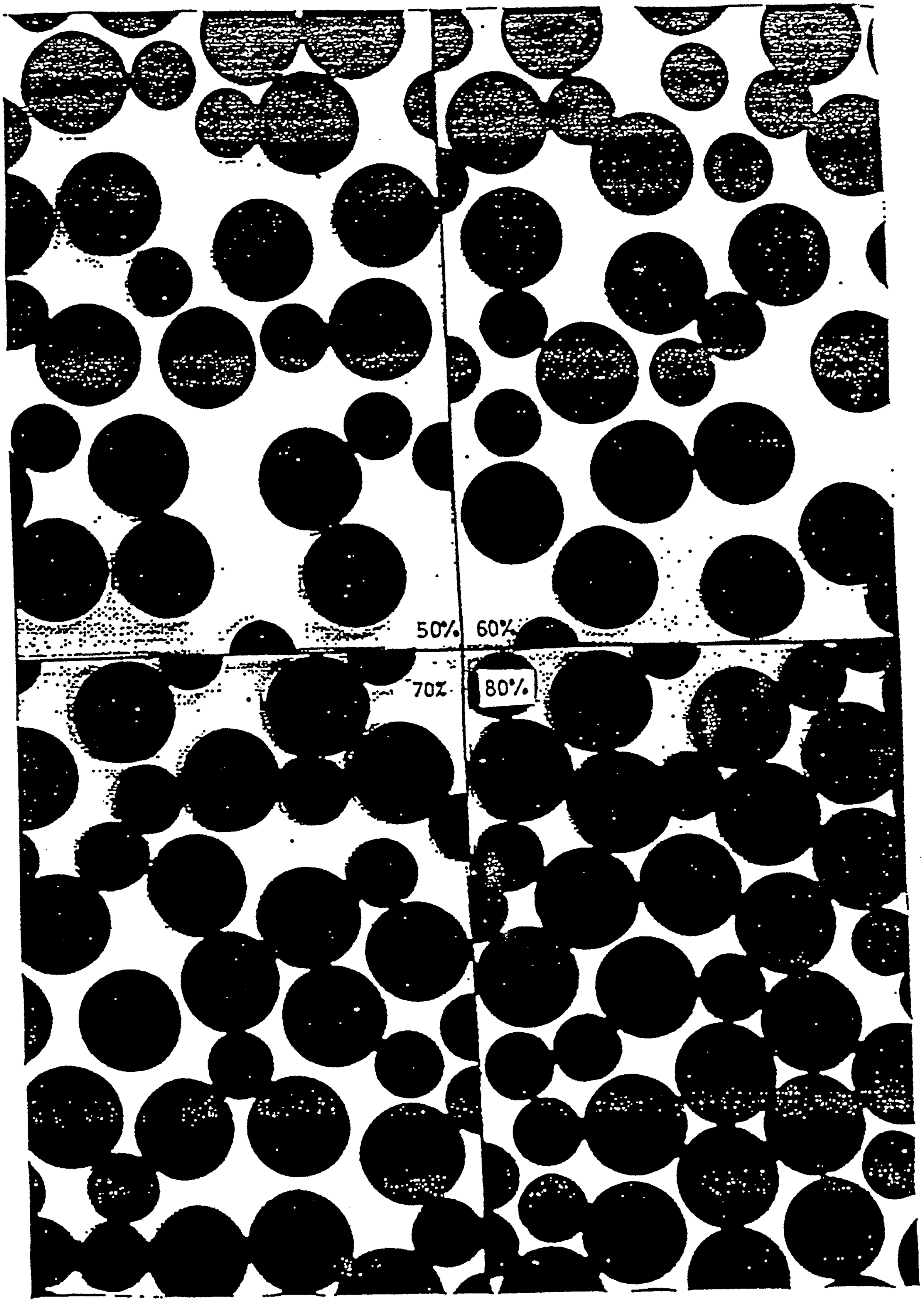
APPENDIX C

VEGETATION COVER ESTIMATION GUIDES

ESTIMATION GUIDES TO DETERMINE 10% - 40% COVER



ESTIMATION GUIDES TO DETERMINE 50% - 80% COVER



APPENDIX D

SPECIES COMPOSITION TABLES

List Of Tree Species (Live Stems ≥ 1" DBH) Encountered In Study Area

Common Name	Scientific Name
Basswood	*Tilia americana* L.
Bigtooth aspen	*Populus grandidentata* Michx.
Bitternut hickory	*Carya cordiformis* (Wangenh.) K. Koch
Black birch	*Betula lenta* L.
Black cherry	*Prunus serotina* Ehrh.
Black gum	*Nyssa sylvatica* L.
Butternut	*Juglans cinerea* L.
Chestnut oak	*Quercus prinus* L.
Choke cherry	*Prunus virginiana* L.
Cucumbertree	*Magnolia acuminata* L.
Dogwood	*Cornus florida* L.
Eastern hemlock	*Tsuga canadensis* L.
Elm	*Ulmus* L.
Hawthorn	*Crataegus* L.
Hophornbeam	*Ostrya virginiana* Scop.
Mockernut hickory	*Carya tomentosa* Nutt.
Mountain laurel	*Kalmia latifolia* L.
Musclewood	*Carpinus caroliniana* Walt.
Pin cherry	*Prunus pensylvanica* L.
Pitch pine	*Pinus rigida* Mill.
Red maple	*Acer rubrum* L.
Red oak	*Quercus rubra* L.
Shadbush	*Amelanchier arborea* (Michx.) Fernald
Shagbark hickory	*Carya ovata* (Mill.) K. Koch
Spicebush	*Lindera benzoin* L.
Striped maple	*Acer pensylvanicum* L.
Sugar maple	*Acer saccharum* Marsh.
Sumac	*Rhus* L.
Viburnum	*Viburnum* L.
White ash	*Fraxinus americanus* L.
White oak	*Quercus alba* L.
White pine	*Pinus strobus* L.
Witch hazel	*Hamamelis virginiana* L.

Percent Frequency Of Identified Ground Species Found In Nested Circular Plots (radii = 3.72 feet, 6.0 feet, 11.75 feet) In Stands 2, 5, and 10 In The Stewardship Woodlot.

		STAND 2			STAND 5			STAND 10		
Common Name	Scientific Name	3.72'	6.0'	11.75'	3.72'	6.0'	11.75'	3.72'	6.0'	11.75'
Alleghany foamflower	Tiarella cordifolia	3	3	3	---	---	---	---	---	---
Arrow-leaved tearthumb	Polygonum sagittatum	---	---	---	---	---	---	12	12	12
Barberry	Berberis thunbergii	28	34	59	6	19	44	25	44	56
Basil balm	Monarda clinopodia	---	---	---	---	6	12	---	---	---
Basswood	Tilia americana	6	6	78	25	50	56	12	31	44
Bedstraw sp.	Galium spp.	19	31	47	63	69	88	12	25	56
Bellwort sp.	Uvularia spp.	3	3	9	12	12	25	6	6	6
Bitternut hickory	Carya cordiformis	---	---	---	50	81	94	19	19	31
Black birch	Betula lenta	3	13	28	---	6	6	12	12	38
Black cherry	Prunus serotina	---	---	---	---	6	25	---	---	---
Black cohosh	Cimicifuga racemosa	3	3	6	13	100	100	6	6	6
Black haw	Viburnum prunifolium	---	---	---	---	---	12	---	---	6
Black snakeroot	Sanicula canadensis	---	---	3	6	6	25	6	12	12
Blueberry	Vaccinium spp.	31	53	75	---	6	6	---	---	6
Celandine	Chelidonium majus	---	---	---	6	6	6	---	---	---
Cherry	Prunus spp.	16	31	63	31	44	62	12	25	50
Chestnut oak	Quercus prinus	---	---	3	---	---	---	---	---	---
Christmas fern	Polystichum acrostichoides	34	53	75	6	6	25	69	88	100
Cinquefoil	Potentilla sp.	25	28	44	---	---	6	6	6	12
Club moss	Lycopodium spp.	3	3	3	6	6	6	---	---	6
Common polypody	Polypodium virgianum	---	3	6	---	---	---	---	6	12
Common speedwell	Veronica officinalis	3	6	9	6	6	6	---	---	---
Currant	Ribes spp.	---	---	3	---	---	---	---	---	---
Dandelion	Taraxacum officinale	---	---	3	---	---	---	---	---	---
Dogwood	Cornus spp.	---	---	---	---	---	6	---	---	6
Downy yellow violet	Viola pubescens	---	---	---	56	69	88	6	6	6
Early meadow rue	Thalictrum dioicum	---	---	---	---	6	12	---	---	---
Eastern hemlock	Tsuga canadensis	22	38	56	---	---	---	19	31	56
Elm	Ulmus spp.	9	9	16	88	100	100	19	38	56
Enchanter's nightshade	Circaea quadrisulcata	6	16	28	38	56	63	19	31	50
False nettle	Boehmaria cylindrica	---	---	---	12	25	31	---	---	---
Fragile fern	Cystopteris fragilis	3	9	31	---	---	---	38	62	69
Goldenrod	Solidago spp.	16	28	44	6	6	6	25	25	38
Grapevine	Vitis spp.	3	3	9	19	25	25	6	12	31

(continued next page)

(Continued) Percent Frequency Of Identified Ground Species Found In Nested Circular Plots (radii = 3.72 feet, 6.0 feet, 11.75 feet) In Stands 2, 5, and 10 In The Stewardship Woodlot.

		STAND 2			STAND 5			STAND 10		
Common Name	Scientific Name	3.72'	6.0'	11.75'	3.72'	6.0'	11.75'	3.72'	6.0'	11.75'
Grass spp.		44	63	84	38	81	94	38	62	75
Green violet	Hybanthus concolor	---	---	---	---	---	6	---	---	---
Greenbriar	Smilax rotundifolia	41	59	75	---	---	6	50	81	81
Hawthorne	Crataegus spp.	6	16	19	6	19	38	19	25	31
Hay-scented fern	Dennstaedtia punctilobula	19	19	34	---	6	12	6	12	12
Heal-all	Prunella vulgaris	---	---	---	---	---	---	---	6	6
Hickory	Carya spp.	53	71	100	12	12	19	31	38	62
Hog peanut	Amphicarpa bracteata	9	9	19	6	19	25	19	19	31
Hophornbeam	Ostrya virginiana	47	75	100	---	---	---	31	44	69
Horsetail	Equisetum spp.	---	---	---	---	---	---	---	---	12
Indian pipe	Monotropa uniflora	---	3	3	---	---	---	6	6	6
Jack-in-the-pulpit	Arisaema triphyllum	---	---	---	6	25	62	---	---	6
Jewelweed	Impatiens capensis	---	---	---	---	---	---		6	12
Jumpseed	Tovara virginiana	---	---	---	25	25	44	---	---	6
Lady Fern	Athyrium filix-femina	---	3	3	---	---	---	---	---	---
Lady's Slipper	Cypripedium acaule	---	3	3	---	---	---	---	---	---
Maidenhair fern	Adiantum pedatum	---	---	---	6	12	25	---	---	---
Marginal wood fern	Dryopteris marginalis	12	28	44	6	6	12	25	44	44
Mayapple	Podophyllum peltatum	3	3	3	44	50	62	12	25	31
Mint sp.	Lamiaceae	---	---	---	---	---	---	6	6	6
Mockernut hickory	Carya tomentosa	---	---	---	---	---	6	---	---	---
Morning glory	Ipomoea spp.	---	---	---	6	12	12	---	---	---
Mountain laurel	Kalmia latifolia	3	3	3	---	---	---	---	---	---
Multiflora rose	Rosa multiflora	9	9	16	6	12	25	6	19	31
New York fern	Thelypteris noveboracensis	---	---	6	---	---	---	19	25	25
Partridgeberry	Mitchella repens	59	75	88	19	31	31	50	62	75
Plantain-leaved pussytoes	Antennaria plantaginifolia	6	6	9	---	---	---	---	---	---
Poison ivy	Toxicodendron radicans	---	---	---	---	---	---	---	6	6
Raspberry	Rubus spp.	19	19	53	25	25	38	6	12	12
Rattlesnake fern	Botrychium virginianum	---	---	---	6	19	19	---	---	---
Rattlesnake plantain	Goodyera pubescens	---	---	---	---	---	---	6	6	6
Red maple	Acer rubrum	91	97	97	12	38	56	69	75	94
Red oak	Quercus rubra	44	69	88		6	6	19	25	38

(Continued next page)

(Continued) Percent Frequency Of Identified Ground Species Found In Nested Circular Plots (radii = 3.72 feet, 6.0 feet, 11.75 feet) In Stands 2, 5, and 10 In The Stewardship Woodlot.

		STAND 2			STAND 5			STAND 10		
Common Name	Scientific Name	3.72'	6.0'	11.75'	3.72'	6.0'	11.75'	3.72'	6.0'	11.75'
Round lobed hepatica	Hepatica americana	---	---	6	12	19	31	---	---	6
Rue anemone	Anemonella thalictroides	---	3	9	25	31	44	---	---	---
Sassafras	Sassafras albidum	---	---	6	---	---	---	---	---	---
Sensitive fern	Onoclea sensibilis	---	---	---	---	---	---	6	12	12
Smooth Solomon's seal	Polygonatum biflorum	16	28	41	6	31	38	6	12	12
Spicebush	Lindera benzoin	31	44	59	62	75	94	56	69	88
Striped maple	Acer pensylvanicum	25	59	81	---	---	6	---	6	6
Sugar maple	Acer saccharum	---	3	3	100	100	100	12	19	38
Sweet cicely	Osmorhiza claytoni	---	---	---	25	38	44	---	---	6
Tall rattlesnake root	Prenanthes trifoliata	9	19	28	25	31	56	---	---	6
Tickseed sunflower	Bidens coronata	---	---	3	---	---	---	---	---	---
Tuberous indian plantain	Cacalia tuberosa	---	---	---	---	---	6	---	---	---
Violet	Viola spp.	25	38	38	81	94	94	31	31	31
Virginia creeper	Parthenocissus quinquifolia	12	19	38	56	56	69	44	56	81
White ash	Fraxinus americana	56	75	88	75	88	100	50	62	81
White mandarin	Streptopus amplexifolius	---	---	---	12	12	12	---	---	6
White oak	Quercus alba	19	31	44	---	---	---	6	6	31
White pine	Pinus strobus	44	75	91	---	---	---	31	44	75
White snakeroot	Eupatorium rugosum	---	3	6	44	50	62	6	6	12
Wild geranium	Geranium maculatum	---	---	---	44	50	62	---	---	---
Wild ginger	Asarum canadense	---	---	---	6	12	12	---	---	---
Witch hazel	Hamamelis virginiana	22	31	41	6	6	6	---	6	12
Wood sorrel	Oxalis montana	3	3	6	6	12	19	---	6	25
Wood strawberry	Fragaria vesca	---	---	---	31	44	69	12	25	44
Yarrow	Achillea millefolium	---	---	3	---	---	6	---	---	---
Yellow rattlesnake weed	Hieracium venosum	6	9	13	---	---	---	---	---	---

Note: 25 herbaceous plants could not be identified due to lack of flower or other vegetative parts and are not included in this list.

$$\% \text{ Frequency} = \frac{\text{\# of plots in which the species occurred}}{\text{total number of plots}} \times 100$$

Percent Frequency Of Shrub Species Found In Nested Circular Plots (radii=3.72 feet, 6.0 feet, 11.75 feet) And Point-Centered Quarter Plots (PCQ) In Stands 2, 5, And 10 In The Stewardship Woodlot.

		STAND 2				STAND 5				STAND 10			
Common name	Scientific name	3.72'	6.00'	11.75'	PCQ	3.72'	6.00'	11.75'	PCQ	3.72'	6.00'	11.75	PCQ
Apple	Malus sp.	---	---	---	---	---	---	---	---	---	---	6	---
Barberry	Berberis thunbergii	3	3	3	9	6	6	6	3		---	6	6
Black birch	Betula lenta	---	---	---	3	---	---	---	---	6	6	12	12
Black gum	Nyssa sylvatica	---	---	---	---	---	---	---	---	---	---	6	---
Blueberry sp.	Vaccinium sp.	3	3	3	3	---	---	---	---	---	---	---	---
Dogwood	Cornus sp.	---	---	---	3	---	---	---	---	---	---	6	---
Elm	Ulmus sp.	---	---	---	---	---	---	---	---	---	---	12	6
Hawthorne	Crateagus sp.	---	---	---	---	---	---	---	---	---	6	12	---
Hophornbeam	Ostrya virginiana	6	22	31	53	---	---	---	---	19	31	31	56
Spicebush	Lindera benzoin	3	16	19	28	50	56	81	100	19	37	62	94
Striped maple	Acer pensylvanicum	3	6	9	19	---	---	---	---	---	---	---	---
Viburnum	Viburnum sp.	---	---	---	---	---	---	---	---	6	6	12	---
White ash	Fraxinus americana	3	6	9	6	---	---	---	---	12	12	19	6
White oak	Quercus alba	---	---	---	---	---	---	---	---	---	6	6	6
White pine	Pinus strobus	12	31	47	66	---	---	---	---	19	25	25	50
Witch hazel	Hamamelis virginiana	---	3	3	6	---	---	---	---	---	---	---	---
Hickory sp.	Carya sp.	---	---	---	3	---	---	---	---	---	---	---	---

$$\% \text{ Frequency} = \frac{\text{\# of plots in which the species occurred}}{\text{total number of plots}} \times 100$$

APPENDIX E

QUESTIONNAIRE MATERIALS

PENNSTATE

College of Agriculture

Cooperative Extension
Forest Resources

(814) 863-0401
110 Ferguson Building
The Pennsylvania State University
University Park, PA 16802

October 8, 1993

address

Dear

Can you spare a couple hours to help advance the cause of conserving biological diversity in Pennsylvania's forests? The School of Forest Resources has undertaken a research project to develop inventory processes for consulting resource professionals. Inventory data, used with a modified version of the U. S. Forest Service's General Technical Report NE-144, "New England Wildlife: Management of Forested Habitats," will assess wildlife habitat availability.

"New England Wildlife" lists key vegetative structural features for all vertebrate species in New England (example enclosed). As you can see from the enclosed example sheet, quantitative measures are given for several structural features (e.g. percent ground cover), but not for others (e.g. amount of dead and down wood).

We're asking members of the Pennsylvania Biological Survey's technical committees for their expert opinions in two areas: 1) establishing thresholds for those structural features not quantified, and 2) describing structural features needed by Pennsylvania species not listed in "New England Wildlife." Enclosed are two survey forms (Form 1 - Pennsylvania species included in "New England Wildlife", and Form 2 - Pennsylvania species not included) and instructions for completing these forms.

We realize that you are extremely busy and we will be grateful for whatever help you can give. This will be an iterative process, that is, we will consolidate and summarize the data from all respondents and return the information at least once in an attempt to reach a consensus. To have the entire process done by Christmas, we're hoping to have the first round responses by October 25. If your schedule doesn't allow you to help, can you suggest another expert we can contact.

The expected outcome of this project is a process that will, as a minimum, introduce resource professionals to the need to conserve natural biological diversity in Pennsylvania's forests, a parallel to the Biological Survey's mission. If you have any questions or want more information on this project please give us a call at 814-865-0401 or 814-865-1441.

Sincerely,

James C. Finley, Ph.D.
Assistant Professor
Forest Resources

Helene Harvey
Graduate Assistant

LETTER 1 - REQUESTING HELP FROM MEMBERS OF THE PENNSYLVANIA BIOLOGICAL SURVEY'S TECHNICAL COMMITTEES

INSTRUCTIONS FOR COMPLETING STRUCTURAL FEATURES FORM

If you're not familiar with the information contained in "New England Wildlife," please take a look at the enclosed example sheet to get an idea of what we're looking for. The authors have listed the structural features needed by each species by use of a darkened square. Amounts or ranges are given for: percent overstory cover, percent ground cover, and types and sizes of snag/cavity trees. Amounts or ranges are not given for the other features, they simply note that the feature must be present for that species. We're trying to determine quantities for these features.

FORM 1 SPECIFIC INSTRUCTIONS - AMPHIBIANS & REPTILES

Form 1 of the survey lists those species included in "New England Wildlife" which also occur in Pennsylvania; therefore, some information is already known about their structural feature requirements. An asterisk (*) marks the structural feature that we wish to quantify. For example: marbled salamander has a *T or P under the WATER block indicating that either a temporary or permanent source of water is needed and you're asked to supply the amount in terms of areal extent, source, depth, and seasonal duration; it has an * under the SUBTERRANEAN block, and you're asked to supply the types it needs; it also has an *D&D under the DEAD & DOWN OR SLASH PILES block indicating that dead and down material is needed and you're asked to supply an amount; the other blocks are blank indicating that they are not a required key habitat feature by the species.

We do NOT intend for you to do a literature search and we realize that research hasn't been done to obtain actual amounts for some species. We ask that for those species you are familiar with please indicate, based on your opinion, an optimum quantity or range for those features marked by an *.

1. SPECIES: Is the species a habitat generalist (G) or habitat specialist (S)? Circle G or S as appropriate under the species name in the species block. If a species is a generalist, no further information is necessary; go on to the next species.

   Generalist - a species that doesn't require a single specific forest habitat, or structural feature, but is very flexible and can successfully shift from one forest condition to another, such as white-tailed deer or blue jay.

   Specialist - a species that requires a special combination of habitat/structural features to survive and reproduce, such as a cavity nester.

2. WATER: List the source (pond, seep, stream) and estimate the duration, depth, areal extent (size),or seasonality of water requirements; T = temporary & P = permanent. Ex: (T) pond, March to May, depth >18", >.1 acre.

3. SUBTERRANEAN: List the types of subterranean habitats needed. Ex: muddy streambanks, rocky crevices, boulder piles, dry sand and gravel banks, etc.

4a. DEAD & DOWN OR SLASH PILES: Estimate the desired amount of dead and down material and slash piles. Ex: species needs 5 slash piles/acre, or 6 logs/acre, or a total of 32 cubic feet/acre.

   Dead & down logs (D&D) - all woody material that is dead and lying on the ground that is at least 3 inches in diameter and at least 3 feet long.
   Slash piles - piled brush.

AMPHIBIAN AND REPTILE COMMITTEE MEMBER QUESTIONNAIRE

4b. If condition of the dead and down material matters (whether it should be intact or decomposed), please use the following decomposition rating:

1 = bark is intact; wood is hard and intact.
3 = has some bark; wood is hard, but in large pieces.
5 = bark is absent; wood is soft and powdery or spongy.

5. GROUND COVER: Ranges of percent ground cover in the 0 to 2 foot height zone are listed as they appear in "New England Wildlife." Ranges: 0%-30% (minimal), 30%-75% (partial), and >75% (dense).

Cover - The area of ground surface included in a vertical projection of individual plant canopies.

6. SHRUB TYPES: Estimate the range of percent cover, or number of stems per acre needed in the 2 to 10 foot height zone for the shrub types: deciduous(D), coniferous(C), ericaceous(E). Ex: Species needs 30-50% D; or >80% D & C.

7. COMMENTS: Items listed here are other habitat features needed by the species.

Note: The numbers listed before the species name in the species block are for our coding purposes.

The following amphibian and reptile species found in Pennsylvania do not require forested habitats to complete their life cycle and will not be considered in the project. If there is an error, please inform us.

Common name	Scientific name
Mudpuppy	*Necturus m. maculosus*
Stinkpot	*Sternotherus odoratus*
Eastern mud turtle	*Kinosternon s. subrubrum*
Spotted turtle	*Clemmys gutata*
Blanding's turtle	*Emydoidea blandingi*
Map turtle	*Graptemys geographica*
Midland painted turtle	*Chrysemys picta marginata*
Redbellied turtle	*Pseudemys rubriventris*
Eastern spiny softshell	*Trionyx s. spineferus*
Midland smooth softshell	*Trionyx m. muticus*

Form 1: information is needed only for those blocks with an *

SPECIES G or S	WATER Size, depth, & duration	SUBTERRANEAN Types	DEAD & DOWN OR SLASH PILES Amounts	GROUND COVER <30%; 30-75%; >75%	SHRUB TYPES Deciduous/Coniferous/ Ericaceous 0 to 100% or #stems/acre	COMMENTS
2 Marbled Salamander *Ambystoma opacum* G or S	*T or P	*	*D&D			
3 Jefferson Salamander *Ambystoma jeffersonianum* G or S	*T		*D&D			
7 Spotted Salamander *Ambystoma maculatum* G or S	*T	*	*D&D			
8 Red-spotted Newt *Notophthalmus v. viridescens* G or S	*T or P		*D&D & slash piles			forest litter & moss
9 Northern Dusky Salamander *Desmognathus f. fuscus* G or S	*seeps	*				
10 Mountain Dusky Salamander *Desmognathus ochrophaeus* G or S	*seeps		*D&D			
11 Redback Salamander *Plethodon cinereus* G or S		*	*D&D & slash piles			

FORM 2 SPECIFIC INSTRUCTIONS

Form 2 lists those species which occur in Pennsylvania, but are not listed in "New England Wildlife." We need information on all structural features required by these species.

Again, we do NOT intend for you to do a literature search and we realize that research hasn't been done to obtain actual amounts for some species. We ask that for those species you are familiar with please indicate (√) whether the structural feature is needed/required by the species and based on your professional opinion an optimum quantity or range. It may be that some features are not required for a species to complete its life cycle, if this is the case leave that space blank.

1a. SPECIES: Is the species a habitat generalist (G) or habitat specialist (S)? Circle G or S as appropriate under the species name in the species block. If a species is a generalist, no further information is necessary; go on to the next species.

Generalist - a species that doesn't require a single specific forest habitat, or structural feature, but is very flexible and can successfully shift from one forest condition to another, such as white-tailed deer or blue jay.

Specialist - a species that requires a special combination of habitat/structural features to survive and reproduce, such as a cavity nester.

1b. If the species requires only nonforest or water habitats, please write nonforest in the species block and go on to the next species.

2. WATER: Is a source of water (pond, stream, seep), either temporary (T) or permanent (P), needed? If so, circle T or P (or both if the species requires it), then list the source and estimate the areal extent (size), duration (seasonality), and depth of the water source. Ex: (T) pond, 1/4 acre, March to May, >18" depth, >.1 acre.

3. SUBTERRANEAN: List the types of subterranean habitats needed. Ex: muddy streambanks, rocky crevices, boulder piles, dry sand and gravel banks, etc.

4a. DEAD & DOWN OR SLASH PILES: Are dead and down logs or slash piles needed? If so, estimate a desired amount. Ex: species needs 5 slash piles/acre; or 6 logs/acre; or a total of 32 cubic feet/acre.

Dead & down logs - all woody material that is dead and lying on the ground that is at least 3 inches in diameter and at least 3 feet long.
Slash piles - piled brush.

4b. If condition of the dead and down material matters (whether it should be intact or decomposed), please use the following decomposition rating:

1 = bark is intact; wood is hard and intact.
3 = has some bark; wood is hard, but in large pieces.
5 = bark is absent; wood is soft and powdery or spongy.

5. GROUND COVER: What percent ground cover of woody seedlings, forbs, grasses, and other herbaceous plants is necessary in the 0 to 2 foot height zone? Use range values of: 0%-30% (minimal); 30%-75% (partial); and >75% (dense).

Cover - The area of ground surface included in a vertical projection of individual plant canopies.

INSTRUCTIONS FOR ALL COMMITTEE MEMBERS FOR FORM 2

6. SHRUB TYPES: What shrub types (deciduous(D), coniferous(C), ericaceous(E)) and amounts (range of percent cover, or number of stems per acre) are needed in the 2 to 10 foot height zone? Ex: species needs 30-50% deciduous cover; or >80% mixed deciduous and coniferous shrub cover.

7. MIDSTORY COVER: What type of midstory (deciduous(D) or coniferous(C) or mixed (M)) is necessary in the 10 to 30 foot zone? What range of percent cover or number of stems per acre is needed? Ex: >400 D stems/acre; or 30-70% C.

8. SNAGS & CAVITIES: Are snags and/or cavities necessary? Estimate size of tree diameter (measured at breast height=4 1/2 feet above ground level), whether the tree is live or dead, and if dead, is it a hard or soft snag. Ex: soft snag >12" in diameter; or live tree >18" in diameter with a cavity.

Snag - any dead tree at least 4 inches in diameter at breast height and at least 6 feet tall.

9. CANOPY COVER: What percent cover in the overstory (trees >30 feet tall) is necessary? Use ranges of: <15% (minimal/open); 16%-30% (partial); 31%-70% (partial); or >70% (closed). Ex: species needs >70% cover; or species needs >70% for breeding and 16%-30% for feeding.

10. COMMENTS: Is there a vegetative feature the species needs that wasn't mentioned? Please note it in the comments column.

Note: A blank table is attached if you wish to add species that we missed.

Form 2: information is needed for all structural features required by the species.

SPECIES G or S	WATER Size, depth, & duration T or P	SUBTER-RANEAN Types	DEAD & DOWN OR SLASH PILES Amounts	GROUND COVER 0-30%; 30-75%; >75%	SHRUB TYPES Deciduous/Coniferous/ Ericaceous 0 to 100% or #stems/acre	MIDSTORY COVER 0 to 100% or #stems/acre	SNAGS & CAVITIES Sizes	CANOPY COVER 0-15%; 16%-30% 31%-70%; >70%	COM-MENTS
Green Salamander *Aneides aeneus* G or S	T or P								
Broad-headed skink *Eumeces laticeps* G or S	T or P								
Rough green snake *Opheodrys aestivus* G or S	T or P								
Northern coal skink *Eumeces a. anthracinus* G or S	T or P								

INSTRUCTIONS FOR COMPLETING STRUCTURAL FEATURES FORM

If you're not familiar with the information contained in "New England Wildlife," please take a look at the enclosed example sheet to get an idea of what we're looking for. The authors have listed the structural features needed by each species by use of a darkened square. Amounts or ranges are given for: percent overstory cover, percent ground cover, and types and sizes of snag/cavity trees. Amounts or ranges are not given for the other features, they simply note that the feature must be present for that species. We're trying to determine quantities for these features.

FORM 1 SPECIFIC INSTRUCTIONS - BIRDS

Form 1 of the survey lists those species included in "New England Wildlife" which also occur in Pennsylvania; therefore, some information is already known about their structural feature requirements. An asterisk (*) marks the structural feature that we wish to quantify. For example: Northern water thrush has a *T under the WATER block indicating that a temporary source of water is needed and you're asked to supply the amount in terms of areal extent, source, depth, and seasonal duration; an *E under the SHRUB TYPES block indicates that it needs an ericaceous shrub layer and you're asked to estimate the range of percent cover or number of stems/acre needed; in the COMMENTS block "forest litter" means that this is required by the species (blocks with information and no asterisk are simply supplied for your information); the other blocks are blank indicating that they are not a required key habitat feature by the species.

We do NOT intend for you to do a literature search and we realize that research hasn't been done to obtain actual amounts for some species. We ask that for those <u>species you are familiar with</u> please indicate, based on your opinion, an optimum quantity or range for those features marked by an *.

1. SPECIES: Is the species a habitat generalist (G) or habitat specialist (S)? Circle G or S as appropriate under the species name in the species block. If a species is a generalist, no further information is necessary; go on to the next species.

    <u>Generalist</u> - a species that doesn't require a single specific forest habitat, or structural feature, but is very flexible and can successfully shift from one forest condition to another, such as white-tailed deer or blue jay.

    <u>Specialist</u> - a species that requires a special combination of habitat/structural features to survive and reproduce, such as a cavity nester.

2. WATER: List the source (pond, seep, stream) and estimate the duration, depth, aerial extent, or seasonality of water requirements; T = temporary & P = permanent. Ex: (T) pond, March to May, depth >18", area >.1 acre.

3. SUBTERRANEAN: List the types of subterranean habitats needed. Ex: muddy streambanks, rocky crevices, boulder piles, dry sand and gravel banks, etc.

4a. DEAD & DOWN OR SLASH PILES: Estimate the desired amount of dead and down material and slash piles. Ex: species needs 5 slash piles/acre, or 6 logs per acre, or a total of 32 cubic feet/acre.

    <u>Dead & down logs</u> (D&D) - all woody material that is dead and lying on the ground that is at least 3 inches in diameter and at least 3 feet long.
    <u>Slash piles</u> - piled brush.

4b. If condition of the dead and down material matters (whether it should be intact or decomposed), please use the following decomposition rating:

1 = bark is intact; wood is hard and intact.
3 = has some bark; wood is hard, but in large pieces.
5 = bark is absent; wood is soft and powdery or spongy.

5. GROUND COVER: Ranges of percent ground cover in the 0 to 2 foot height zone are listed as they appear in "New England Wildlife." Ranges: 0%-30% (minimal), 30%-75% (partial), and >75% (dense).

Cover - The area of ground surface included in a vertical projection of individual plant canopies.

6. SHRUB TYPES: Estimate the range of percent cover, or number of stems per acre needed in the 2 to 10 foot height zone for the shrub types: deciduous(D), coniferous(C), ericaceous(E). Ex: Species needs 30-50% D cover; or >80% D & C shrub cover.

7. MIDSTORY COVER: What range of percent cover or number of stems per acre are needed in the 10 to 30 foot zone (deciduous (D) or coniferous (C))? Ex: >400 D stems per acre; or 30-70% C.

8. SNAGS & CAVITIES: Sizes of snags and/or cavity trees are listed as given in "New England Wildlife."

Snag - any dead tree at least 4 inches in diameter at breast height and at least 6 feet tall.

9. CANOPY COVER: Ranges of percent cover in the overstory (trees >30 feet tall) are listed as given in "New England Wildlife." Ranges: <15% (minimal); 16%-30% (partial); 31%-70%(partial); or >70% (closed).

10. COMMENTS: Items listed here are other habitat features needed by the species.

Note: The numbers listed before the species name in the species block are for our coding purposes.

The following bird species found in Pennsylvania do not require forested habitats to complete their life cycle and will not be considered in the project. If there is an error, please inform us.

Common name	Scientific name
Common loon	*Gavia immer*
Red-throated loon	*Gavia stellata*
Red-necked grebe	*Podiceps grisegena*
Horned grebe	*Podiceps auritus*
Pied-billed grebe	*Podilymbus podiceps*
Double-crested cormorant	*Phalacrocorax auritus*
Black-crowned night-heron	*Nycticorax nycticorax*
Yellow-crowned night-heron	*Nycticorax violaceus*
Least bittern	*Ixobrychus exilis*
American bittern	*Botaurus lentiginosus*
Glossy ibis	*Plegadis falcinellus*
Mute swan	*Cygnus olar*
Tundra swan	*Cygnus columgianus*
Canada goose	*Branta canadensis*
Atlantic brant	*Branta bernicla*
Greater white-fronted goose	*Anser albifrons*
Snow goose	*Chen caerulescens*
Ross' goose	*Chen rossi*
Mallard	*Anas platyrhynchos*
Muscovy duck	*Cairina moschata*
Gadwall	*Anas strepera*
Northern pintail	*Anas acuta*
Green-winged teal	*Anas crecca*
Eurasian wigeon	*Anas penelope*
Blue-winged teal	*Anas discors*
Northern shoveler	*Anas clypeata*
American wigeon	*Anas americana*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Canvasback	*Aythya valisineria*
Greater scaup	*Aythya marila*
Lesser scaup	*Aythya affinis*
Bufflehead	*Bucephala albeola*
Old squaw	*Clangula hyemalis*
King Eider	*Someteria spectabilis*
White-winged scoter	*Melanitta fusca*
Black scoter	*Melanitta nigra*
Ruddy duck	*Oxyura jamaicensis*
Red-breasted merganser	*Mergus serrator*
Black vulture	*Coragyps atratus*
Rough-legged hawk	*Buteo lagopus*
Northern harrier	*Circus cyaneus*
Osprey	*Pandion haliaetus*
Northern bobwhite	*Colinus virginianus*
Ring-necked pheasant	*Phasianus colchicus*
Sandhill crane	*Grus canadensis*
King rail	*Rallus elegans*
Virginia rail	*Rallus limicola*
Sora	*Porzana carolina*
Yellow rail	*Coturnicops noveboracensis*
Black rail	*Laterallus jamaicensis*
Common moorhen	*Gallinula chloropus*

American coot	*Fulica americana*
Semipalmated plover	*Charadrius semipalmatus*
Piping plover	*Charadrius melodus*
Killdeer	*Characriuss vociferous*
Lesser golden-plover	*Pluvialis dominica*
Black-bellied plover	*Pluvialis squatarola*
Ruddy turnstone	*Arenaria interpres*
Common snipe	*Gallinago gallinago*
Whimbrel	*Numerius phaeopus*
Upland sandpiper	*Bartramia longicauda*
Spotted sandpiper	*Actitis macularia*
Solitary sandpiper	*Tringa solitaria*
Greater yellowlegs	*Tringa melanoleuca*
Lesser yellowlegs	*Tringa flavipes*
Willet	*Catoptrophorus semipalmatus*
Red knot	*Calidris canutus*
Purple sandpiper	*Calidris maritima*
Pectoral sandpiper	*Calidris melanotos*
White-rumped sandpiper	*Calidris fuscicollis*
Baird's sandpiper	*Calidris bairdii*
Least sandpiper	*Calidris minutilla*
Dunlin	*Calidris alpina*
Semipalmated sandpiper	*Calidris pusilla*
Western sandpiper1	*Calidris mauri*
Sanderling	*Calidris alba*
Short-billed dowitcher	*Limnodromus griseus*
Stilt sandpiper	*Calidris himantopus*
Buff-breasted sandpiper	*Tryngites subruficollis*
Marbled godwit	*Limosa fedoa*
Hudsonian godwit	*Limosa haemastica*
Red phalarope	*Phalaropus fulicaria*
Wilson's phalarope	*Phalaropus tricolor*
Red-necked phalarope	*Phalaropus labatus*
Glaucous gull	*Larus hyperboreus*
Greater black-backed gull	*Larus marinus*
Herring gull	*Larus argentatus*
Ring-billed gull	*Larus delawarensis*
Laughing gull	*Larus atricilla*
Franklin's gull	*Larus pipixcan*
Little gull	*Larus minutus*
Black-legged kittiwake	*Rissa tridactyla*
Forster's tern	*Sterna forsteri*
Common tern	*Sterna hirundo*
Least tern	*Sterna antillarum*
Caspian tern	*Sterna caspia*
Black tern	*Chlindonias niger*
Rock dove	*Columba livia*
Barn owl	*Tyto alba*
Snowy owl	*Nyctea scandiaca*
Short-eared owl	*Asio flammeus*
Chimney swift	*Chaetura pelagica*
Belted kingfisher	*Ceryle alcyon*
Horned lark	*Eremophila alpestris*
Fish crow	*Corvus ossifragus*
Bewick's wren	*Thryomanes bewickii*
Marsh wren	*Cistothorus palustris*

Sedge wren	*Cistothorus platensis*
Water pipit	*Anthus spinoletta*
Bobolink	*Dolichonyx oryzivorus*
Eastern meadowlark	*Sturnella magna*
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*
Red-winged blackbird	*Agelaius phoeniceus*
Rusty blackbird	*Euphagus carolinus*
Common grackle	*Quiscalus quiscula*
Dickcissel	*Spiza americana*
Savannah sparrow	*Passerculus sandwichensis*
Grasshopper sparrow	*Ammodramus savannarum*
Henlow's sparrow	*Ammodramus henslowii*
Sharp-tailed sparrow	*Ammodramus caudacutus*
Vesper sparrow	*Pooecetes gramineus*
Lincoln's sparrow	*Melospiza lincolnii*
Lapland longspur	*Calcarius lapponicus*
Snow bunting	*Plectrophenax nivalis*

The following species are considered forest habitat generalists which require no specific structural features.

Common name	Scientific name
Blue jay	*Cyanocitta cristata*
American crow	*Corvus brachyrhynchos*
House wren	*Troglodytes aedon*
American robin	*Turdus migratorius*
European starling	*Sturnus vulgaris*
House sparrow	*Passer domesticus*
House finch	*Carpodacus mexicanus*

The following species are rarely found in Pennsylvania and will not be considered in the project.

Common name	Scientific name
Western Kingbird	*Tyrannus verticalis*
Loggerhead shrike	*Lanius ludovicianus*
Orchard oriole	*Icterus spurius*
Summer tanager	*Piranga rubra*
Hoary redpoll	*Carduelis hornemanni*
Harris sparrow	*Zonotrichia querula*

BIRDS: Form 1: Information is only needed for those blocks with an *

SPECIES G or S	WATER Size, source, depth, & duration	SUBTER-RANEAN Types	DEAD & DOWN OR SLASH PILES Amounts	GROUND COVER <30%; 30-75%; >75%	SHRUB TYPES Deciduous/Coniferous/Ericaceous 0 to 100% or #stems/acre	MIDSTORY COVER 0 to 100% or # stems/acre	SNAGS & CAVITIES Sizes	CANOPY COVER <15%; 16-30%; 31-70%;>70%	COM-MENTS
231 Northern water thrush *Seiurus noveboracensis* G or S	*T				*E				forest litter
232 Louisiana waterthrush *Seiurus motacilla* G or S	*T				*E				
102 Ruffed grouse *Bonasa umbellus* G or S			*D&D	>75%				16-30% for feeding; 31-70% for shelter	mast
103 Wild turkey *Meleagris gallopavo* G or S	*Seeps			>75%	*E			16-30% for feeding; 31-70% for shelter	mast
123 Black-billed cuckoo *Coccyzus erythropthalmus* G or S					*D&E			16-30%	
124 Yellow-billed cuckoo *Coccyzus americanus* G or S					*D&E			16-30%	
154 Alder flycatcher *Empidonax alnorum* G or S					*D&E			16-30%	

INSTRUCTIONS FOR COMPLETING STRUCTURAL FEATURES FORM

If you're not familiar with the information contained in "New England Wildlife," please take a look at the enclosed example sheet to get an idea of what we're looking for. The authors have listed the structural features needed by each species by use of a darkened square. Amounts or ranges are given for: percent overstory cover, percent ground cover, and types and sizes of snag/cavity trees. Amounts or ranges are not given for the other features, they simply note that the feature must be present for that species. We're trying to determine quantities for these features.

FORM 1 SPECIFIC INSTRUCTIONS - MAMMALS

FORM 1 of the survey lists those species included in "New England Wildlife" which also occur in Pennsylvania; therefore, some information is already known about their structural feature requirements. An asterisk (*) marks the structural feature that we wish to quantify. For example: the Virginia Opossum has *D&D & slash piles listed under the DEAD & DOWN OR SLASH PILES block, you are asked to supply an amount; under SNAGS & CAVITIES and COMMENTS, data from "New England Wildlife" is supplied for your information; the other blocks are blank indicating that they are not a required habitat feature by the species.

We do NOT intend for you to do a literature search and we realize that research hasn't been done to obtain actual amounts for some species. We ask that for those <u>species you are familiar with</u> please indicate, based on your opinion, an optimum quantity or range for those features marked by an *.

1. SPECIES: Is the species a habitat generalist (G) or habitat specialist (S)? Circle G or S as appropriate under the species name in the species block. If a species is a generalist, no further information is necessary; go on to the next species.

   <u>Generalist</u> - a species that doesn't require a single specific forest habitat, or structural feature, but is very flexible and can successfully shift from one forest condition to another, such as white-tailed deer or blue jay.

   <u>Specialist</u> - a species that requires a special combination of habitat/structural features to survive and reproduce, such as a cavity nester.

2. WATER: List the source (pond, seep, stream) and estimate the duration, depth, areal extent, or seasonality of water requirements; T = temporary & P = permanent. Ex: (T) pond, March to May, depth >18", >.1 acre.

3. SUBTERRANEAN: List the types of subterranean habitats needed. Ex: muddy streambanks, rocky crevices, boulder piles, dry sand and gravel banks, etc.

4a. DEAD & DOWN OR SLASH PILES: Estimate the desired amount of dead and down material and slash piles. Ex: species needs 5 slash piles/acre, or 6 logs/acre, or a total of 32 cubic feet/acre.

   <u>Dead & down logs</u> (D&D) - all woody material that is dead and lying on the ground that is at least 3 inches in diameter and at least 3 feet long.
   <u>Slash piles</u> - piled brush.

MAMMAL COMMITTEE MEMBER QUESTIONNAIRE

4b. If condition of the dead and down material matters (whether it should be intact or decomposed), please use the following decomposition rating:

1 = bark is intact; wood is hard and intact.
3 = has some bark; wood is hard, but in large pieces.
5 = bark is absent; wood is soft and powdery or spongy.

5. GROUND COVER: Ranges of percent ground cover in the 0 to 2 foot height zone are listed as they appear in "New England Wildlife." Ranges: 0%-30% (minimal), 30%-75% (partial), and >75% (dense).

Cover - The area of ground surface included in a vertical projection of individual plant canopies.

6. SHRUB TYPES: Estimate the range of percent cover, or number of stems per acre needed in the 2 to 10 foot height zone for the shrub types: deciduous(D), coniferous(C), ericaceous(E). Ex: Species needs 30-50% D; or >80% D & C.

7. SNAGS & CAVITIES: Sizes of snags and/or cavity trees are listed as given in "New England Wildlife."

Snag - any dead tree at least 4 inches in diameter at breast height and at least 6 feet tall.

8. CANOPY COVER: Ranges of percent cover in the overstory (trees >30 feet tall) are listed as given in "New England Wildlife." Ranges: <15% (minimal); 16%-30% (partial); 31%-70%(partial); or >70% (closed).

9. COMMENTS: Items listed here are other habitat features needed by the species.

Note: The numbers listed before the species name in the species block are for our coding purposes.

The following mammal species found in Pennsylvania do not require forested habitats to complete their life cycle and will not be considered in the project. If there is an error, please inform us.

Common name	Scientific name
Marsh rice rat	*Oryzomys palustris*
Muskrat	*Ondatra zibethicus*
Norway rat	*Rattus norvegicus*
House mouse	*Mus musculus*

MAMMALS: Form 1: Information is only needed for those blocks with an *

SPECIES G or S	WATER Size, source, depth, & duration	SUBTER-RANEAN Types	DEAD & DOWN OR SLASH PILES Amounts	GROUND COVER <30%; 30-75%; >75%	SHRUB TYPES Deciduous/Coniferous/Ericaceous 0 to 100% or #stems/acre	SNAGS & CAVITIES Sizes	CANOPY COVER <15%; 16-30%; 31-70%;>70%	COM-MENTS
278 Virginia Opossum *Didelphis virginiana* G or S			*D&D & slash piles			live hollow trees >24"		mast
279 Masked Shrew *Sorex cinereus* G or S			*D&D					damp woodlands
280 Water Shrew *Sorex palustris* G or S	*T				*E			
281 Smoky Shrew *Sorex fumeus* G or S			*D&D					deciduous overstory inclusions
282 Long-tailed Shrew *Sorex dispar* G or S		*	*D&D					
283 Pygmy Shrew *Sorex hoyi* G or S			*D&D					

PENNSTATE

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Cooperative Extension
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The Pennsylvania State University
University Park, PA 16802

December 2, 1993

«Prefix Name» «First Name» «Middle Initial» «Last Name» «Suffix Name»
«Business Name»
«Street»
«City\State» «Zip Code»

Dear «Prefix Name» «Last Name»,

Thank you for looking over our questionnaire on wildlife habitat features; we appreciated all the responses. The response rate was lower than expected due to peoples' heavy schedules and our short time frame. However, we feel that significant information has been provided.

We know your schedule is still hectic, but would you spare one hour to look over the enclosed survey results? Why should you? Because you can make a difference in how Pennsylvania's forests are managed. Information you provide about these habitat features will be a part of an education program for consulting foresters and forest landowners; it will not just go into some report and sit on the shelf.

The questionnaires' form is similar to the original's. You'll notice that for some species a lot of habitat information was acquired, for others, none. We're hoping that the missing information will be acquired in this round.

Please take a moment to look over the instructions and the questionnaire. The information you supply is important to us and we believe it will make a difference, especially in non-game habitat management. We'd like to have your responses in by December 20.

Thank you for your time, we appreciate it.

Sincerely,

James C. Finley, Ph.D.
Assistant Professor
Forest Resources

Helene Harvey
Graduate Assistant
Forest Resources

LETTER 2 - REQUEST FOR HELP IN ROUND 2

FORMS 1 & 2 INSTRUCTIONS

The original questionnaire asked whether certain vegetative structural features were needed by a species and if possible to provide quantitative ranges. The responses were consolidated, if possible, and are listed under the appropriate feature.

Form 1 includes those Pennsylvania species listed in "New England Wildlife: Management of Forested Habitats," by R. DeGraaf, M. Yamasaki, W. Leak, and J. Lanier. Information from this report is listed on the questionnaire in **bold print** while the panel's responses are in regular print. A blank cell in the table indicates that the structural feature is not required by the species.

Form 2 includes Pennsylvania species not listed in "New England Wildlife;" all of the information came from your responses.

In front of each response is a parenthesis ( ); for all responses please insert either:

(Y) for yes, I agree with the statement;
(N) for no, I don't agree with the statement; or
( ) left blank, indicating that you have no opinion about the statement.

Feel free to comment and add more information, use the back of the paper if you need to.

Important: Some of the responses ask for further information on quantities needed. We understand your reluctance to give quantities for some habitat features such as the number of dead and down logs. We know there is no single magic number or threshold level. But just as guidelines on the number of cavity trees and snags have been formulated, we hope to formulate guidelines on other features and need to know possible ranges. At least provide an estimate of the high end amount that you believe the species requires. Without your estimates resource managers will determine their own less informed guidelines, some of which will certainly not be sufficient.

In the bottom right corner of each block you'll notice a number, e.g. [2], this indicates the number of people who provided statements about the habitat feature. Some blocks have no number listed, but contain information in bold print; this indicates that the information came only from "New England Wildlife."

Abbreviations and Definitions used:

Species : G = Generalist - a species that doesn't require a single specific forest habitat, or structural feature, but is very flexible and can successfully shift from one forest condition to another.

S = Specialist - a species that requires a special combination of habitat/structural features to survive and reproduce, such as a cavity nester.

ROUND 2 INSTRUCTIONS FOR ALL COMMITTEE MEMBERS

Nonforest - a species that requires only nonforest habitats to complete its life cycle.

Water: T = temporary, P = permanent.

Dead & down or slash piles: Dead & down logs (D&D) - all woody material that is dead and lying on the ground that is at least 3 inches in diameter and at least 3 feet long.
Slash piles - piled brush.

Shrub & midstory cover: D = deciduous, C = coniferous, E = ericaceous.

Snag: any dead tree at least 4 inches in diameter at breast height (measured at 4 1/2 feet above the ground) and at least 6 feet tall.

Amphibians & Reptiles: Form 1: bold print indicates information from "New England Wildlife"

SPECIES G = generalist S = specialist	WATER Size, depth, & duration T=temporary P=permanent	SUBTERRANEAN Types	DEAD & DOWN (D&D) OR SLASH PILES Amounts: number/acre; % cover	COMMENTS
2 Marbled Salamander *Ambystoma opacum* ( )Specialist [2]	( ) uses temporary sources only ( ) >6" (15 cm) depth and >1076 ft^2 (100 m^2) area ( ) duration: September to June/July. [2]	( ) rocks; estimate % cover: ( ) muddy pond banks [1]	( ) requires D&D; estimate # of logs/acre & proximity of D&D to the water source: ( ) uses leaf litter and logs [2]	
3 Jefferson Salamander *Ambystoma jeffersonianum* ( )Specialist [2]	( ) uses temporary sources only ( ) >6" (15 cm) depth and >1076 ft^2 (100m^2) area ( ) duration: February to August [2]	( ) loose soil and leaf litter [1]	( ) requires D&D; estimate # of logs/acre & proximity of D&D to the water source: ( ) uses leaf litter and logs. [2]	
7 Spotted Salamander *Ambystoma maculatum* ( )Specialist [2]	( ) T sources used ( ) >6" (15 cm) depth and > 1076 ft^2 (100m^2) area ( ) duration: February to August ( ) also use permanent water on occasion. [2]	( ) rocks; estimate % cover: ( ) loose soil and leaf litter [2]	( ) requires D&D; estimate # of logs/acre & proximity of D&D to the water source: ( ) D & D used occasionally. ( ) uses leaf litter and logs [2]	
8 Red-spotted Newt *Notophthalmus v. viridescens* ( )Specialist [1]	( ) T or P sources used ( ) ponds <1076 ft^2 (100 m^2) in area to the edges of large lakes. ( ) usually permanent waters, but must have water spring to fall. ( ) 6" (15 cm) to several feet deep ( ) March to September. [2]		( ) requires D&D & slash piles; estimate # of logs & slash piles/acre & their proximity to the water source: ( ) D&D & slash piles may not be needed [1]	( ) needs forest litter & moss
9 Northern Dusky Salamander *Desmognathus f. fuscus* ( )Specialist [1]	( ) uses seeps ( ) also permanent small streams. ( ) slow first and second order creeks. [2]	( ) rocky crevices and scattered rock. ( ) rocky streambanks [2]	( ) uses leaf litter and logs; estimate #logs/acre: [2]	

APPENDIX F

SPECIES MATRIX

Cluster Analysis Species Matrix. Presence (1) indicates that the feature is required by the species. Absence (0) indicates that the feature is not required. Codes are explained on the last page.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
1	#	name	T	P	S	DD	G<30	Gmd	G>75	ShD	ShC	ShDC	ShE	Ssm	Smd	Slg	MD	MC	MB	Snag	Up1	Up2	Up3	Up4	R	L	M	Hi	Low	
2	2	Marbled Salamander	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	
3	3	Jefferson Salamander	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
4	7	Spotted Salamander	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	
5	8	Red-spotted Newt	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
6	9	Northern Dusky Salamand	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	
7	10	Mountain Dusky Salamand	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	
8	11	Redback Salamander	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	
9	12	Slimy Salamander	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	
10	13	Four-toed Salamander	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
11	14	Northern Spring Salamand	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
12	15	N. Two-lined Salamander	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	
13	17	Eastern American Toad	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
14	18	Fowler's Toad	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
15	19	Spring Peeper	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
16	20	Gray Treefrog	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
17	21	Bullfrog	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
18	22	Green Frog	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
19	24	Wood Frog	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
20	25	Northern Leopard Frog	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
21	26	Pickerel Frog	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
22	30	Bog Turtle	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
23	31	Wood Turtle	0	1	1	1	0	1	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
24	32	Eastern Box Turtle	0	0	0	1	0	1	1	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
25	40	Five-lined Skink	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
26	41	Northern Water Snake	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
27	42	Northern Brown Snake	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
28	43	Northern Redbelly Snake	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
29	44	Eastern Garter Snake	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
30	46	Eastern Ribbon Snake	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
31	49	Northern Ringneck Snake	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	

Cluster Analysis Species Matrix. Presence (1) indicates that the feature is required by the species. Absence (0) indicates that the feature is not required. Codes are explained on the last page.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
32	#	name	T	P	S	DD	G<30	Gmd	G>75	ShD	ShC	ShDC	ShE	Ssm	Smd	Slg	MD	MC	MB	Snag	Up1	Up2	Up3	Up4	R	L	M	Hi	Low	
33	51	Northern Black Racer	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
34	52	East. Smooth Green Snak	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
35	53	Black Rat Snake	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
36	54	Eastern Milk Snake	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
37	55	Northern Copperhead	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
38	56	Timber Rattlesnake	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
39	901	Green Salamander	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	
40	902	Northern coal skink	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	
41	903	Hellbender	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	
42	904	Ravine salamander	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	
43	905	Wehrle's salamander	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	
44	906	Queen snake	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
45	907	Broad-headed skink	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	
46	908	Seal salamander	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	
47	84	Turkey Vulture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	1	0	
48	88	Sharp-shinned Hawk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
49	89	Cooper's Hawk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	
50	90	Northern Goshawk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	
51	91	Red-shouldered Hawk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	
52	92	Broad-winged Hawk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
53	93	Red-tailed Hawk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	
54	95	Golden Eagle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	
55	96	American Kestrel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	
56	102	Ruffed Grouse	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	
57	103	Wild Turkey	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	
58	115	American Woodcock	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	
59	122	Mourning Dove	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	
60	123	Black-billed Cuckoo	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	
61	124	Yellow-billed Cuckoo	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	
62	126	Eastern Screech Owl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
63	#	name	T	P	S	DD	G<30	Gmd	G>75	ShD	ShC	ShDC	ShE	Ssm	Smd	Slg	MD	MC	MB	Snag	Up1	Up2	Up3	Up4	R	L	M	Hi	Low	
64	127	Great Horned Owl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
65	130	Barred Owl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	
66	131	Great Grey Owl	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
67	135	Northern Saw-whet Owl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	
68	137	Whip-poor-will	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
69	139	Ruby-throated Hummingb	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
70	141	Red-headed Woodpecker	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	
71	142	Red-bellied Woodpecker	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	
72	143	Yellow-bellied Sapsucker	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
73	144	Downy Woodpecker	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	
74	145	Hairy Woodpecker	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	
75	148	Northern Flicker	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	
76	149	Pileated Woodpecker	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	
77	150	Olive-sided Flycatcher	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	
78	151	Eastern Wood-Pewee	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	
79	153	Acadian Flycatcher	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	
80	154	Alder Flycatcher	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	
81	155	Willow Flycatcher	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	
82	156	Least Flycatcher	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
83	157	Eastern Phoebe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
84	158	Great Crested Flycatcher	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	
85	159	Eastern Kingbird	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	
86	161	Purple Martin	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
87	162	Tree Swallow	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
88	166	Barn Swallow	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
89	168	Blue Jay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	
90	169	American Crow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	
91	171	Raven	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	
92	172	Black-capped Chickadee	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	
93	909	Carolina Chickadee	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
94	#	name	T	P	S	DD	G<30	Gmd	G>75	ShD	ShC	ShDC	ShE	Ssm	Smd	Slg	MD	MC	MB	Snag	Up1	Up2	Up3	Up4	R	L	M	Hi	Low	
95	174	Tufted Titmouse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	
96	175	Red-breasted Nuthatch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
97	176	White-breasted Nuthatch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	
98	177	Brown Creeper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	
99	178	Carolina Wren	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
100	179	House Wren	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	
101	180	Winter Wren	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
102	183	Golden-crowned Kinglet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
103	184	Ruby-crowned Kinglet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
104	185	Blue-gray Gnatcatcher	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
105	186	Eastern Bluebird	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	
106	187	Veery	0	0	0	0	0	0	0	1	0	0	1	0	1	1	1	0	0	0	0	0	0	1	0	1	0	0	0	
107	188	Gray-cheeked Thrush	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	
108	189	Swainson's Thrush	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	
109	190	Hermit Thrush	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	
110	191	Wood Thrush	0	0	0	0	0	0	0	1	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	
111	192	American Robin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	
112	193	Gray Catbird	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	
113	194	Northern Mockingbird	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	
114	195	Brown Thrasher	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	
115	196	Bohemian Waxwing	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	
116	197	Cedar Waxwing	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	
117	198	Northern Shrike	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	
118	200	European Starling	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
119	201	White-eyed vireo	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
120	202	Solitary Vireo	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	
121	203	Yellow-throated Vireo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
122	204	Warbling Vireo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	
123	205	Philadelphia Vireo	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	
124	206	Red-eyed Vireo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
125	#	name	T	P	S	DD	G<30	Gmd	G>75	ShD	ShC	ShDC	ShE	Ssm	Smd	Slg	MD	MC	MB	Snag	Up1	Up2	Up3	Up4	R	L	M	Hi	Low	
126	207	Blue-winged Warbler	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
127	208	Golden-winged Warbler	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
128	209	Tennessee Warbler	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
129	210	Nashville Warbler	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	
130	211	Northern Parula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	
131	212	Yellow Warbler	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
132	213	Chestnut-sided Warbler	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
133	214	Magnolia Warbler	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	
134	215	Cape May Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
135	216	Black-throated Blue Warb	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	
136	217	Yellow-rumped warbler	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	
137	218	black-throated green war	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	
138	219	Blackburnian Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
139	220	Pine Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	
140	223	Bay-breasted Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
141	224	Blackpoll Warbler	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	
142	225	Cerulean Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
143	226	black-and-white warbler	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	
144	227	American Redstart	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
145	228	Prothonotary Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
146	229	Worm-eating Warbler	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	
147	230	Ovenbird	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	
148	231	Northern Waterthrush	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
149	232	Louisiana Waterthrush	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
150	233	Mourning Warbler	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
151	235	Hooded Warbler	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
152	236	Wilson's Warbler	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
153	237	Canada Warbler	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	
154	238	Yellow-breasted chat	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
155	910	Summer Tanager	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
156	#	name	T	P	S	DD	G<30	Gmd	G>75	ShD	ShC	ShDC	ShE	Ssm	Smd	Slg	MD	MC	MB	Snag	Up1	Up2	Up3	Up4	R	L	M	Hi	Low	
157	239	Scarlet Tanager	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
158	240	Northern Cardinal	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	1	
159	241	Rose-breasted Grosbeak	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
160	242	Indigo Bunting	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	
161	243	Rufous-sided Towhee	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	
162	244	American Tree Sparrow	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
163	245	Chipping Sparrow	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	1	
164	251	Fox Sparrow	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
165	252	Song Sparrow	0	0	0	0	0	0	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
166	253	Lincoln's Sparrow	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
167	255	White-throated Sparrow	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
168	256	Dark-eyed Junco	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
169	262	Rusty Blackbird	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
170	263	Common Grackle	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	
171	264	Brown-headed Cowbird	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	
172	265	Orchard Oriole	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	
173	266	Northern Oriole	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
174	267	Pine Grosbeak	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	
175	268	Purple Finch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
176	269	House Finch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
177	270	Red Crossbill	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	
178	271	White-winged Crossbill	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	
179	272	Common Redpoll	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
180	274	Pine Siskin	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	
181	275	American Goldfinch	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
182	276	Evening Grosbeak	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
183	278	Virginia Opossum	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	
184	282	Long-tailed Shrew	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
185	279	Masked Shrew	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
186	281	Smoky Shrew	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
187	#	name	T	P	S	DD	G<30	Gmd	G>75	ShD	ShC	ShDC	ShE	Ssm	Smd	Slg	MD	MC	MB	Snag	Up1	Up2	Up3	Up4	R	L	M	Hi	Low	
188	283	Pygmy Shrew	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
189	284	North. short-tailed shrew	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	
190	920	Maryland Shrew	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
191	286	Hairy-tailed Mole	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
192	287	Eastern Mole	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
193	288	Star-nosed Mole	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
194	289	Little Brown Myotis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
195	290	Keen's Myotis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
196	291	Indiana Myotis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
197	292	Small-footed Myotis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
198	293	Silver-haired Bat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
199	294	Eastern Pipistrelle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
200	295	Big-brown Bat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
201	296	Red Bat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
202	297	Hoary Bat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
203	299	New England Cottontail	0	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	
204	300	Snowshoe Hare	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
205	301	European Hare	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
206	302	Eastern Chipmunk	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	
207	304	Gray Squirrel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	
208	305	Red Squirrel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	
209	306	southern flying squirrel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	
210	307	northern flying squirrel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	
211	911	Eastern Fox Squirrel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
212	308	Beaver	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
213	309	Deer Mouse	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	
214	310	White-footed Mouse	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	
215	311	southern red-backed vole	0	1	1	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	
216	313	Rock Vole	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
217	314	Woodland Vole	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
218	#	name	T	P	S	DD	G<30	Gmd	G>75	ShD	ShC	ShDC	ShE	Ssm	Smd	Slg	MD	MC	MB	Snag	Up1	Up2	Up3	Up4	R	L	M	Hi	Low	
219	316	Southern Bog Lemming	1	0	1	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	
220	321	woodland jumping mouse	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
221	912	Eastern Woodrat	0	0	1	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	
222	322	Porcupine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	
223	323	Coyote	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
224	325	Gray Fox	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	
225	326	Black Bear	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	
226	327	Raccoon	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
227	913	Least Weasel	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
228	330	Ermine	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	
229	331	Long-tailed Weasel	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	
230	332	Mink	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
231	333	Striped Skunk	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	
232	334	River Otter	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
233	337	Bobcat	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	
234	338	White-tailed Deer	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Explanation Of Codes Used With The Cluster Analysis Species Matrix.

Column	Title	Explanation
A	#	Numbers used for coding purposes. '900' series are those species that inhabit Pennsylvania, but not found in DeGraaf et al. (1992).
B	name	Common name of vertebrate species used in the analysis.
C	T	Temporary water.
D	P	Permanent water.
E	S	Subterranean habitat.
F	DD	Dead & down woody debris and slash piles.
G	G<30	Percent ground cover less than 30%.
H	Gmd	Percent ground cover from 30% to 75%.
I	G>75	Percent ground cover greater than 75%.
J	ShD	Deciduous shrubs.
K	ShC	Coniferous shrubs.
L	ShDC	Deciduous and coniferous shrubs.
M	ShE	Ericaceous shrubs.
N	Ssm	Percent shrub cover less than 20%.
O	Smd	Percent shrub cover from 20 to 50%.
P	Slg	Percent shrub cover greater than 50%.
Q	MD	Deciduous midstory.
R	MC	Coniferous midstory.
S	MB	Deciduous and coniferous midstory.
T	Snag	Snags and/or cavity trees.
U	Up1	Overstory percent cover less than 15%.
V	Up2	Overstory percent cover from 16% to 30%.
W	Up3	Overstory percent cover from 31% to 70%.
X	Up4	Overstory percent cover greater than 70%.
Y	R	Rocks.
Z	L	Forest and leaf litter.
AA	M	Soft and hard mast.
AB	Hi	High perches.
AC	Low	Low perches.

APPENDIX G

DRAFT MANUAL FORMAT OF THE WILDLIFE HABITAT ASSESSMENT PROCESS

Example Of Using The Manual Format To Assess Wildlife Habitat Based On The Functional Group Matrix

This example uses information from stand 5 obtained during the inventory process to assess which wildlife habitats are present. First, a summary stand tally sheet (table A) is completed for stand 5. Table A is used to list the stand's forest type, size class, and physiographic province and summarize the habitat structural features found there. This information is then used to answer a series of questions about the presence or absence of habitat structural features. Answers appear in the shaded boxes.

If a particular structural feature is absent, then any functional groups (groups of wildlife species) requiring the absent feature will be dropped from the analysis. This is accomplished by drawing a line through the appropriate group number in the first column of the functional group matrix (table B) Please note: once a group is crossed out, it is never considered again.

Table A. Summary Stand Tally Sheet For Structural Features In Stand 5

Property name: Stewardship Woodlot **Stand #:** 5 Area: 4 acres

Physiographic province: Valley & Ridge

Forest type: Northern hardwood **Size-class:** Small sawtimber

Structural features - Stand summary:

Temporary water: none

Permanent water: none

Subterranean habitats: rock walls, rock piles, friable soils

Dead & down material: approximately 500 cubic feet per acre

% rock cover: 15%

Forest litter: present; >30%

% ground cover: 40%

% shrub cover: 10%

Shrub types: deciduous (100%) coniferous (0%) ericaceous (0%)

% midstory cover: 35%

Midstory types: deciduous (100%) coniferous (0%)

Snags and/or cavity trees: 8 snags; 5 trees with cavities per acre

% overstory cover: 85%

Mast: Hard (√) Soft (√); hickories, oaks, butternuts, cherries

High or low perches: High ( ) Low (√)

Stewardship prescription: Commercial thinning - reduce basal area to 100 square feet per acre removing cull and unacceptable growing stock first. Leave all cavity trees and snags unless they pose a hazard.

The following questions are used with stand 5's summary tally sheet (table A) and the functional group matrix (table B).

1. Are there any temporary ponds in the stand?
   If YES, go to question 2.
   If NO, draw a line through every row with the number 1 in it, then go to question 2.

> Table A lists no temporary ponds in the stand, so lines are drawn through groups #1 & 2 (the first two rows found on table B)

2. Are there any permanent water sources (seeps, permanent ponds, or perennial streams) in the stand?
   If YES, go to question 3.
   If NO, draw a line through every row with the number 2 in it, then go to question 3.

> No permanent water sources are in the stand, so lines are drawn through groups #3, 4, 5, 6, & 7.

3. Is subterranean habitat present (this includes rock crevices, rock piles, caves, and friable soils)?
   If YES, go to question 4.
   If NO, draw a line through every row with the number 3 in it, then go to question 4.

> Subterranean habitat is present, no groups are crossed out.

4. Is there more than 50 cubic feet of dead and down material (including slash piles) or more than 50 downed logs in the stand?
   If YES, go to question 5.
   If NO, draw a line through every row with the number 4 in it, then go to question 5.

> Ample dead & down material exists, no groups are crossed out.

5. Is there more than 25% rock cover in the stand?
   If YES, go to question 6.
   If NO, draw a line through every row with the number 5 in it, then go to question 6.

> Only 15% rock cover exists, groups #10 & 14 are crossed out.

6. Is more than 30% of the ground area covered by forest litter?
   If YES, go to question 7.
   If NO, draw a line through every row with the number 6 in it, then go to question 7.

> Greater than 30% forest litter in the stand, no groups are crossed out.

7. What is the percent ground cover? Choose one. (These ranges come straight out of DeGraaf et al., 1992.)

If it's between 0% and 29%, draw a line through every row with the number 8 in it, then go to question 8.

If it's between 30% and 75%, draw a line through every row with the numbers 7 and/or 8 then go to question 8.

If it's greater than 75%, draw a line through every row with the number 7 in it, then go to question 8.

> Percent ground cover is 40%; groups #15, 16, 17, 18, 19, & 20 are crossed out.

8. What is the percent shrub cover? Choose one. (these ranges were chosen after reviewing the responses.)

If it's between 0% and 20%, draw a line through every row with the numbers 9, 10, 11, and/or 12, then go to question 12.

If it's between 21% and 50%, draw a line through every row with the number 9 in it, then go to question 9.

If it's greater than 50%, then go to question 9.

> Percent shrub cover is 10%; groups #12, 21, 22, 23, 24, & 25 are crossed out. Ignore questions 9 through 11.

9. Are at least 25% of the shrubs deciduous?

If YES, go to question 10.

If NO, draw a line through every row with the number 10 in it, then go to question 10.

> This question is not considered.

10. Are at least 25% of the shrubs coniferous?

If YES, go to question 11.

If NO, draw a line through every row with the number 11 in it, then go to question 11.

> This question is not considered.

11. Are at least 25% of the shrubs ericaceous?
If YES, go to question 12.
If NO, draw a line through every row with the number 12 in it, then go to question 12

This question is not considered.

12. Is percent midstory cover >25%?
If YES, then go to question 13.
If NO, draw a line through every row with the numbers 13 and/or 14, then go to question 15.

Percent midstory cover is 35%, no groups are crossed out.

13. Is the midstory composed of at least 25% deciduous species?
If YES, then go to question 14.
If NO, draw a line through every row with the number 13 in it, then go to question 14.

The midstory is 100% deciduous; no groups are crossed out.

14. Is the midstory composed of at least 25% coniferous species?
If YES, then go to question 15.
If NO, draw a line through every row with the number 14 in it, then go to question 15.

No coniferous midstory present; group #27 is crossed out.

15. Are there snags and/or cavity trees present?
If YES, go to question 16.
If NO, draw a line through every row with the number 15 in it, then go to question 16.

Numerous snags and/or cavity trees are present; no groups are crossed out.

16. What is the percent overstory cover? Choose one.
If it's between 0% and 15%, draw a line through every row with the numbers 17, 18, and/or 19, then go to question 17.
If it's between 16% and 30%, draw a line through every row with the numbers 16, 18, and/or 19, then go to question 17.
If it's between 31% and 70%, draw a line through every row with the numbers 16, 17, and/or 19, then go to question 17.
If it's greater than 71%, draw a line through every row with the numbers 16, 17, and/or 18, then go to question 17.

> Percent overstory cover is 85%; groups #29, 31, 32, & 33 are crossed out.

17. Are either hard or soft mast species present?
If YES, go to question 18.
If NO, draw a line through every row with the number 20 in it, then go to question 18.

> Both soft and hard mast available; no groups are crossed out.

18. Are there high perches in the stand?
If YES, go to question 19.
If NO, draw a line through every row with the number 21 in it, then go to question 19.

> No high perches are in the stand; group #35 is crossed out.

19. Are there low perches in the stand?
If YES, go to question 20.
If NO, draw a line through every row with the number 22 in it, then go to question 20.

> Several low perches exist; no groups are crossed out.

20. At this point, all of the questions about vegetative structural features have been answered.

Notice that several rows on table B are not crossed out; these rows contain wildlife groups that have habitat in the stand. The groups remaining are: 8, 9, 11, 13, 26, 28, 30, 34, 36, & 37. Although the group numbers are shown, we need to know the species within each group.

In chapter 4, results and discussion, table 22 listed the species that are in particular functional groups. Table 22 is the master list. This list needs to be modified to reflect that certain species will not inhabit a particular forest type or size class. In this example the appropriate forest type is northern hardwoods (listed on the top of table A) and the size class is small sawtimber. Table C lists the modified functional groups and associated species for a small sawtimber sized northern hardwoods stand.

Group numbers that were not crossed out through the question and answer process are listed near the top of table C; these are the functional groups that have habitat in stand 5. Groups that have been eliminated (crossed out on the functional group matrix, table B) appear shaded in table C.

Notice that in group 34 the summer tanager is also shaded. This reflects the fact that the summer tanager's range does not include the Valley and Ridge physiographic province in Pennsylvania. The remaining unshaded groups and species are those that should inhabit stand 5.

Table B. Functional Group Matrix.

GROUP #	TEMPORARY WATER	PERMANENT WATER	SUBTERRANEAN	DEAD & DOWN	% ROCKS	% LITTER	<30% GROUND COVER	>75% GROUND COVER	>50% SHRUB COVER	DECIDUOUS SHRUBS	CONIFEROUS SHRUBS	ERICACEOUS SHRUBS	DECIDUOUS MIDSTORY	CONIFEROUS MIDSTORY	CAVITY TREES & SNAGS	<15% OVERSTORY	16 TO 30% OVERSTORY	31 TO 70% OVERSTORY	>70% OVERSTORY	MAST	HI PERCH	LO PERCH
1	1																					
2	1			4		6																
3		2																				
4		2	3			6			9													
5		2		4	5	6																
6		2			5																	
7		2				6	7															
8			3																			
9			3	4																20		
10				4	5																	
11				4		6																
12				4		6				10									19			
13				4											15							
14					5																	
15								8														
16								8	9	10												
17								8		10		12				16						22
18								8			11	12										
19								8							15							
20								8									17			20		
21									9	10		12										
22										10	11	12				16				20		
23										10		12						18				
24										10			13									
25											11			14								
26													13							20		
27														14					19			
28															15							
29															15		17					
30															15					20		
31																16					21	
32																	17					
33																		18				
34																			19			
35																					21	22
36																						22
37																						

Table C. Functional Groups For The Northern Hardwood Forest Type
And Small Sawtimber Size Class

Northern Hardwoods - Small Sawtimber

Stand 5 present functional groups: 8, 9, 11, 13, 26, 28, 30, 34, 36, & 37

Group Number	Species	
#1	eastern American toad spring peeper	gray treefrog bog turtle
#2	Jefferson salamander spotted salamander	red-spotted newt four-toed salamander wood frog
#3	eastern American toad spring peeper gray treefrog racoon	pickerel frog bullfrog river otter beaver
#4	wood turtle northern short-tailed shrew southern red-backed vole	woodland vole southern bog lemming mink
#5	red-spotted newt spotted salamander northern dusky salamander mountain dusky salamander	four-toed salamander wood frog northern two-lined salamander Jefferson salamander
#6	northern coal skink Queen snake seal salamander	northern spring salamander eastern ribbon snake rock vole
#7	northern waterthrush	
#8	hairy-tailed mole	coyote
#9	black bear striped skunk	eastern chipmunk

(Continued) Table C. Functional Groups For The Northern Hardwood Forest Type And Small Sawtimber Size Class

Group Number	Species	
#10	woodland jumping mouse northern brown snake five-lined skink	eastern milk snake northern black racer long-tailed shrew
#11	Maryland shrew redback salamander	pygmy shrew masked shrew smoky shrew
#12	hermit thrush worm-eating warbler Canada warbler Wehrle's salamander	ermine bobcat ravine salamander slimy salamander
#13	broad-headed skink gray fox house wren	Virginia opossum winter wren
#14	northern ringneck snake timber rattlesnake	northern redbelly snake
#15	eastern smooth green snake	eastern garter snake
#16	eastern box turtle white-tailed deer	hooded warbler
#17	northern shrike yellow warbler	song sparrow American goldfinch
#18	dark-eyed junco white-throated sparrow	snowshoe hare
#19	European starling	
#20	ruffed grouse wild turkey	deer mouse white-footed mouse

(Continued) Table C. Functional Groups For The Northern Hardwood Forest Type And Small Sawtimber Size Class

Group Number	Species	
#21	yellow-billed cuckoo gray catbird	black-throated blue warbler
#22	cedar waxwing	
#23	black-billed cuckoo whip-poor-will	ruby-throated hummingbird eastern woodrat
#24	American robin veery wood thrush	American redstart rose-breasted grosbeak
#25	Swainson's thrush yellow-rumped warbler	blackpoll warbler white-winged crossbill
#26	raven American crow	blue jay
#27	solitary vireo northern parula	pine grosbeak pine siskin
#28	eastern fox squirrel barred owl yellow-bellied sapsucker red-breasted nuthatch great crested flycatcher	little brown myotis northern myotis Indiana myotis silver-haired myotis big brown bat

(Continued) Table C. Functional Groups For The Northern Hardwood Forest Type And Small Sawtimber Size Class

Group Number	Species	
#29	turkey vulture	northern flicker
	eastern screech owl	pileated woodpecker
	northern saw-whet owl	downy woodpecker
#30	Carolina chickadee	brown creeper
	hairy woodpecker	gray squirrel
	black-capped chickadee	red squirrel
	tufted titmouse	southern flying squirrel
	white-breasted nuthatch	northern flying squirrel
		porcupine
#31	Cooper's hawk	golden eagle
	red-tailed hawk	northern oriole
#32	red-shouldered hawk	mourning dove
	golden eagle	warbling vireo
	American woodcock	
#33	eastern pipistrelle	blue-gray gnatcatcher
	Cooper's hawk	yellow-throated vireo
	northern goshawk	
#34	summer tanager	red-eyed vireo
	sharp-shinned hawk	black-throated green warbler
	northern goshawk	Blackburnian warbler
	red-shouldered hawk	scarlet tanager
	broad-winged hawk	red bat
	great horned owl	hoary bat
	least flycatcher	golden-crowned kinglet
	red-tailed hawk	ovenbird
	black & white warbler	
#35	brown-headed cowbird	
#36	eastern phoebe	eastern wood-pewee
#37	purple finch	evening grosbeak

To predict which functional groups and species will inhabit stand 5 after the proposed commercial thinning (this prescription is listed at the bottom of table A), it is first necessary to fill out a summary stand tally sheet listing the changes to the vegetative structural features caused by the thinning. Table D shows that the forester predicts that both percent ground and shrub cover will increase, midstory percent cover will decrease, and the remaining structural features should exhibit no change from the present conditions.

Table D. Predicted Structural Feature Changes Due To Commercial Thinning Of Stand 5

Property name: Stewardship Woodlot **Stand #:** 5 Area: 4 acres

Physiographic province: Valley & Ridge

Forest type: Northern hardwood **Size-class:** Small sawtimber

Structural features - Stand summary:

Temporary water: none; no change

Permanent water: none; no change

Subterranean habitats: rock walls, rock piles, friable soils; no change

Dead & down material: >500 cubic feet; increases from cut tops and cull logs

% rock cover: 15%; no change

Forest litter: >30%; no change

% ground cover: increases to >75% from increased sunlight

% shrub cover: increases to >20% but < 50%

Shrub types: deciduous (100%) coniferous (0%) ericaceous (0%); no change

% midstory cover: decreases to less than 25%

Midstory types: deciduous (100%) coniferous (0%); no change

% overstory cover: decreases, but still > 70%

Snags and/or cavity trees: no change or slight reduction

Mast: no change in species, should increase production

High or low perches: new low perches created from residual tops

By repeating the process of answering the original twenty questions with the information in table D, a new set of functional groups is predicted. Table E lists both the present and predicted functional group numbers. Notice that wildlife habitat for one of the original groups is eliminated (group 26) while providing habitat for two new groups (groups 15 and 19).

Table E. Comparison Of Present And Predicted Functional Groups In Stand 5

Present	Predicted
8	8
9	9
11	11
13	13
26	15
28	19
30	28
34	30
36	34
37	36
	37

All of the species affected by the predicted vegetative changes are quite common, such as the crow. But whether common or uncommon, the next step is to decide whether habitat exists in the surrounding area for the eliminated species. A check of inventory data for the Stewardship Woodlot and examination of aerial photos reveals that appropriate habitat exists in the surrounding landscape for species whose habitat would be eliminated through a commerical thinning of stand 5.

If habitat was not available in the surrounding area, alternatives could be considered such as:

- modifying the prescription to leave more midstory cover;
- delaying the thinning until suitable habitat is available in the surrounding area;
- deciding to proceed with the thinning considering that the landowner's objectives do not include management of the 'eliminated species'.

APPENDIX H

DRAFT COMPUTER FORMAT OF THE
WILDLIFE HABITAT ASSESSMENT PROCESS

This program was constructed through a system called GNOSIS. The concept of GNOSIS is that you shouldn't have to do all of the work when using a computer--so GNOSIS has enlisted a group of "gnomes" to do it for you. All *you* have to do is insert the diskette, and from DOS, change the default directory to the diskette's drive, type "RUN" and hit RETURN. The gnomes will do the rest. The gnomes of GNOSIS were discovered at the Pennsylvania State University by Dr. Wayne L. Myers and Dr. Michael Foster.

HABITAT gnomes will work only on IBM-compatible machines. The computer must have at least 640K of memory available, and have the capacity to handle a high density disk. The gnomes will ask you a series of questions about the habitat structure characteristics found in the stand (see the following page), then automatically compare these values to the habitat requirements of the wildlife species of concern. If your computer is connected to a printer, the gnomes will let you print a list of the species; otherwise, you can ask them to display the list of species on the screen.

The following pages take you through a sample run of the program. The program includes descriptions of each choice, as well as directions on how to understand each screen and select the appropriate answer. But don't worry about memorizing the entire manual--the gnomes will be there to help if you get confused while you're trying to run the program.

What is the forest type of the stand?

Aspen-Birch	Spruce-Fir	Red oak-White pine-Red maple mix
Northern hardwood	Eastern hemlock	White pine
Red maple	Northern red oak	

What is the size class of the stand?

Seedling | Sapling-Pole | Small sawtimber | Large sawtimber

What physiographic province is the stand in?

Central Lowland	Appalachian Plateau	Valley and Ridge
Blue Ridge	New England	Piedmont Plateau
Coastal Plain		

Is there at least 50 cubic feet of dead or downed wood on the forest floor?

Yes | No

Is there at least 25% rock cover on the forest floor?

Yes | No

Does forest litter cover at least 30% of the ground?

Yes | No

What is the percent vegetative ground cover in the stand?

0-29% | 30-75% | ≥76%

What is the percent shrub cover in the stand?

0-20% | 21-50% | ≥51%

What types of shrub species are present? (Select all that apply.)

Deciduous | Coniferous | Ericaceous

What types of midstory species are present? (Select all that apply.)

Deciduous | Coniferous

What is the percent overstory cover in the stand?

0-15% | 16-30% | 31-70% | ≥71%

Which of these water sources appear in the stand? (Select all that apply.)

Temporary ponds | Permanent ponds | Permanent streams | Seeps

Which subterranean features appear in the stand? (Select all that apply.)

Loose soil | Rock piles | Rock crevices | Caves

Which of these features appear in the stand? (Select all that apply.)

Dead cavity trees	Soft mast producers	High perches
Live cavity trees	Hard mast producers	Low perches

```
C:\>B:

B:\>run

b:\>echo off
SOFTWARE LOADING IN PROGRESS - Please wait for direction.
```

To run the program HABITAT, all you have to do is insert the disk, change the current directory to the diskette's drive (in this case, the B: drive), type "run", and hit ENTER. There will be a slight wait while the computer wakes the gnomes up, especially on the older computers. (It seems that those older gnomes tire more easily.) Be patient, and the gnomes will eventually bring up the next screen.

Press the ENTER key for colorful personality.
Other keys give offcolor expression.

The gnomes behind the scenes are rather quirky individuals. This is their way of asking you if you have a color monitor. If you do, and you want to see the program in color, hit ENTER. Hitting any other key will produce a black and white session. If you have a black-and-white monitor, it will not matter what key you press. Once the gnomes know what you prefer, they will begin the actual program.

Gives cursor position as you scroll through introduction.

Line 1 Column 1

Welcome to the wildlife habitat evaluation system. This computer program is a tool to help you evaluate wildlife habitat from information on habitat structural features measured during a forest inventory. The various combinations of vertical and horizontal vegetative structural features, such as the amount of dead and down material or percent cover of different vegetative layers, define available wildlife habitat.

By answering a series of questions, the program will produce a list of wildlife species that could inhabit the stand under those conditions. Future wildlife habitat can be obtained by running the program again, but this time predicting changes to vegetative structural features caused by prescribed management activities. By evaluating which habitats increase or decrease, are created or eliminated, you can decide whether the changes meet the landowner's objectives or if the management activities should be modified.

How accurate is the database?

Guidance

Use arrows as necessary to read the above introduction.
Then press the F10 key to continue.

Instructions on how to read introduction.

This screen gives you a brief introduction to the system. Notice that the bottom portion of the screen is labeled "Guidance." When you see the word "Guidance" on the lower section, that means that the gnomes are providing you with some instructions. In this case, they are telling you how to scroll through the screen so you can read the entire document, and how to exit the introduction screen and proceed to the program.

Tells which screen is showing

MainMenu NEXUS showing ITEMs 1 - 6 of 6

Review introduction. ← *Return to the first screen.*

Begin consultation. ← *Enter stand characteristics.*

Display results of habitat assessment on the screen. ← *Show list on monitor.*

Print out results of habitat assessment. ← *Send species list to the printer.*

Quit. ← *Exits the system.*

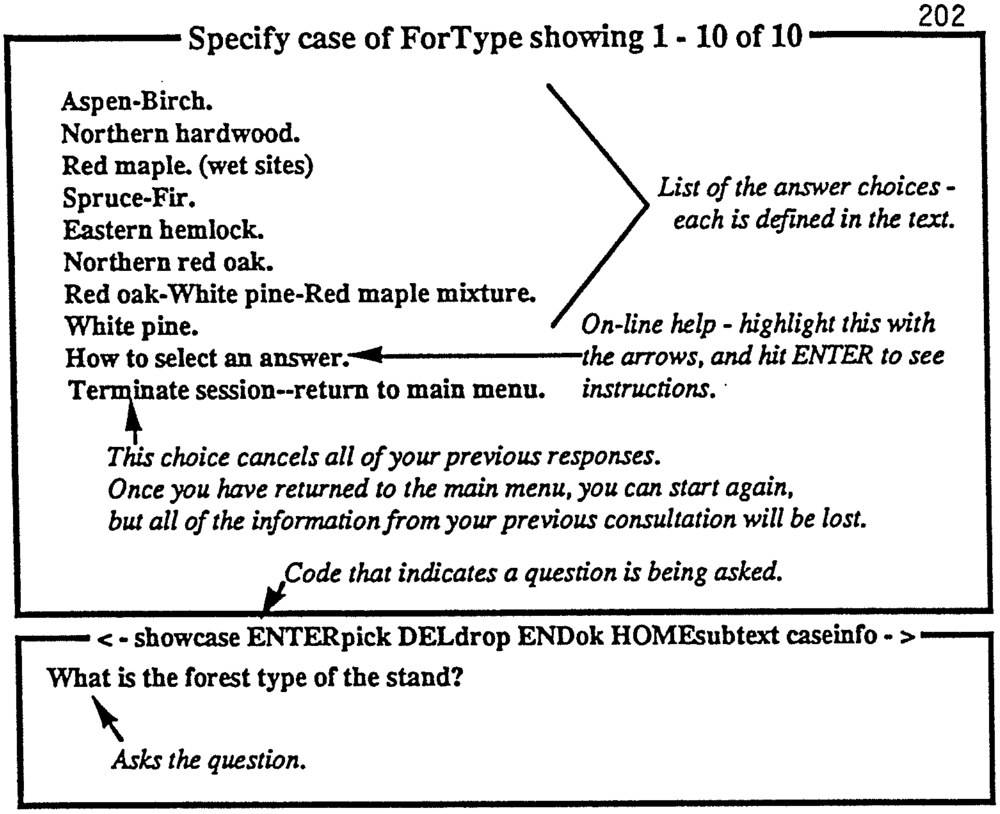
Instructions on how to make your choice.

Guidance

Use up/down arrow keys to step over items. Use ENTER key to select an item.
Right arrow key gives ITEMaid. Left arrow is backpedal key.
Use ESC key to interrupt session for later pickup at same point.

At this screen, the gnomes are really ready to go to work. There are several things you should know about the different choices. First, if you select either the "Display..." or "Print..." option before you have entered any stand characteristics, the results will be left over from the previous evaluation. They will not be erased between runs, so you can keep the answers until you need to use the system again. If you select "Begin consultation," and later need to break out of the question sequence (perhaps because of an incorrect response), you will no longer be able to access the results from the previous consultation. Old results are erased each time "Begin consultation" is selected. Additionally, the gnomes will not be able to run the habitat assessment if you have broken out of the sequence--you must answer all of the questions to get an evaluation.

Here again, the gnomes are providing instructions. The "Guidance" tells you how to make your selection. We have chosen "Begin consultation."



After a brief pause (which will be slightly longer because of the older, tired gnomes in the older computers), you will see this screen. This is the first question the gnomes ask you. Before we choose an answer, we will show you how to ask the gnomes for help. Remember, you can ask them to remind you how to choose your answer from any screen.

Specify case of ForType showing 1 - 10 of 10

Aspen-Birch.
Northern hardwoods
Red maple. (wet sites)
Spruce-Fir.
Eastern hemlock.
Northern red oak.
Red oak-White pine-Red maple mixture.
White pine.
How to select an answer.
Terminate session--return to main manu.

Instructions on how to exit the "How to..." mode.

Press an active key to continue.

Highlight your answer with up/down arrow keys.
ENTER for initial selection, and ENTER again or END to finalize.
DEL cancels initial selection. Left arrow for graphic if available.
Right arrow for extended description of answer if available.

Graphics are not available in this program.
However, hitting the right arrow key will cause a definition similar to the one found in the text to appear on the screen.

After highlighting "How to select an answer," hit ENTER. The gnomes will print out their instruction in the bottom portion of the screen. Then, when you are through reading their advice, simply hit any key on the keyboard to return to the choices and make your selection.

Specify case of ForType showing 1 - 10 of 10

Aspen-Birch.
Northern hardwood.
Red maple.
Spruce-Fir.
EASTERN HEMLOCK.
Northern red oak.
Red oak-White pine-Red maple mixture.
White pine.
How to select an answer.
Terminate session--return to Main Menu.

Highlight your choice and hit ENTER - the choice will appear in all capitals. You must hit ENTER again to tell the computer to save this answer.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

What is the forest type of the stand?

This and the next fifteen pages will show the answers we have given to the gnomes. Between each question, the gnomes will take a short moment to save the information you have provided. When you see the words "A MOMENT FOR THOUGHT ... PATIENCE IS A VIRTUE" at the bottom of the screen, it means that the gnomes are at work. It is important that you DO NOT press any keys until the next question appears. If you do, you may accidentally make a selection for the next question. You cannot change any wrong answers without breaking out of the whole system and starting over.

Specify case of ForSize showing 1 - 7 of 7

Seedling.
Sapling-pole.
SMALL SAWTIMBER *(Our choice - notice the capital letters.)*
Large sawtimber.
Uneven-aged stand. (NOTE: for Northern hardwood type only.)
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

What is the size class of the stand?

Specify case of Province showing 1 - 9 of 9

Central Lowland.
Appalachian Plateau.
Valley and Ridge.
BLUE RIDGE.
New England.
Piedmont Plateau.
Coastal Plain.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

What physiographic province is the stand in?

Specify case of Dead showing 1 - 4 of 4

YES.
No.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

Is there at least 50 cubic feet of dead or downed wood on the forest floor?

Specify case of Rock showing 1 - 4 of 4

YES.
No.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

Is there at least 25% rock cover on the forest floor?

Specify case of Litter showing 1 - 4 of 4

YES.
No.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

Does forest litter cover at least 30% of the ground?

Specify case of GCover showing 1 - 5 of 5

0-29% ground cover.
30-75% GROUND COVER.
76% or greater ground cover.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

What is the percent vegetative ground cover in the stand?

Specify case of SCover showing 1 - 5 of 5

0-20% shrub cover.
21-50% shrub cover.
51% OR GREATER SHRUB COVER.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

What is the percent shrub cover in the stand?

Specify case(s) of SComp showing 1 - 5 of 5

DECIDUOUS.
Coniferous.
ERICACEOUS.
How to select an answer.
Terminate session--return to Main Menu.

When you are asked to choose more than one answer, do so by highlighting and hitting ENTER on each choice separately. Then, when all of your choices are in capital letters, hit ENTER again on your last choice to save them all to the computer's memory.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

What types of shrub species are present?
(Select all that apply.)

Specify case(s) of MComp showing 1 - 5 of 5

Deciduous.
Coniferous.
THERE IS LESS THAN 25 PERCENT MIDSTORY COVER.
How to select an answer.
Terminate session--return to Main Menu.

If there is less than 25% midstory cover, you do not need to specify what types of plants are present. Choose this answer by itself.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

What types of midstory species are present?
(Select all that apply.)

Specify case of OCover showing 1 - 6 of 6

0-15% overstory cover.
16-30% overstory cover.
31-70% OVERSTORY COVER.
71% or greater overstory cover.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

What is the percent overstory cover in the stand?

Specify case(s) of Water showing 1 - 7 of 7

TEMPORARY PONDS.
Permanent ponds.
SEEPS.
Streams.
None of the above.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

Which of these water sources appear in the stand?
(Select all that apply.)

Specify case(s) of Subter showing 1 - 7 of 7

LOOSE SOILS.
Rock piles.
Rock crevices.
Caves.
None of the above.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

Which of these subterranean features appear in the stand?
(Select all that apply.)

Specify case(s) of Snag showing 1 - 5 of 5

Dead cavity trees.
Live cavity trees.
NONE OF THE ABOVE.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

Which of these features appear in the stand?
(Select all that apply.)

Specify case(s) of Mast showing 1 - 5 of 5

SOFT MAST PRODUCERS.
HARD MAST PRODUCERS.
None of the above.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

Which of these features appear in the stand?
(Select all that apply.)

Specify case(s) of Perch showing 1 - 5 of 5

High perches.
LOW PERCHES.
None of the above.
How to select an answer.
Terminate session--return to Main Menu.

< - showcase ENTERpick DELdrop ENDok HOMEsubtext caseinfo - >

Which of these features appear in the stand?
(Select all that apply.)

This is the final question. Once you have entered your response, the gnomes will begin their work on comparing the stand characteristics to the wildlife species habitat requirements. While they do this, you will see only a blank screen with what looks like a cursor flashing at the top. This is normal--fast gnomes will only take several seconds to complete their task, but the older gnomes will need a longer time. Have patience, and they will eventually take you once again to the main menu.

MainMenu NEXUS showing ITEMs 1 - 6 of 6

Review introduction.

Begin consultation.

Display results of habitat assessment on the screen.

Print out results of habitat assessment.

Quit.

Guidance

Use up/down arrow keys to step over items. Use ENTER key to select an item.
Right arrow key gives ITEMaid. Left arrow is backpedal key.
Use ESC key to interrupt session for later pickup at same point.

The gnomes will automatically assume that after you have finished your consultation, you will want to see your results. If you want to see them printed to the screen, simply hit ENTER, and they will appear. If you want to print them out, move the highlight with the arrow keys, and hit ENTER on the "Print out results..." choice.

Line 1 Column 1

Redback salamander
Slimy salamander
Eastern American toad
Northern brown snake
Northern redbelly snake
Northern ringneck snake
Northern copperhead
Cooper's hawk
Northern goshawk
Ruby-throated hummingbird
Eastern phoebe
American crow
Ovenbird
Common yellowthroat
Purple finch
Evening grosbeak

Guidance

Use arrows as necessary to read the above introduction.
Then press the F10 key to continue.

This is the final list of species whose habitat requirements are met by the stand's present characteristics. Again, remember that this is not a guarantee that all of these species will be there. This is simply the results based on a "snapshot in time" of the stand. If you like, return to the main menu and begin the consultation again, but this time enter the characteristics which you project will be present after some management activity. You can compare the two lists to determine which species may be affected--some may disappear from the list, and others may only show up only after the changes.

Sometimes, there may be slight discrepancies between the results you get from the manual matrix and the computer system. These differences will most likely be negligible, and result from the need to group similar species together in the matrix. The matrix may take a bit more time to complete, but you get to see the limiting factors for the groups of species which do not appear in the results. But once you understand how to operate the computer system, the gnomes will provide results much more quickly.

APPENDIX F

Chart to Convert BAF Tally Trees to Number of Trees/Acre

Chart To Convert The Number Of Trees Tallied In A BAF plot To Numbers Of Trees Per Acre

Number of trees tallied	Diameter class (inches)												
	2	4	6	8	10	12	14	16	18	20	22	24	26
1	458	115	51	29	18	13	9	7	6	5	4	3	3
2	917	229	102	57	37	25	19	14	11	9	8	6	5
3	1375	344	153	86	55	38	28	21	17	14	11	10	8
4	1834	458	204	115	73	51	37	29	23	18	15	13	11
5	2292	573	255	143	92	64	47	36	28	23	19	16	13
6	2750	688	306	172	110	76	56	43	34	27	23	19	16
7	3209	802	357	201	128	89	65	50	40	32	26	23	19
8	3667	917	407	229	147	102	75	57	45	36	30	26	21
9	4125	1031	458	258	165	115	84	64	51	41	34	29	24
10	4584	1146	509	287	183	127	93	71	57	46	38	32	27
11	5042	1260	560	315	202	140	103	78	62	50	42	35	29
12	5501	1375	611	344	220	153	112	86	68	55	45	39	32
13	5959	1490	662	373	238	165	121	93	74	59	49	42	35
14	6417	1604	713	401	257	178	131	100	79	64	53	45	37
15	6875	1719	764	430	275	191	140	107	85	68	57	48	40
16	7333	1834	815	459	293	204	149	114	91	73	60	52	43
17	7792	1948	866	487	312	216	159	121	96	77	64	55	45
18	8250	2063	917	516	330	229	168	128	102	82	68	58	48
19	8707	2177	968	545	348	242	177	136	108	87	72	61	51
20	9167	2292	1019	573	367	255	187	143	113	91	76	64	53

EX: The following trees were tallied on a 10 BAF prism plot:

three 16" DBH trees
five 12" DBH trees
one 6" DBH tree.

The number of trees per acre determined from this plot is:

21 + 64 + 51 = 136 trees per acre.

APPENDIX G

Alphabetical List of Species Included in Assessment

Common name	Species name
Acadian flycatcher	*Empidonax virescens*
Alder flycatcher	*Empidonax alnorum*
American crow	*Corvus brachyrhynchos*
American goldfinch	*Carduelis tristis*
American kestrel	*Falco sparverius*
American redstart	*Setophaga ruticilla*
American robin	*Turdus migratorius*
American tree sparrow	*Spizella arborea*
American woodcock	*Scolopax minor*
Barn swallow	*Hirundo rustica*
Barred owl	*Strix varia*
Bay-breasted warbler	*Dendroica castanea*
Beaver	*Castor canadensis*
Big brown bat	*Eptesicus fuscus*
Black bear	*Ursus americanus*
Black rat snake	*Elaphe o. obsoleta*
Black-and-white warbler	*Mniotilta varia*
Black-billed cuckoo	*Coccyzus erythropthalmus*
Black-capped chickadee	*Parus atricapillus*
Black-throated blue warbler	*Dendroica caerulescens*
Black-throated green warbler	*Dendroica virens*
Blackburnian warbler	*Dendroica fusca*
Blackpoll warbler	*Dendroica striata*
Blue jay	*Cyanocitta cristata*
Blue-gray gnatcatcher	*Polioptila caerulea*
Blue-winged warbler	*Vermivora pinus*
Bobcat	*Felis rufus*
Bog turtle	*Clemmys muhlenbergii*
Broad-headed skink	*Eumeces laticeps*
Broad-winged hawk	*Buteo platypterus*
Brown creeper	*Certhia americana*
Brown thrasher	*Toxostoma rufum*
Brown-headed cowbird	*Molothrus ater*
Bullfrog	*Rana catesbeiana*
Canada warbler	*Wilsonia canadensis*
Cape May warbler	*Dendroica tigrina*
Carolina chickadee	*Parus carolinensis*
Carolina wren	*Thryothorus ludovicianus*
Cedar waxwing	*Bombycilla cedrorum*
Cerulean warbler	*Dendroica cerulea*
Chestnut-sided warbler	*Dendroica pensylvanica*
Chipping sparrow	*Spizella passerina*
Common grackle	*Quiscalus quiscula*
Cooper's hawk	*Accipiter cooperii*
Coyote	*Canis latrans*
Dark-eyed junco	*Junco hyemalis*
Deer mouse	*Peromyscus maniculatus*
Downy woodpecker	*Picoides pubescens*
Eastern American toad	*Bufo a. americanus*
Eastern bluebird	*Sialia sialis*
Eastern box turtle	*Terrapene c. carolina*
Eastern chipmunk	*Tamias striatus*

Eastern fox squirrel	*Sciurus niger vulpinus*
Eastern garter snake	*Thamnophis s. sirtalis*
Eastern kingbird	*Tyrannus tyrannus*
Eastern milk snake	*Lampropeltis t. triangulum*
Eastern mole	*Scalopus aquaticus*
Eastern phoebe	*Sayornis phoebe*
Eastern pipistrelle	*Pipistrellus subflavus*
Eastern ribbon snake	*Thamnophis s. sauritus*
Eastern screech owl	*Otus asio*
Eastern smooth green snake	*Opheodrys v. vernalis*
Eastern spadefoot	*Scaphiopus h. holbrookii*
Eastern wood-pewee	*Contopus virens*
Eastern woodrat	*Neotoma magister*
Ermine	*Mustela erminea*
European starling	*Sturnis vulgaris*
Evening grosbeak	*Coccothraustes vespertinus*
Five-lined skink	*Eumeces fasciatus*
Four-toed salamander	*Hemidactylium scutatum*
Fowler's toad	*Bufo woodhousii fowleri*
Fox sparrow	*Passerella iliaca*
Golden eagle	*Aquila chrysaetos*
Golden-crowned kinglet	*Regulus satrapa*
Golden-winged warbler	*Vermivora chrysoptera*
Gray catbird	*Dumetella carolinensis*
Gray fox	*Urocyon cinereoargenteus*
Gray squirrel	*Sciurus carolinensis*
Gray treefrog	*Hyla versicolor*
Gray-cheeked thrush	*Catharus minimus*
Great crested flycatcher	*Myiarchus crinitus*
Great horned owl	*Bubo virginianus*
Green frog	*Rana clamitans melanota*
Green salamander	*Aneides aeneus*
Hairy woodpecker	*Picoides villosus*
Hairy-tailed mole	*Parascalops breweri*
Hermit thrush	*Catharus guttatus*
Hoary bat	*Lasiurus cinereus*
Hooded warbler	*Wilsonia citrina*
House finch	*Carpodacus mexicanus*
House wren	*Troglodytes aedon*
Indiana myotis	*Myotis sodalis*
Indigo bunting	*Passerina cyanea*
Jefferson salamander	*Ambystoma jeffersonianum*
Kentucky warbler	*Oporornis formosus*
Least flycatcher	*Empidonax minimus*
Least weasel	*Mustela rixosa*
Lincoln's sparrow	*Melospiza lincolnii*
Little brown myotis	*Myotis lucifugus*
Long-tailed shrew	*Sorex dispar*
Long-tailed weasel	*Mustela frenata*
Louisiana waterthrush	*Seiurus motacilla*
Magnolia warbler	*Dendroica magnolia*
Marbled salamander	*Ambystoma opacum*
Maryland shrew	*Sorex fontinalis*
Masked shrew	*Sorex cinereus*

Mink	*Mustela vison*
Mountain dusky salamander	*Desmognathus ochrophaeus*
Mourning dove	*Zenaida macroura*
Mourning warbler	*Oporornis philadelphia*
Nashville warbler	*Vermivora ruficapilla*
New England cottontail	*Sylvilagus floridanus*
Northern black racer	*Coluber c. constrictor*
Northern brown snake	*Storeria d. dekayi*
Northern cardinal	*Cardinalis cardinalis*
Northern coal skink	*Eumeces a. Anthracinus*
Northern copperhead	*Agkistrodon contortrix mokeson*
Northern dusky salamander	*Desmognathus f. fuscus*
Northern flicker	*Colaptes auratus*
Northern flying squirrel	*Glaucomys sabrinus*
Northern goshawk	*Accipiter gentilis*
Northern leopard frog	*Rana pipiens*
Northern mockingbird	*Mimus polyglottos*
Northern myotis	*Myotis* sp.
Northern oriole	*Icterus galbula*
Northern parula	*Parula americana*
Northern redbelly snake	*Storeria o. occipitomaculata*
Northern ringneck snake	*Diadophis punctatus edwardsi*
Northern saw-whet owl	*Aegolius acadicus*
Northern short-tailed shrew	*Blarina brevicauda*
Northern shrike	*Lanius excubitor*
Northern spring salamander	*Gyrinophilus p. porphyriticus*
Northern two-lined salamander	*Eurycea b. bislineata*
Northern water snake	*Nerodia s. sipedon*
Northern waterthrush	*Seiurus noveboracensis*
Olive-sided flycatcher	*Contopus borealis*
Orchard oriole	*Icterus spurius*
Ovenbird	*Seiurus auraocapillus*
Philadelphia vireo	*Vireo philadelphicus*
Pickerel frog	*Rana palustris*
Pileated woodpecker	*Dryocopus pileatus*
Pine grosbeak	*Pinicola enucleator*
Pine siskin	*Carduelis pinus*
Pine warbler	*Dendroica pinus*
Porcupine	*Erethizon dorsatum*
Prothonotary warbler	*Protonotaria citrea*
Purple finch	*Carpodacus purpureus*
Purple martin	*Progne subis*
Pygmy shrew	*Sorex hoyi*
Queen snake	*Regina septemvittata*
Raccoon	*Procyon lotor*
Raven	*Corvus corax*
Ravine salamander	*Plethodon richmondi*
Red bat	*Lasiurus borealis*
Red squirrel	*Tamiasciurus hudsonicus*
Red-bellied woodpecker	*Melanerpes carolinus*
Red-breasted nuthatch	*Sitta canadensis*
Red-eyed vireo	*Vireo olivaceus*
Red-headed woodpecker	*Melanerpes erythrocephalus*
Red-shouldered hawk	*Buteo lineatus*

Red-spotted newt	*Notophthalmus v. viridescens*
Red-tailed hawk	*Buteo jamaicensis*
Redback salamander	*Plethodon cinereus*
River otter	*Lutra canadensis*
Rock vole	*Microtus chrotorrhinus*
Rose-breasted grosbeak	*Pheucticus ludovicianus*
Ruby-crowned kinglet	*Regulus calendula*
Ruby-throated hummingbird	*Archilochus colubris*
Ruffed grouse	*Bonasa umbellus*
Rufous-sided towhee	*Pipilo erythrophthalmus*
Rusty blackbird	*Euphagus carolinus*
Scarlet tanager	*Piranga olivacea*
Seal salamander	*Desmognathus monticola*
Sharp-shinned hawk	*Accipiter striatus*
Silver-haired bat	*Lasionycteris noctivagans*
Slimy salamander	*Plethodon g. glutinosus*
Small-footed myotis	*Myotis leibii*
Smoky shrew	*Sorex fumeus*
Snowshoe hare	*Lepus americanus*
Solitary vireo	*Vireo solitarius*
Song sparrow	*Melospiza melodia*
Southern bog lemming	*Synaptomys borealis*
Southern flying squirrel	*Glaucomys volans*
Southern red-backed vole	*Clethrionomys gapperi*
Spotted salamander	*Ambystoma maculatum*
Spring peeper	*Hyla c. crucifer*
Star-nosed mole	*Condylura cristata*
Striped skunk	*Mephitis mephitis*
Summer tanager	*Piranga rubra*
Swainson's thrush	*Catharus ustulatus*
Tennessee warbler	*Vermivora peregrina*
Timber rattlesnake	*Crotalus horridus*
Tree swallow	*Tachycineta bicolor*
Tufted titmouse	*Parus bicolor*
Turkey vulture	*Cathartes aura*
Veery	*Catharus fuscescens*
Virginia opossum	*Didelphis virginiana*
Warbling vireo	*Vireo gilvus*
Wehrle's salamander	*Plethodon wehrlei*
Whip-poor-will	*Caprimulgus vociferus*
White-breasted nuthatch	*Sitta carolinensis*
White-eyed vireo	*Vireo griseus*
White-tailed deer	*Odocoileus virginianus*
White-throated sparrow	*Zonotrichia albicollis*
White-winged crossbill	*Loxia leucoptera*
Whte-footed mouse	*Peromyscus leucopus*
Wild turkey	*Meleagris gallopavo*
Willow flycatcher	*Empidonax traillii*
Wilson's warbler	*Wilsonia pusilla*
Winter wren	*Troglodytes troglodytes*
Wood frog	*Rana sylvatica*
Wood thrush	*Hylocichla mustelina*
Wood turtle	*Clemmys insculpta*
Woodland jumping mouse	*Napaeozapus insignis*

Woodland vole	*Microtus pinetorum*
Worm-eating warbler	*Helmitheros vermivorus*
Yellow warbler	*Dendroica petechia*
Yellow-bellied sapsucker	*Sphyrapicus varius*
Yellow-billed cuckoo	*Coccyzus americanus*
Yellow-breasted chat	*Icteria virens*
Yellow-rumped warbler	*Dendroica coronata*
Yellow-throated vireo	*Vireo flavifrons*

Species name	Common name
Accipiter cooperii	Cooper's hawk
Accipiter gentilis	Northern goshawk
Accipiter striatus	Sharp-shinned hawk
Aegolius acadicus	Northern saw-whet owl
Agkistrodon contortrix mokeson	Northern copperhead
Ambystoma jeffersonianum	Jefferson salamander
Ambystoma maculatum	Spotted salamander
Ambystoma opacum	Marbled salamander
Aneides aeneus	Green salamander
Aquila chrysaetos	Golden eagle
Archilochus colubris	Ruby-throated hummingbird
Blarina brevicauda	Northern short-tailed shrew
Bombycilla cedrorum	Cedar waxwing
Bonasa umbellus	Ruffed grouse
Bubo virginianus	Great horned owl
Bufo a. americanus	Eastern American toad
Bufo woodhousii fowleri	Fowler's toad
Buteo jamaicensis	Red-tailed hawk
Buteo lineatus	Red-shouldered hawk
Buteo platypterus	Broad-winged hawk
Canis latrans	Coyote
Caprimulgus vociferus	Whip-poor-will
Cardinalis cardinalis	Northern cardinal
Carduelis pinus	Pine siskin
Carduelis tristis	American goldfinch
Carpodacus mexicanusq	House finch
Carpodacus purpureus	Purple finch
Castor canadensis	Beaver
Cathartes aura	Turkey vulture
Catharus fuscescens	Veery
Catharus guttatus	Hermit thrush
Catharus minimus	Gray-cheeked thrush
Catharus ustulatus	Swainson's thrush
Certhia americana	Brown creeper
Clemmys insculpta	Wood turtle
Clemmys muhlenbergii	Bog turtle
Clethrionomys gapperi	Southern red-backed vole
Coccothraustes vespertinus	Evening grosbeak
Coccyzus americanus	Yellow-billed cuckoo
Coccyzus erythropthalmus	Black-billed cuckoo
Colaptes auratus	Northern flicker
Coluber c. constrictor	Northern black racer
Condylura cristata	Star-nosed mole
Contopus borealis	Olive-sided flycatcher
Contopus virens	Eastern wood-pewee
Corvus brachyrhynchos	American crow
Corvus corax	Raven
Crotalus horridus	Timber rattlesnake
Cyanocitta cristata	Blue jay
Dendroica caerulescens	Black-throated blue warbler
Dendroica castanea	Bay-breasted warbler
Dendroica cerulea	Cerulean warbler

Dendroica coronata	Yellow-rumped warbler
Dendroica fusca	Blackburnian warbler
Dendroica magnolia	Magnolia warbler
Dendroica pensylvanica	Chestnut-sided warbler
Dendroica petechia	Yellow warbler
Dendroica pinus	Pine warbler
Dendroica striata	Blackpoll warbler
Dendroica tigrina	Cape May warbler
Dendroica virens	Black-throated green warbler
Desmognathus f. fuscus	Northern dusky salamander
Desmognathus monticola	Seal salamander
Desmognathus ochrophaeus	Mountain dusky salamander
Diadophis punctatus edwardsi	Northern ringneck snake
Didelphis virginiana	Virginia opossum
Dryocopus pileatus	Pileated woodpecker
Dumetella carolinensis	Gray catbird
Elaphe o. obsoleta	Black rat snake
Empidonax alnorum	Alder flycatcher
Empidonax minimus	Least flycatcher
Empidonax traillii	Willow flycatcher
Empidonax virescens	Acadian flycatcher
Eptesicus fuscus	Big brown bat
Erethizon dorsatum	Porcupine
Eumeces a. Anthracinus	Northern coal skink
Eumeces fasciatus	Five-lined skink
Eumeces laticeps	Broad-headed skink
Euphagus carolinus	Rusty blackbird
Eurycea b. bislineata	Northern two-lined salamander
Falco sparverius	American kestrel
Felis rufus	Bobcat
Glaucomys sabrinus	Northern flying squirrel
Glaucomys volans	Southern flying squirrel
Gyrinophilus p. porphyriticus	Northern spring salamander
Helmitheros vermivorus	Worm-eating warbler
Hemidactylium scutatum	Four-toed salamander
Hirundo rustica	Barn swallow
Hyla c. crucifer	Spring peeper
Hyla versicolor	Gray treefrog
Hylocichla mustelina	Wood thrush
Icteria virens	Yellow-breasted chat
Icterus galbula	Northern oriole
Icterus spurius	Orchard oriole
Junco hyemalis	Dark-eyed junco
Lampropeltis t. triangulum	Eastern milk snake
Lanius excubitor	Northern shrike
Lasionycteris noctivagans	Silver-haired bat
Lasiurus borealis	Red bat
Lasiurus cinereus	Hoary bat
Lepus americanus	Snowshoe hare
Loxia leucoptera	White-winged crossbill
Lutra canadensis	River otter
Melanerpes carolinus	Red-bellied woodpecker
Melanerpes erythrocephalus	Red-headed woodpecker
Meleagris gallopavo	Wild turkey

Melospiza lincolnii	Lincoln's sparrow
Melospiza melodia	Song sparrow
Mephitis mephitis	Striped skunk
Microtus chrotorrhinus	Rock vole
Microtus pinetorum	Woodland vole
Mimus polyglottos	Northern mockingbird
Mniotilta varia	Black-and-white warbler
Molothrus ater	Brown-headed cowbird
Mustela erminea	Ermine
Mustela frenata	Long-tailed weasel
Mustela rixosa	Least weasel
Mustela vison	Mink
Myiarchus crinitus	Great crested flycatcher
Myotis leibii	Small-footed myotis
Myotis lucifugus	Little brown myotis
Myotis sodalis	Indiana myotis
Myotis sp.	Northern myotis
Napaeozapus insignis	Woodland jumping mouse
Neotoma magister	Eastern woodrat
Nerodia s. sipedon	Northern water snake
Notophthalmus v. viridescens	Red-spotted newt
Odocoileus virginianus	White-tailed deer
Opheodrys v. vernalis	Eastern smooth green snake
Oporornis formosus	Kentucky warbler
Oporornis philadelphia	Mourning warbler
Otus asio	Eastern screech owl
Parascalops breweri	Hairy-tailed mole
Parula americana	Northern parula
Parus atricapillus	Black-capped chickadee
Parus bicolor	Tufted titmouse
Parus carolinensis	Carolina chickadee
Passerella iliaca	Fox sparrow
Passerina cyanea	Indigo bunting
Peromyscus leucopus	Whte-footed mouse
Peromyscus maniculatus	Deer mouse
Pheucticus ludovicianus	Rose-breasted grosbeak
Picoides pubescens	Downy woodpecker
Picoides villosus	Hairy woodpecker
Pinicola enucleator	Pine grosbeak
Pipilo erythrophthalmus	Rufous-sided towhee
Pipistrellus subflavus	Eastern pipistrelle
Piranga olivacea	Scarlet tanager
Piranga rubra	Summer tanager
Plethodon cinereus	Redback salamander
Plethodon g. glutinosus	Slimy salamander
Plethodon richmondi	Ravine salamander
Plethodon wehrlei	Wehrle's salamander
Polioptila caerulea	Blue-gray gnatcatcher
Procyon lotor	Raccoon
Progne subis	Purple martin
Protonotaria citrea	Prothonotary warbler
Quiscalus quiscula	Common grackle
Rana catesbeiana	Bullfrog
Rana clamitans melanota	Green frog

Rana palustris	Pickerel frog
Rana pipiens	Northern leopard frog
Rana sylvatica	Wood frog
Regina septemvittata	Queen snake
Regulus calendula	Ruby-crowned kinglet
Regulus satrapa	Golden-crowned kinglet
Sayornis phoebe	Eastern phoebe
Scalopus aquaticus	Eastern mole
Scaphiopus h. holbrookii	Eastern spadefoot
Sciurus carolinensis	Gray squirrel
Sciurus niger vulpinus	Eastern fox squirrel
Scolopax minor	American woodcock
Seiurus auraocapillus	Ovenbird
Seiurus motacilla	Louisiana waterthrush
Seiurus noveboracensis	Northern waterthrush
Setophaga ruticilla	American redstart
Sialia sialis	Eastern bluebird
Sitta canadensis	Red-breasted nuthatch
Sitta carolinensis	White-breasted nuthatch
Sorex cinereus	Masked shrew
Sorex dispar	Long-tailed shrew
Sorex fontinalis	Maryland shrew
Sorex fumeus	Smoky shrew
Sorex hoyi	Pygmy shrew
Sphyrapicus varius	Yellow-bellied sapsucker
Spizella arborea	American tree sparrow
Spizella passerina	Chipping sparrow
Storeria d. dekayi	Northern brown snake
Storeria o. occipitomaculata	Northern redbelly snake
Strix varia	Barred owl
Sturnis vulgaris	European starling
Sylvilagus floridanus	New England cottontail
Synaptomys borealis	Southern bog lemming
Tachycineta bicolor	Tree swallow
Tamias striatus	Eastern chipmunk
Tamiasciurus hudsonicus	Red squirrel
Terrapene c. carolina	Eastern box turtle
Thamnophis s. sauritus	Eastern ribbon snake
Thamnophis s. sirtalis	Eastern garter snake
Thryothorus ludovicianus	Carolina wren
Toxostoma rufum	Brown thrasher
Troglodytes aedon	House wren
Troglodytes troglodytes	Winter wren
Turdus migratorius	American robin
Tyrannus tyrannus	Eastern kingbird
Urocyon cinereoargenteus	Gray fox
Ursus americanus	Black bear
Vermivora chrysoptera	Golden-winged warbler
Vermivora peregrina	Tennessee warbler
Vermivora pinus	Blue-winged warbler
Vermivora ruficapilla	Nashville warbler
Vireo flavifrons	Yellow-throated vireo
Vireo gilvus	Warbling vireo
Vireo griseus	White-eyed vireo

Vireo olivaceus	Red-eyed vireo
Vireo philadelphicus	Philadelphia vireo
Vireo solitarius	Solitary vireo
Wilsonia canadensis	Canada warbler
Wilsonia citrina	Hooded warbler
Wilsonia pusilla	Wilson's warbler
Zenaida macroura	Mourning dove
Zonotrichia albicollis	White-throated sparrow

APPENDIX H

Assessment Matrices

GROUP #	TEMPORARY WATER	PERMANENT WATER	SUBTERRANEAN	DEAD & DOWN	% ROCKS	% LITTER	≤30% GROUND COVER	>75% GROUND COVER	>50% SHRUB COVER	DECIDUOUS SHRUBS	CONIFEROUS SHRUBS	ERICACEOUS SHRUBS	DECIDUOUS MIDSTORY	CONIFEROUS MIDSTORY	CAVITY TREES & SNAGS	≤15% OVERSTORY	16 TO 30% OVERSTORY	31 TO 70% OVERSTORY	>70% OVERSTORY	MAST	HIGH PERCH	LOW PERCH
1	1																					
2	1			4		6																
3		2																				
4		2	3			6																
5		2		4		6																
6		2			5																	
7		2					7															
8			3																			
9			3	4																20		
10				4	5																	
11				4		6													19			
12				4		6				10	11											
13				4											15							
14					5																	
15								8														
16								8	9	10												
17								8		10		12										
18								8							15							
19								8									17			20		
20									9	10		12										
21										10		12				16				20		
22										10	11	12						18				
23										10			13									
24											11	12										
25											11			14								
26													13							20		
27														14					19			
28															15							
29															15		17					
30															15					20		
31																16					21	
32																	17					
33																		18				
34																			19			
35																					21	22
36																						22
37																						

GROUP #	TEMPORARY WATER	PERMANENT WATER	SUBTERRANEAN	DEAD & DOWN	% ROCKS	% LITTER	≤30% GROUND COVER	>75% GROUND COVER	>50% SHRUB COVER	DECIDUOUS SHRUBS	CONIFEROUS SHRUBS	ERICACEOUS SHRUBS	DECIDUOUS MIDSTORY	CONIFEROUS MIDSTORY	CAVITY TREES & SNAGS	≤15% OVERSTORY	16 TO 30% OVERSTORY	31 TO 70% OVERSTORY	>70% OVERSTORY	MAST	HIGH PERCH	LOW PERCH
1	1																					
2	1			4		6																
3		2																				
4		2	3			6																
5		2		4		6																
6		2			5																	
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8			3																			
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37																						

APPENDIX I

Stand Summary Sheets

Summary Stand Tally Sheet

Property name:____________________ Stand #:______ Area:______

Physiographic province:______________________________

Forest type:______________________________ Size-class:____________

Structural features - Stand summary:

Temporary water:____

Permanent water:____

Subterranean habitats:____

Dead & down material:____

% rock cover:____

Forest litter:____

% ground cover:____

% shrub cover:____

Shrub types: deciduous (%) coniferous (%) ericaceous (%)

% midstory cover:____

Midstory types: deciduous (%) coniferous (%)____________

Snags and/or cavity trees:_______________________________________

% overstory cover:____

Mast:____

High or low perches: High (   ) Low (   )________________

Stewardship prescription: ____

____

____

Summary Stand Tally Sheet

Property name:________________ Stand #:______ Area:________

Physiographic province:________________________

Forest type:________________________ Size-class:______________

Structural features - Stand summary:

Temporary water:____

Permanent water:____

Subterranean habitats:___________________________________

Dead & down material:___________________________________

% rock cover:____

Forest litter:____

% ground cover:____

% shrub cover:____

Shrub types: deciduous (%) coniferous (%) ericaceous (%)

% midstory cover:_______________________________________

Midstory types: deciduous (%) coniferous (%)__________

Snags and/or cavity trees:_______________________________

% overstory cover:______________________________________

Mast:____

High or low perches: High ( ) Low ( )_________

Stewardship prescription: ______________________________

____

____

APPENDIX J

List of Species which Do Not Inhabit Each Physiographic Province

The species following the Physiographic Province name are NOT found in that province.

CENTRAL LOWLANDS

marbled salamander (groups 2 & 5)
five-lined skink (group 10)
northern copperhead (group 10)
raven (group 26)
summer tanager (group 34)
pygmy shrew (group 11)
eastern mole (group 8)
small-footed myotis (group 37)
eastern fox squirrel (group 28)
rock vole (group 6)
black bear (group 9)
bog turtle (group 1)
eastern smooth green snake (group 15)
timber rattlesnake (group 14)
Carolina chickadee (group 30)
long-tailed shrew (group 10)
northern short-tailed shrew (group 4)
Indiana myotis (group 28)
New England cottontail (group 20)
deer mouse (group 19)
eastern wood rat (group 22)
river otter (group 3)

APPALACHIAN PLATEAUS

eastern mole (group 8)
eastern fox squirrel (group 28)
Indiana myotis (group 28)

VALLEY & RIDGE

eastern smooth green snake (group 15)
northern short-tailed shrew (group 4)
summer tanager (group 34)
rock vole (group 6)

BLUE RIDGE

mountain dusky salamander (group 6)
northern shrike (group 17)
long-tailed shrew 10)
northern short-tailed shrew (group 4)
small-footed myotis (group 37)
snowshoe hare (group 24)
deer mouse (group 19)
woodland jumping mouse (group 10)
river otter (group 3)
eastern smooth green snake (group 15)
summer tanager (group 34)
pygmy shrew (group 11)
Indiana myotis (group 28)
silver-haired bat (group 28)
northern flying squirrel (group 30)
rock vole (group 6)
black bear (group 9)
bobcat (group 12)

NEW ENGLAND

mountain dusky salamander (group 6)
timber rattlesnake (group 14)
Carolina chickadee (group 30)
pygmy shrew (group 11)
Indiana myotis (group 28)
silver-haired bat (group 28)
snowshoe hare (group 24)
eastern fox squirrel (group 28)
rock vole (group 6)
porcupine (group 30)
river otter (group 3)
eastern smooth green snake (group 15)
raven (group 26)
summer tanager (group 34)
northern short-tailed shrew (group 4)
small-footed myotis (group 37)
New England cottontail (group 20)
northern flying squirrel (group 30)
deer mouse (group 19)
eastern wood rat (group 22)
black bear (group 9)

PIEDMONT

mountain dusky salamander (group 6)
red-headed woodpecker (group 19)
northern shrike (group 17)
pygmy shrew (group 11)
Indiana myotis (group 28)
silver-haired bat (group 28)
northern flying squirrel (group 30)
rock vole (group 6)
porcupine (group 30)
river otter (group 3)
timber rattlesnake (group 14)
raven (group 26)
summer tanager (group 34)
northern short-tailed shrew (group 4)
small-footed myotis (group 37)
snowshoe hare (group 24)
deer mouse (group 19)
eastern wood rat (group 22)
black bear (group 9)
bobcat (group 12)

COASTAL PLAIN

mountain dusky salamander (group 6)
northern leopard frog (groups 1 & 3)
ruffed grouse (group 19)
barred owl (group 28)
raven (group 26)
summer tanager (group 34)
white-winged crossbill (group 25)
pygmy shrew (group 11)
hairy-tailed mole (group 8)
small-footed myotis (group 37)
New England cottontail (group 20)
deer mouse (group 19)
southern bog lemming (group 4)
eastern wood rat (group 22)
black bear (group 9)
bobcat (group 12)
northern spring salamander (group 6)
timber rattlesnake (group 14)
wild turkey (group 19)
red-headed woodpecker (group 19)
northern shrike (group 17)
pine grosbeak (group 27)
long-tailed shrew (group 10)
northern short-tailed shrew (group 4)
Indiana myotis (group 28)
silver-haired bat (group 28)
northern flying squirrel (group 30)
rock vole (group 6)
woodland jumping mouse (group 10)
porcupine (group 30)
river otter (group 3)

APPENDIX K

Lists of Groups which Inhabit Each Forest Type and Size Class

APPENDIX L

List of Species by Groups

Group	Species
1	eastern American toad (*Bufo a. americanus*)
	Fowler's toad (*Bufo woodhousii fowleri*)
	spring peeper (*Hyla c. crucifer*)
	gray treefrog (*Hyla versicolor*)
	green frog (*Rana clamitans melanota*)
	northern leopard frog (*Rana pipiens*)
	bog turtle (*Clemmys insculpta*)
2	marbled salamander (*Ambystoma opacum*)
	Jefferson salamander (*Ambystoma jeffersonianum*)
	spotted salamander (*Ambystoma maculatum*)
	red-spotted newt (*Notophthalmus v. viridescens*)
	four-toed salamander (*Hemidactylium scutatum*)
	wood frog (*Rana sylvatica*)
3	eastern American toad (*Bufo a. americanus*)
	Fowler's toad (*Bufo woodhousii fowleri*)
	spring peeper (*Hyla c. crucifer*)
	gray treefrog (*Hyla versicolor*)
	green frog (*Rana clamitans melanota*)
	northern leopard frog (*Rana pipiens*)
	pickerel frog (*Rana palustris*)
	bullfrog (*Rana catesbeiana*)
	common grackle (*Quiscalua quiscula*)
	beaver (*Castor canadensis*)
	racoon (*Procyon lotor*)
	river otter (*Lutra canadensis*)
4	wood turtle (*Clemmys insculpta*)
	northern short-tailed shrew (*Blarina brevicauda*)
	star-nosed mole (*Condylura cristata*)
	southern red-backed vole (*Clethrionomys gapperi*)
	woodland vole (*Microtum pinetorum*)
	southern bog lemming (*Synaptomys borealis*)
	mink (*Mustela vison*)
5	marbled salamander (*Ambystoma opacum*)
	spotted salamander (*Ambystoma maculatum*)
	red-spotted newt (*Notophthalmus v. viridescens*)
	four-toed salamander (*Hemidactylium scutatum*)
	wood frog (*Rana sylvatica*)
6	northern coal skink (*Eumeces a. anthracinus*)
	Queen snake (*Natrix septemvittata*)
	seal salamander (*Desmognathus monticola*)
	northern dusky salamander (*Desmognathus f. fuscus*)
	mountain dusky salamander (*Desmognathus ochrophaeus*)
	northern spring salamander (*Gyrinophilus p. porphyriticus*)
	northern two-lined salamander (*Eurycea b. bislineata*)
	northern water snake (*Nerodia s. sipedon*)
	eastern ribbon snake (*Thamnophis s. sauritus*)
	rock vole (*Microtus chrotorrhinus*)

7 northern waterthrush (*Seiurus noveboracensis*)
Louisiana waterthrush (*Seiurus motacilla*)
common redpoll (*Carduelis flammea*)

8 hairy-tailed mole (*Parascalops breweri*)
eastern mole (*Scalopus aquaticus*)
coyote (*Canis latrans*)

9 eastern chipmunk (*Tamias striatus*)
black bear (*Ursus americanus*)
striped skunk (*Mephitis mephitis*)

10 ravine salamander (*Plethodon richmondi*)
Wehrle's salamander (*Plethodon wehrlei*)
five-lined skink (*Eumeces fasciatus*)
northern brown snake (*Storeria d. dekayi*)
northern black racer (*Coluber c. constrictor*)
eastern milk snake (*Lampropeltis t. triangulum*)
northern copperhead (*Agkistrodon contortrix mokeson*)
long-tailed shrew (*Sorex dispar*)
woodland jumping mouse (*Napaeozapus insignis*)

11 Maryland shrew (*Sorex fontinalis*)
redback salamander (*Plethodon cinereus*)
slimy salamander (*Plethodon g. glutinosus*)
black rat snake (*Elaphe o. obsoleta*)
black-and-white warbler (*Mniotilta varia*)
ovenbird (*Seiurus aurocapillus*)
masked shrew (*Sorex cinereus*)
smoky shrew (*Sorex fumeus*)
pygmy shrew (*Sorex hoyi*)

12 hermit thrush (*Catharus guttatus*)
worm-eating warbler (*Helmitheros vermivorus*)
Canada warbler (*Wilsonia canadensis*)
ermine (*Mustela erminea*)
bobcat (*Felis rufus*)

13 broad-headed skink (*Eumeces laticeps*)
great crested flycatcher (*Myiarchus crinitus*)
house wren (*Troglodytes aedon*)
winter wren (*Troglodytes troglodytes*)
Virginia opossum (*Didelphis virginiana*)
long-tailed weasel (*Mustela frenata*)
gray fox (*Urocyon cinereoargenteus*)

14 green salamander (*Aneides aeneus*)
northern redbelly snake (*Storeria o. occipitomaculata*)
northern ringneck snake (*Diadophis punctatus edwardsi*)
timber rattlesnake (*Crotalus horridus*)

15 eastern garter snake (*Thamnophis s. sirtalis*)
eastern smooth green snake (*Opheodrys v. vernalis*)
barn swallow (*Hirundo rustica*)

16 eastern box turtle (*Terrapene c. carolina*)
Carolina wren (*Thryothorus ludovicianus*)
blue-winged warbler (*Vermivora pinus*)
mourning warbler (*Oporornis philadelphia*)
chipping sparrow (*Spizella passerina*)
Lincoln's sparrow (*Melospiza lincolnii*)

17 eastern kingbird (*Tyrannus tyrannus*)
northern shrike (*Lanius excubitor*)
golden-winged warbler (*Vermivora chrysoptera*)
Tennessee warbler (*Vermivora peregrina*)
Nashville warbler (*Vermivora ruficapilla*)
yellow warbler (*Dendroica petechia*)
hooded warbler (*Wilsonia citrina*)
indigo bunting (*Passerina cyanea*)
song sparrow (*Melospiza melodia*)
American goldfinch (*Carduelis tristis*)
white-tailed deer (*Odocoileus virginianus*)

18 purple martin (*Progne subis*)
tree swallow (*Tachycineta bicolor*)
European starling (*Sturnis vulgaris*)

19 ruffed grouse (*Bonasa umbellus*)
wild turkey (*Meleagris gallopavo*)
red-headed woodpecker (*Melanerpes erythrocephalus*)
deer mouse (*Peromyscus maniculatus*)
white-footed mouse (*Peromyscus leucopus*)

20 yellow-billed cuckoo (*Coccyzus americanus*)
alder flycatcher (*Empidonax alnorum*)
willow flycatcher (*Empidonax traillii*)
gray catbird (*Dumetella carolinensis*)
black-throated blue warbler (*Dendroica caerulescens*)
yellow-breasted chat (*Icteria virens*)
New England cottontail (*Sylvilagus transitionalis*)

21 brown thrasher (*Toxostoma rufum*)
cedar waxwing (*Bombycilla cedrorum*)
northern cardinal (*Cardinalis cardinalis*)
rufous-sided towhee (*Pipilo erythrophthalmus*)

22 black-billed cuckoo (*Coccyzus erythropthalmus*)
whip-poor-will (*Caprimulgus vociferus*)
ruby-throated hummingbird (*Archilochus colubris*)
chestnut-sided warbler (*Dendroica pensylvanica*)
American tree sparrow (*Spizella arborea*)
fox sparrow (*Passerella iliaca*)
eastern woodrat (*Neotoma magister*)

23 acadian flycatcher (*Empidonax virescens*)
veery (*Catharus fuscescens*)
wood thrush (*Hylocichla mustelina*)
American robin (*Turdus migratorius*)
white-eyed vireo (*Vireo griseus*)
Philadelphia vireo (*Vireo philadelphicus*)
American redstart (*Setophaga ruticilla*)
rose-breasted grosbeak (*Pheucticus ludovicianus*)

24 Wilson's warbler (*Wilsonia pusilla*)
white-throated sparrow (*Zonotrichia albicollis*)
dark-eyed junco (*Junco hyemalis*)
rusty blackbird (*Euphagus carolinus*)
snowshoe hare (*Lepus americanus*)

25 gray-cheeked thrush (*Catharus minimus*)
Swainson's thrush (*Catharus ustulatus*)
yellow-rumped warbler (*Dendroica coronata*)
blackpoll warbler (*Dendroica striata*)
white-winged crossbill (*Loxia leucoptera*)

26 blue jay (*Cyanocitta cristata*)
American crow (*Corvus brachyrhynchos*)
common raven (*Corvus corax*)
northern mockingbird (*Mimus polyglottos*)

27 solitary vireo (*Vireo solitarius*)
northern parula (*Parula americana*)
magnolia warbler (*Dendroica magnolia*)
pine grosbeak (*Pinicola enucleator*)
pine siskin (*Carduelis pinus*)

28 eastern fox squirrel (*Sciurus niger vulpinus*)
barred owl (*Strix varia*)
yellow-bellied sapsucker (*Sphyrapicus varius*)
red-breasted nuthatch (*Sitta canadensis*)
prothonotary warbler (*Protonotaria citrea*)
little brown myotis (*Myotis lucifugus*)
northern myotis (*Myotis* sp.)
Indiana myotis (*Nyotis sodalis*)
silver-haired myotis (*Lasionycteris noctivagans*)
big brown bat (*Eptesicus fuscus*)

29 turkey vulture (*Cathartes aura*)
eastern screech owl (*Otus asio*)
northern saw-whet owl (*Aegolius acadicus*)
downy woodpecker (*Picoides pubescens*)
northern flicker (*Colaptes auratus*)
pileated woodpecker (*Dryocopus pileatus*)
eastern bluebird (*Sialia sialis*)

30 Carolina chickadee (*Parus carolinensis*)
red-bellied woodpecker (*Melanerpes carolinus*)
hairy woodpecker (*Picoides villosus*)
black-capped chickadee (*Parus atricapillus*)
tufted titmouse (*Parus bicolor*)
white-breasted nuthatch (*Sitta carolinensis*)
brown creeper (*Certhia americana*)
gray squirrel (*Sciurus carolinensis*)
red squirrel (*Tamiasciurus hudsonicus*)
southern flying squirrel (*Glaucomys volans*)
northern flying squirrel (*Glaucomys sabrinus*)
porcupine (*Erethizon dorsatum*)

31 Cooper's hawk (*Accipiter cooperii*)
red-tailed hawk (*Buteo jamaicensis*)
golden eagle (*Aquila chrysaetos*)
American kestrel (*Falco sparverius*)
northern oriole (*Icterus galbula*)

32 red-shouldered hawk (*Buteo lineatus*)
golden eagle (*Aquila chrysaetos*)
American woodcock (*Scolopax minor*)
mourning dove (*Zenaida macroura*)
warbling vireo (*Vireo gilvus*)
orchard oriole (*Icterus spurius*)

33 eastern pipistrelle (*Pipistrellus subflavus*)
Cooper's hawk (*Accipiter cooperii*)
northern goshawk (*Accipiter gentilis*)
blue-gray gnatcatcher (*Polioptila caerulea*)
yellow-throated vireo (*Vireo flavifrons*)
pine warbler (*Dendroica pinus*)

34 summer tanager (*Piranga rubra*)
sharp-shinned hawk (*Accipiter striatus*)
northern goshawk (*Accipiter gentilis*)
red-shouldered hawk (*Buteo lineatus*)
broad-winged hawk (*Buteo platypterus*)
great horned owl (*Bubo virginianus*)
least flycatcher (*Empidonax minimus*)
golden-crowned kinglet (*Regulus satrapa*)
ruby-crowned kinglet (*Regulus calendula*)
red-eyed vireo (*Vireo olivaceus*)
Cape May warbler (*Dendroica tigrina*)
black-throated green warbler (*Dendroica virens*)
Blackburnian warbler (*Dendroica fusca*)
pine warbler (*Dendroica pinus*)
bay-breasted warbler (*Dendroica castanea*)
cerulean warbler (*Dendroica cerulea*)
scarlet tanager (*Piranga olivacea*)
red bat (*Lasiurus borealis*)
hoary bat (*Lasiurus cinereus*)

35 brown-headed cowbird (*Molothrus ater*)
olive-sided flycatcher (*Contopus borealis*)

36 eastern wood-pewee (*Contopus virens*)
eastern phoebe (*Sayornis phoebe*)

37 purple finch (*Carpodacus purpureus*)
house finch (*Carpodacus mexicanus*)
evening grosbeak (*Coccothraustes vespertinus*)
small-footed myotis (*Myotis leibii*)

APPENDIX C.

Questionnaires, Before And After Training

Biodiversity Evaluation

Please answer as completely as you can.
All answers will be kept strictly confidential.

Name (optional)________________________ Agency_________________________

What do you think of when you hear the term "biodiversity?"

Is biodiversity important? Why or why not?

Is biodiversity a new concept?

What is the definition of biodiversity?

In your opinion, can biodiversity be assessed? Why or why not?

How difficult is it to assess biodiversity? Very Difficult Difficult Not Sure Easy Very Easy

What **techniques** do you currently use to assess biodiversity?

What **tools** do you currently use, or might help you, in assessing biodiversity?

Biodiversity Evaluation

Please answer as completely as you can.
All answers will be kept strictly confidential.

Name (optional)________________________ Agency_________________________

What do you think of when you hear the term "biodiversity?"

Is biodiversity important? Why or why not?

Is biodiversity a new concept?

What is the definition of biodiversity?

In your opinion, can biodiversity be assessed? Why or why not?

How difficult is it to assess biodiversity? Very Difficult Difficult Not Sure Easy Very Easy

What **techniques** do you currently use to assess biodiversity?

What **tools** do you currently use, or might help you, in assessing biodiversity?

How has this workshop changed your views about biodiversity?

Workshop Evaluation

Please answer as completely as you can.
All answers will be kept strictly confidential.

Name (optional)________________________ Agency_________________________

1. Please rate this workshop overall in terms of its helpfulness.

Very Helpful	Somewhat Helpful	Not Sure	Not Helpful	Very Unhelpful

2. Please rate this workshop overall in terms of its organization.

Very Organized	Somewhat Organized	Not Sure	Not Organized	Very Unorganized

3. Please rate this workshop overall in terms of its importance.

Very Important	Somewhat Important	Not Sure	Not Important	Very Unimportant

4. The most helpful part of this workshop was. . .

5. The most important thing I would change about this workshop is. . .

6. Would you recommend this workshop to other foresters? Why or why not?

7. Do you have any comments/suggestions/criticisms about the workshop?

OTHER STRATEGIES FOR REDUCED PESTICIDE USE

Selective pesticides

Much of a successful IPM program depends on not disrupting natural predators and parasites, and using only the most selective pesticides when needed to manage pest populations. Use of products that are highly toxic to beneficials will decrease natural pest control in an orchard, and increase the amount of pesticides needed to manage pests. Without predation and parasitism, insects and mites previously controlled by beneficials may attain secondary pest status, necessitating additional pesticide use.

Pesticides that are most disruptive to beneficial insects and mites are the synthetic pyrethroids: Ambush, Pounce, Pydrin, and Asana. Lannate, Phosphamidon, Sevin, and high rates of Vydate and Carzol are also toxic to beneficials. Benlate is moderately toxic to *A. fallacis* and also suppresses egg laying (see Table 12).

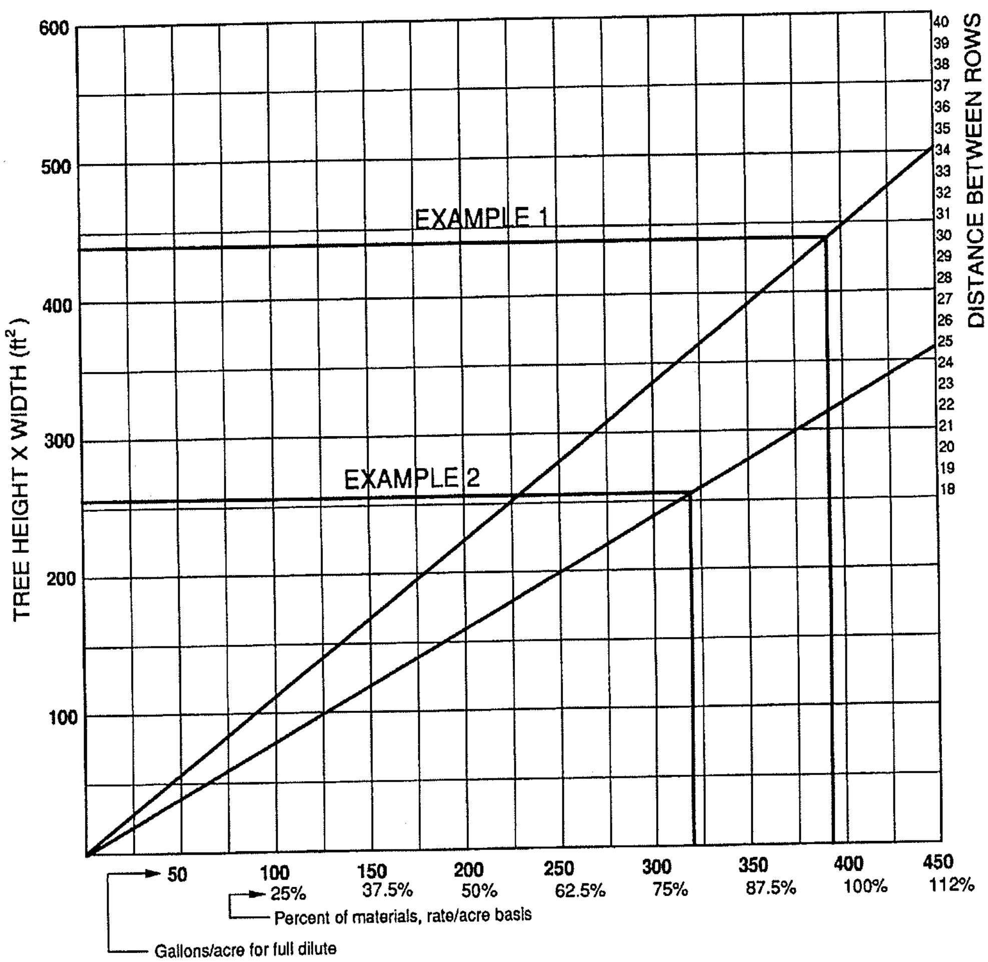
Tree row volume (TRV) (see Figure 79)

Calculating spray volume and pesticide rates with the TRV method allows calibration for spray delivery at minimum volume and rates for blocks of various size trees. To calculate the tree row volume of a block, determine tree width, tree height, and the distance between rows (used to calculate the running feet of row per acre).

Running feet of row per acre = 43560/distance between rows.

Tree row volume (TRV) per acre = tree width x tree height x running feet of row per acre.

TRV defines the orchard target so that the optimum amount of pesticide and spray volume can be used. A spray volume of 0.7 to 0.8 gallons per 1,000 cubic feet of TRV is adequate to achieve the drip point (dilute) in most cases. A spray volume of 0.09 gallons per 1,000 cubic feet of TRV seems to be an adequate limit for determining concentrate sprays. Figure 79 may be used as a shortcut to determine the spray volume and pesticide rate needed in various instances. The chart should be used as follows: Multiply tree height x width and draw a line from that number in the left axis horizontally toward the distance-between-rows axis. Draw a diagonal line from the number matching your distance between rows toward the lower left corner of the chart. Where these lines intersect, draw a line straight down to the lower horizontal axis. This indicates gallons-per-acre needed for dilute sprays, and the required pesticide rate compared to a full dilute rate per acre. By using this method, an orchard planted 16' x 22' on M7, with trees that are 13' high and 12' wide (ht. x width = 156 ft^2), requires a dilute volume of not less than 215 gallons per acre, and 54 percent of a full pesticide rate. Other examples are given on the chart. Pesticide rates determined by TRV calculations do have a limit: Even with smaller trees, the rate per acre should not be less than the base per 100 gallon rate.



Example 1: Trees spaced 35' x 35'; 19' high, 23' wide; 390 gpa dilute or 98% of rate/acre

Example 2: Trees spaced 16' x 25'; 16' high; 313 gpa dilute or 78% of rate/acre

Figure 79: Tree-row-volume determination in apple orchards (Source: Virginia Cooperative Extension Service, 1989 Spray Guide)

Table 12: Relative toxicity of pesticides to various beneficial arthropods at recommended field rates: A. fallacis *and* T. pyri *(predatory mites,* Stethorus punctum *(ladybird beetle mite predator), and* Aphidoletes aphidimyze *(cecidomyiid aphid predator)*

Material - Trade Name (Common Name)	*A.fallacis*	*T. pyri*	*Stethorus punctum* Adult	*Stethorus punctum* larvae	*Aphidoletes*
Insecticides					
•Ambush,Pounce (permethrin)	+ + +	+ + +	+ + +	+ + +	+
Cygon (dimethoate)	+ + +	+ + +	+ +	+ +	+ + +
Dipel *(Bacillus thuringiensis)*	no data	no data	0	0	no data
(diazinon)	no data	no data	+ +	+ +	+ + +
•Guthion (azinphos-methyl)	+	+	+	+	+ + +
Imidan (phosmet)	+	+	+	+	+ +
•Lannate (methomyl)	+ + +	+ + +	+ +	+ + +	+ + +
Lorsban (chlorpyrifos)	+ +	+ + +	+	+	no data
•Parathion	+ + [1]	+ + [1]	+	+ +	no data
•Penncap-M (methyl parathion)	+	+	+	+	no data
•Phosphamidon	+ + +	+ + +	+ +	+ +	+
•Pydrin (fenvalerate)	+ + +	+ + +	+ + +	+ + +	+ +
Sevin (carbaryl)	+ +	+	+ + +	+ + +	+ + +
•Supracide (methidathion)	+	+ + +	no data	no data	no data
•Thiodan (endosulfan)	+	+	+ +	+ +	+ +
•Vydate (oxamyl)	+ + +	+ + +	+	+	+ +
Acaricides					
Carzol (formetanate)	+ + +	+ + +	+ +	+ +	no data
Kelthane (dicofol)	+ +	+	+	+	+
Omite (propargite)	+	+	+	+	+
Oil	no data	+ [1]	+	+	
Morestan (oxythioquinox)	+	+ +	no data	no data	+ +
Vendex (hexakis)	+	+	+	+	+
Fungicides					
Bayleton (triadimefon)	+	+	no data	no data	no data
Benlate (benomyl)	+ + [2]	+	+	+	+
Captan	+	+	no data	no data	+
Dodine	+ [1]	+ [1]	no data	no data	+
Dikar (mancozeb + dinocap)	+ [1]	+	+	+	+
Funginex (triforine)	+	+	no data	no data	no data
Glyodin	+ + [1]	+ +	no data	no data	no data
Karathane (dinocap)	+	+	+	+	no data
Manzate (mancozeb)	+ +	+	no data	no data	no data
Nustar (flusilazol)	+	+	no data	no data	no data
Polyram (metiram)	+ [1]	+ [1]	no data	no data	+
Ronilan (vinclozolin)	+	no data	no data	no data	no data
Rovral (iprodione)	+	no data	no data	no data	no data
Rubigan (fenarimol)	+	+	no data	no data	no data
Sulfur	+ [1]	+ [1]	no data	no data	no data
Thiram	+ [1]	no data	no data	no data	no data

•restricted use pesticides

Note: Information compiled from 48-hr residue tests conducted at NYSAES in 1987, and from other states (PA, NJ, NY, VA, WV). (Pesticides with a long residual period, like pyrethroids, will have a more negative impact than pesticides with short-lived residue, like some organophosphates.)

0 = No impact on population.
+ = Low impact on population (less than 30% mortality after 48 hr)
+ + = Moderate impact on population (between 30% and 70% mortality after 48 hr)
+ + + = Severe impact on population (over 70% mortality after 48 hr)
1 - This information derived from 24-hr slide dip tests conducted at NYSAES.
2 - Benlate supresses egg-laying almost completely and is harmful to immature *A. fallacis*.

Alternate middle spraying

Alternate middle spraying is spraying every other row with both sides of your sprayer open, then returning three to ten days later and treating the alternate middles not previously sprayed. The first spray applied each year should be a complete spray.

The principle behind alternate middle spraying is to apply pesticides more frequently than in every row spraying, but to do so at reduced rates, usually 1/3 to 1/2 of label rates per application. Pesticides are applied in combination, which further helps reduce rates and adverse effects on beneficials. Because pesticides are applied more frequently, the time lapse between a product's breakdown to its half life and the time of re-application is reduced; thereby minimizing the time that the orchard is unprotected and increasing pest control. This principle is especially effective against insects that have prolonged egg-laying or emergence periods and need extended coverage.

Applications require a sprayer that can cover 100 percent of the tree side being sprayed, while blowing the material through to cover 75 percent of the opposite side. This enables the grower to spend half the time normally required in an every-row spray system, and still obtain adequate protection in most instances. Under certain circumstances, an alternate middle spray practice requires a complete spray, or an extra half spray of one ingredient (such as a fungicide under wet conditions). Alternate middle spraying requires close attention to pest pressure, weather conditions, and pesticide longevity.

In summary, the advantages of this practice compared to every-row treatment are:

1. The rate of pesticide use is reduced.
2. Populations of predators will most likely increase.
3. Decision making regarding pesticides and rates is improved.
4. Time and farm equipment can be managed more efficiently.
5. Pests are less likely to develop resistance to chemicals.
6. Control of certain pests is increased.

Border row applications

In some cases, particularly involving apple maggot and plum curculio, most of the pests migrate from outside the orchard. In areas of low activity, border sprays starting in late June for apple maggot fly control may be all that is needed. Where AM pressure is high, supplemental treatments on only the outside rows may be used instead of repeatedly treating the entire block.

Plum curculio typically migrates into an orchard from wooded areas early in the season; usually bloom to petal fall. Since early-season sprays for PC usually target other insects as well, border treatments alone are not generally useful at this time. But if migrating adults are seen during the summer generation (mid-July), border row applications can be useful because little insect pressure from other pests may exist at that time.

Sanitation methods and control of AM, CM and leafrollers

Sanitation is an important low-input pest management practice. Removal of mature drops prevents apple maggot buildup in the orchard and eliminates overwintering sites. This is especially important where earlier varieties are grown next to later-maturing types. Removal of drops also helps keep the AM source outside the orchard.

Codling moth must usually be controlled during its first generation. As an integrated part of CM control, alternate hosts can be removed from within 100 to 200 yards of the orchard, to reduce the immigration of second generation adults. Hosts include abandoned apple, pear, hawthorn, and quince trees. This will also serve to reduce the influx of summer leafrollers and tufted apple budmoth. Most female moth pests do not fly more than 200 yards to find egg-laying sites.

Groundcover management to control tarnished plant bug

Tarnished plant bugs are found on more than thirty species of weeds common to orchard floors. Among the more common weed hosts are yellow sweet clover, red clover, alfalfa, white-top fleabane, curly dock, dandelion, field sorrel, lambsquarters, goldenrod, blackberry, horseweed, and pigweed. Many of these plants also serve as hosts for stink bugs and other true bugs that cause cat-facing damage. TPB is not a major apple pest and proper management of its other host plants can help minimize damage.

Although many people recommend weed free grass middles and bare ground within the tree row, certain IPM practices require increased plant diversity and recommend maintaining some broadleaf weeds in the orchard. When maintaining diverse groundcover, discing the middles is discouraged at any time, but especially early in the season. Discing or mowing between pink and first cover removes the bugs' hosts, and drives them into the trees.

Effect of fertilization and summer pruning on apple aphid

Tree growth should be assessed carefully before making nitrogen applications. Excessive vegetative growth is the major contributor to GAA infestations. Mature trees that grow more than 12" per year are more likely to have high numbers of GAA than trees that grow less. Aphids infest any soft, green terminals; therefore, avoid fertility programs that increase the time that trees remain in this state. Under ideal conditions, terminals begin to harden off by early to mid-July, depending on location, and aphid colonies will die off naturally.

During May and June, GAA will also infest water sprouts not in the fruiting zone. Because these remain green for a prolonged period, aphicides can often be avoided by pruning out water sprouts. Treating pruning cuts with an NAA (1-Naphthalene-acetic acid) solution to prevent water sprouts is also an effective cultural method for reducing insect injury.

Mating disruption

Mating disruption is a new technique for pest control, and is the subject of much current research. Unmated females produce the pheromone that attracts males for mating. As adult males emerge, they orient to the female by flying in the direction from which they detect the pheromone. Mating disruption involves the mass placement of insect sex pheromone dispensers in the orchard. When a synthetic mating attractant saturates the orchard, the male becomes disoriented and cannot find a point source (a female), so reproduction does not take place.

The principle of mating disruption is to have no mated females within the orchard. In large orchards, or orchards with many alternate hosts for the target pest, mating disruption must involve at least five to ten acres. Ultimately, mating disruption techniques may be used alone or combined with other pest management practices.

Two pests, codling moth and tufted apple budmoth, are currently the subject of mating disruption research in apples. Fully proven systems for use by conventional commercial apple growers are not yet in place, but an Oriental fruit moth system is used currently by commercial peach growers.

SECOND STAGE IPM

Much of the information discussed here converges as second stage IPM. Researchers in Massachusetts have shown that small orchards can produce high quality fruit with two to three insecticide sprays and one oil spray per season. This practice is still under investigation but can be outlined here:

1. Dormant oil applied at six gallons per acre at the half-inch green stage of bud development is targeted against European red mite eggs, aphid eggs, and San Jose scale.
2. Abandoned alternate hosts (apple, pear, hawthorn and quince trees) are removed from within at least 100 yards of the orchard, thus reducing second generation codling moth and summer leafrollers. If some pests, particularly leafrollers, get through, then a *Bacillus thuringiensis* insecticide can be used to control very young larvae.
3. Two applications of Imidan (phosmet) sprays are made to control plum curculio, European apple sawfly, fruitworms, and first generation codling moth and leafroller larvae. The first spray is applied at petal fall, or when the first egg-laying scars from PC appear. On full size trees, Imidan 50W is used at 5 lb per acre with a sticker. The second application is made ten to fourteen days later. Botanical sprays do not work under this program.
4. Red sphere AMF traps, baited with synthetic apple volatile, are placed at five-yard intervals around the orchard perimeter. This serves as a "behavioral wall" which intercepts apple maggot flies coming from hosts outside the orchard.
5. All fruit drops after mid-August are removed weekly to reduce buildup of apple maggot, codling moth, and several leafrollers.
6. Mating disruption strategies may be used if codling moth or leafrollers are present.

APPENDIX I: FURTHER READING

ECONOMICS:

A Survey of the Cost of Growing and Harvesting Apples in Eastern New York in 1988 by Mark Castaldi, 1989, Cornell University Extension Bulletin # XB016

The Costs of Establishing and Operating a 'McIntosh', 'Red Delicious' and 'Empire' Orchard in The Hudson Valley of Eastern New York by Mark Castaldi, 1987, Cornell University Extension Bulletin # XB007

The Economic and Financial Feasibility of Producing Fresh Market Apples in The Hudson Valley of Eastern New York by Mark Castaldi, 1987, Cornell University Extension Bulletin # XB010

Estimating the Cost of Owning and Operating Farm Machinery, 1987, Cornell University Extension Bulletin # XB004

HORTICULTURE

Tree Fruit Production Guides May be Obtained From:

Pennsylvania - The Pennsylvania State University, Cooperative Extension Service, Agricultural Administration Building, University Park, PA 16802

Maryland - Cooperative Extension Service, University of Maryland, Rm 1214, Symons Hall, College Park, MD 20742

New Jersey - Rutgers University Cooperative Extension Service, PO Box 231, Cook College, New Brunswick, NJ 08903-0231

New York - Cornell University Cooperative Extension Service, Distribution Office, Cornell University, Ithaca, NY 14853

Virginia - Cooperative Extension Services, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

West Virginia - West Virginia University, Morgantown, WV 26506

The *New England Apple Spray Guide* is available from the Cooperative Extension Services of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont

Guides for Organic Tree Fruit Management:

The Orchard Almanac - A Spray Saver Guide by Stephen Page and Joseph Smillie. Includes references, suppliers, organizations, 145 pp. Spraysaver Publications, Rockport, ME 04856

Proceedings of the Organic and Low-Spray Fruit Production Conference by the Natural Organic Farmers Association of New York, Inc. Held at Cornell University, January 24 and 25, 1987. Includes basic pest monitoring and marketing information, charts, supplier lists, 133 pp. NOFA-NY, PO Box 454, Ithaca, NY 14851

1988 Apple Orchard Summary by Sarah Wolfgang. Organic pest management field trial observations, 37 pp. Rodale Research Center, 611 Siegfriedale Road, Kutztown, PA 19530. Publication # RRC HO-89/3

Newsletters

The Apple Press Department of Plant and Soil Sciences, 206 Hills Building, University of Vermont, Burlington, VT 05405

Fruit Notes Department of Plant and Soil Sciences, 205 Bowditch Hall, University of Massachusetts, Amherst, MA 01003

Northeast LISA Apple Newsletter Department of Plant Pathology, Fernald Hall, University of Massachusetts, Amherst, MA 01003

Also: Contact your state's Extension tree fruit specialist for information about local apple newsletters for growers.

Industry Publications

American Fruit Grower 37841 Euclid Avenue, Willoughby, OH 44094

The Good Fruit Grower 1005 Tieton Drive, Yakima, WA 98902-3587

The Great Lakes Fruit Grower News PO Box 128, Sparta, MI 49345

New England Farmer 50 Bay Street, PO Box 391, Saint Johnsbury, VT 05819

The Packer 7950 College Blvd., Overland Park, KS 66210

Apple Guides

Annual Apple Spray Guide Contact your state's Extension specialist in entomology, plant pathology, or tree fruit for availability.

Apple Production Guide Contact your state's Extension tree fruit specialist for availability.

Books

Modern Fruit Science, 1983, Horticultural Publications, 3906 NW 31 Place, Gainsville, FL 32606

Rootstocks for Fruit Crops, 1987, John Wiley & Sons, Inc., 605 Third Ave., New York, NY 10158

DISEASES

Diseases of Fruit Crops by H. W. Anderson, 1956, 501 pp. McGraw-Hill Book Company, Inc., New York, NY

Diseases of Tree Fruits by A. L. Jones and T. B. Sutton, 1984, 59 pp. Cooperative Extension Service, Michigan State University, East Lansing, MI

Compendium of Apple and Pear Diseases, edited by A. L. Jones, H. S. Aldwinckle, and S. V. Thomson, 1990, APS Press, St. Paul, MN

INSECTS:

Simplified Insect Management Program - A Guide for Apple Sampling Procedures in New York by A. Agnello, et al., 1989, Cornell University Extension Bulletin IPM No. 201A

Instruction Manual: Biological Monitoring in Apple Orchards edited by S. L.Battenfield, 1983, Michigan State University Cooperative Extension Service

Pear Pest Management edited by R. S. Bethell, 1978, Regents University of California, #4086

Tree Fruit Insects by J. F. Brunner,et al., 1981, Michigan State University, NCR Extension Publication #63

Integrated Management of Apple Pests in Massachusetts and New England by W. M. Coli, et al., 1984, University of Massachusetts

Integrated Orchard Management in West Virginia by H. W. Hogmire, et al., 1986, Cooperative Extension Service, West Virginia University, # OM 104

Proceedings of the Organic and Low-Spray Fruit Production Conference by J. Lyons and L. Ward, 1988, Natural Organic Farmers Association (NOFA) of New York

"Decrease pesticide costs by using traps" by G. B. MacCollom, in *American Fruit Grower* (April, 1987) pp.42-43

Spotted Tentiform Leafminer - A Pest of Wisconsin Apple Orchards by D. L. Mahr and N. Ravdin, 1983, University of Wisconsin, Cooperative Extension Bulletin #A3211

Destructive and Useful Insects by C. L. Metcalf, W.P. Flint, and R.L. Metcalf, 1962, 1087 pp., McGraw-Hill, New York, NY

"Beyond the first stage of apple IPM in Massachusetts" by R. J. Prokopy, 1988, in *Proceedings of the 93rd Annual Meeting:Massachusetts Fruit Growers Association.* Concord, New Hampshire, Vol. 93, pp. 78-81

"Minimizing pesticide use in apple production" by R. J. Prokopy, 1989, in Proceedings of New York Horticultural Society

11th Annual March Message to Massachusetts Tree Fruit Growers by R. J. Prokopy, et al., 1989, Department of Entomology, University of Massachusetts

APPENDIX II: SUPPLIERS

General Supplies: (insect traps, lures, monitoring equipment, botanical insecticides, beneficial organisms, and disease control supplies)

Great Lakes IPM
10220 Church Road, NE
Vestaburg, Michigan 48891
517-268-5693

Pest Management Supply Co.
P.O. Box 938
Amherst, Massachusetts 01004
413-256-0886
800-272-7672

Harmony Farm Supply
PO Box 451
4050 Ross Road
Graton, CA 95444
707-823-9125

Nature's Way Products
Earlee, Inc.
726 Spring Street
Jeffersonville, IN 47130
812-282-9134

Peaceful Valley Farm Supply
11173 Peaceful Valley Road
NevadaCity, CA 95959
916-265-FARM

Safer Agro-Chem, Inc.
PO Box 649
Jamul, CA 92035
619-464-0775

Growing Naturally
149 Pine Lane
PO Box 54
Pineville, PA 18946
215-598-7025

Natural Farm Products
Rte 2
Box 201A
Spencer Road
Kalkaska, MI 49646
616-258-2377

Necessary Trading Co.
Newcastle, VA 24127
703-864-5103

Natural Gardening Research Center
Hwy 48, PO Box 149
Sunman, IN 47041
812-623-3800

Insect Traps:

Bio-Control Services
2949 Chemin Ste-Foy
Ste-Foy, Quebec, Canada G1X 1P3
418-653-3101

Consep Membranes, Inc.
213 Southwest Columbia
P.O. Box 6059
Bend, Oregon 97708
503-388-3688

Hara Products Ltd.
P.O. Box 134
1981 Chaplin Street W.
Swidt Current, Sask. Canada S9H 3Y5
306-773-2131

Hercon Laboratories, Inc.
200B Corporate Court
Middlesex Business Center
South Plainfield, New Jersey 07080
201-755-7730

Insects Limited Inc.
10505 N. College Ave.
Indianapolis, Indiana 46280
315-846-5444

Ladd Research Industries, Inc.
P.O. Box 1005
Burlington, Vermont 05402
802-658-4961

Olson Products, Inc.
P.O. Box 1043
Medina, Ohio 44258
216-723-3210

Raylo Chemicals Ltd.
Subsidiary of Terochem Laboratories, Ltd.
8045 Argyll Rd.
Edmonton, Alberta Canada T6C 4A9

Scentry Inc.
A United Agri Products Company
P.O. Box 426
Buckeye, Arizona 85326
602-386-6737, 233-1772

Trece Inc.
P.O. Box 5267
635 South Sanborn Rd., Suite 17
Salinas, California 93915
408-758-0205

Weather, Degree Day, and Disease Monitoring Supplies:

Belfort Instrument Co. (Hygrothermographs)
727 South Wolfe St.
Baltimore, MD 21231
301-342-2626

Gottfried Pessl (Metos weather and disease warning device)
Schlachthausgasse 23
8160 Weiz, Austria
Tel. 03172/5521

Neogen Food Technology Corp. (Weather and disease warning device)
620 Lesher Place
Lansing, Mi. 48912
517-372-9200

Omnidata International Inc. (Weather monitoring and degree day counting units)
P.O. Box 3489
Logan, Utah 84321
801-753-7760

Paar USA Inc. (Weather monitor and scab warning device)
340 Constance Drive
Warminster, PA. 18974
215-443-7570
800-722-7556

RainWise, Inc. (Weather monitoring equipment)
25 Federal St. / P.O. Box 443
Bar Harbor, ME 04609
207-288-5169

Reuter-Stokes Instruments Inc. (Weather monitoring and disease warning devices)
18530 South Miles Parkway
Cleveland, Ohio 44128
216-581-9400

Weathermeasure (Weather monitoring equipment, hygrothermographs)
P.O. Box 41257
Sacramento, California 95813
916-481-7565

Beneficial Insects and Mites:

Beneficial Insectary
14751 Oak Run Road
Oak Run, CA 96069
916-472-3715

Rincon-Vitova Insectaries, Inc.
PO Box 95
Oakview, CA 93022
805-643-5407

Integrated Orchard Management
821 North Stevenson Street
Visalia, CA 93291
209-625-5199

Gerhart, Inc.
6346 Avon Belden Road
North Ridgeville, OH 44039
216-327-8056

Beneficial Parasitic Nematodes:

BioLogic
418 Briar Lane
Chembersburg, PA 17201
717-263-2789

BioSys
1057 East Meadow Circle
Palo Alto, CA 94303
415-856-9500

Bacillus thuringiensis:

Abbott Laboratories
Dept. D-44C
1400 Sheridan Road
North Chicago, IL 60064
312-937-7909

Ecogen, Inc.
2005 Cabot Blvd. West
Langhorn, PA 19047
215-757-1590

Fairfax Biological Laboratory, Inc.
Clinton Corners, NY 12514
914-266-3705

Mycogen Corporation
5451 Oberlin Drive
San Diego, CA 92121
619-453-8030

Sandoz Crop Protection
Box 10975
Palo Alto, CA 94303
415-227-8929, 415-859-1130

Certification Information:

1990 Organic Wholesalers Directory and Yearbook: Organic Food and Farm Supplies edited by Doreen Stabinski. Arranged on a state-by-state basis. Lists organic state laws and certification groups 224 pages. Can be ordered from: California Action Network, PO Box 464, Davis, CA 95617; telephone: 916-756-8518.

CONNECTICUT:

Natural Organic Farmers Association/Connecticut
Route 2, Box 229
Durham, CT 06422
203-349-1417
Contact: Barbara Buffo

MAINE:

Maine Organic Farmers and Gardeners Association
Box 2176
283 Water Street
Augusta, ME 04330
207-622-3118
Contact: Eric Sideman, Director of Technical Services

MASSACHUSETTS:

Natural Organic Farmers Association/Massachusetts
RFD 2 Sheldon Road
Barre, MA 01005
508-355-2853
Contact: Julie Rawson

NEW HAMPSHIRE:

Department of Agriculture, Bureau of Markets
Caller Box 2042
Concord, NH 03302
603-271-3685

NEW JERSEY:

Natural Organic Farmers Association/New Jersey
Jennifer Morgan
RD 2 Box 263A
Pennington, NJ 08534
609-737-3735

NEW YORK:

Natural Organic Farmers Association/New York
PO Box 454
Ithaca, NY 14851
607-648-5557

PENNSYLVANIA:

Pennsylvania Organic Crop Improvement Association
18315 Kings Road
Whitehall, MD 21161
301-343-1828
Contact: Drew Norman

VERMONT:

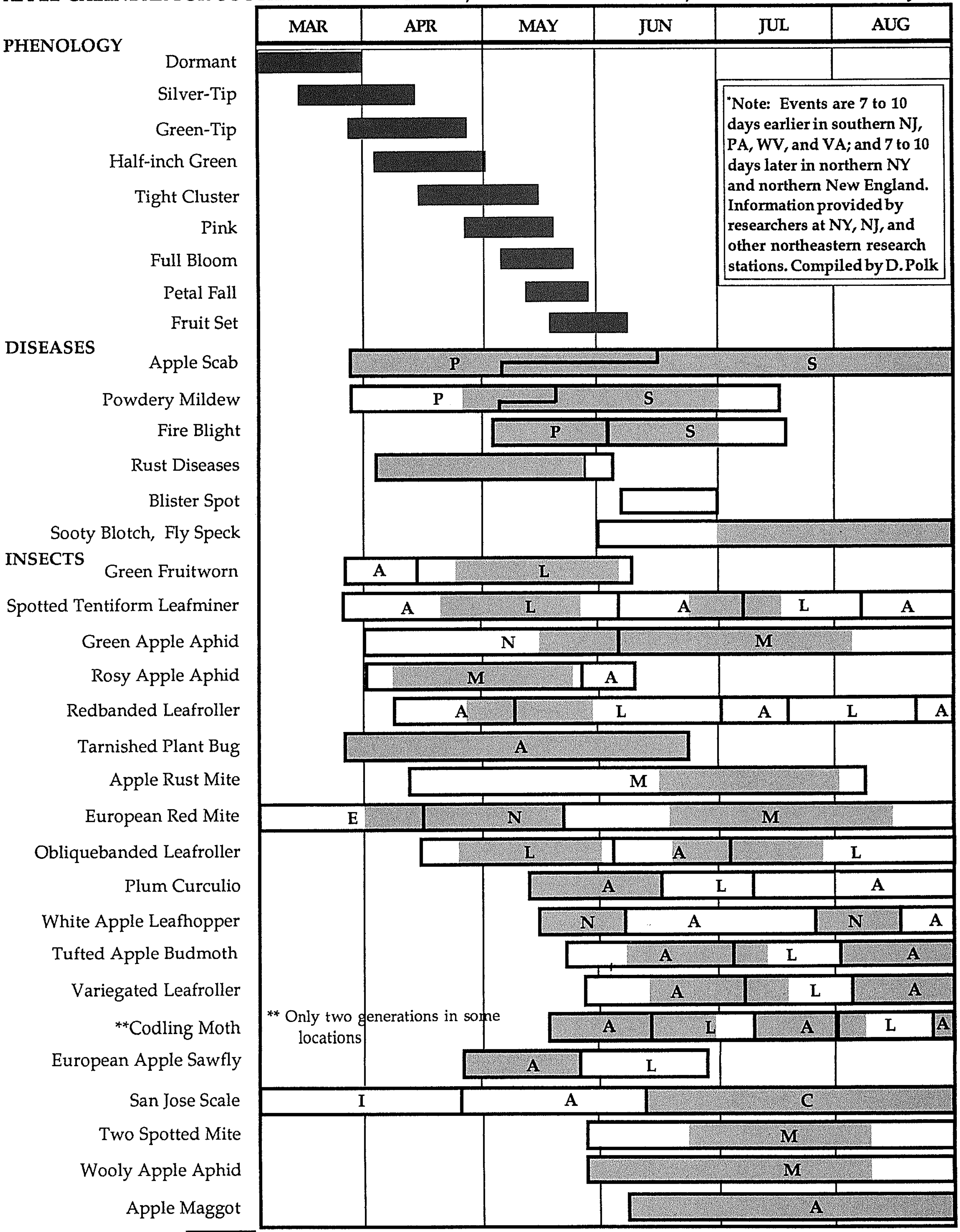
Vermont Organic Crop Improvement Associaton
Box 84, RFD 3
St. Johnsbury, VT 05819
802-633-4152
Contact: Grace Gershunye

APPENDIX III: METRIC CONVERSION TABLE

To convert Column 1 into Column 2, multiply by	Column 1 SI Unit	Column 2 non-SI Unit	To convert Column 2 into Column 1 multiply by
Length			
0.621	kilometer, km (10^3 m)	mile, mi	1.609
1.094	meter, m	yard, yd	0.914
3.28	meter, m	foot, ft	0.304
3.94×10^{-2}	millimeter, mm (10^{-3} m)	inch, in	25.4
Area			
2.47	hectare, ha	acre	0.405
247	square kilometer, $km^2(10^3\ m)^2$	acre	4.05×10^{-3}
0.386	square kilometer, $km^2(10^3\ m)^2$	square mile, mi^2	2.590
2.47×10^{-4}	square meter, m^2	acre	4.05×10^{3}
10.76	square meter, m^2	square foot, ft^2	9.29×10^{-2}
1.55×10^{-3}	square millimeter, $mm^2(10^{-3}m)^2$	square inch, in^2	645
Volume			
9.73×10^{-3}	cubic meter, m^3	acre-inch	102.8
35.3	cubic meter, m^3	cubic foot, ft^3	2.83×10^{-2}
6.10×10^{4}	cubic meter, m^3	cubic inch, in^3	1.64×10^{-5}
2.84×10^{-2}	liter, L ($10^{-3}m^3$)	bushel, bu	35.24
1.057	liter, L ($10^{-3}m^3$)	quart (liquid), qt	0.946
3.53×10^{-2}	liter, L ($10^{-3}m^3$)	cubic foot, ft^3	28.3
0.265	liter, L ($10^{-3}m^3$)	gallon	3.78
33.78	liter, L ($10^{-3}m^3$)	ounce (fluid), oz	2.96×10^{-2}
2.11	liter, L ($10^{-3}m^3$)	pint (fluid), pt	0.473
Mass			
2.20×10^{-3}	gram, g(10^{-3}kg)	pound, lb	454
3.52×10^{-2}	gram, g(10^{-3}kg)	ounce (avdp), oz	28.4
2.205	kilogram, kg	pound, lb	0.454
1.10×10^{-3}	kilogram, kg	ton (2000 lb), ton	907
1.102	tonne, t	ton (U.S.), ton	0.907
Yield and Rate			
0.893	kilogram per hectare, kg ha^{-1}	pound per acre, lb $acre^{-1}$	1.12
7.77×10^{-2}	kilogram per cubic meter, kg m^{-3}	pound per bushel, lb bu^{-1}	12.87
1.49×10^{-2}	kilogram per hectare, kg ha^{-1}	bushel per acre, 60 lb	67.19
1.59×10^{-2}	kilogram per hectare, kg ha^{-1}	bushel per acre, 56 lb	62.71
1.86×10^{-2}	kilogram per hectare, kg ha^{-1}	bushel per acre, 48 lb	53.75
0.107	liter per hectare, L ha^{-1}	gallon per acre	9.35
893	tonnes per hectare, t ha^{-1}	pound per acre, lb $acre^{-1}$	1.12×10^{-3}
893	megagram per hectare, Mg ha^{-1}	pound per acre, lb $acre^{-1}$	1.12×10^{-3}
0.446	megagram per hectare, Mg ha^{-1}	ton (2000 lb) per acre, ton $acre^{-1}$	2.24
2.24	meter per second, m s^{-1}	mile per hour	0.447
Temperature			
1.00 (K - 273)	Kelvin, K	Celsius, °C	1.00 (°C + 273)
(9/5 °C) + 32	Celsius, °C	Fahrenheit, °F	5/9 (°F - 32)
Concentrations			
0.1	gram per kilogram, g kg^{-1}	percent, %	10
1	milligram per kilogram, mg kg^{-1}	parts per million, ppm	1
Plant Nutrient Conversion			
2.29	P	P_2O_5	0.437
1.20	K	K_2O	0.830
1.39	Ca	CaO	0.715
1.66	Mg	MgO	0.602

NOTES

APPLE CALENDAR FOR SOUTHERN NEW ENGLAND, SOUTHERN NEW YORK, AND NORTHERN NEW JERSEY*



Critical Monitoring Time P = Primary infection period S = Secondary infection period

Predominant Stage: A = Adult, L = Larva, E = Egg, N = Nymph, C = Crawlers, M = Mixed, I = Immature