2000

Predicting habitat suitability for American woodcock and landscape-level assessment of habitat in West Virginia

Ann Klein Steketee
West Virginia University

Follow this and additional works at: <https://researchrepository.wvu.edu/etd>

Recommended Citation

Steketee, Ann Klein, "Predicting habitat suitability for American woodcock and landscape-level assessment of habitat in West Virginia" (2000). *Graduate Theses, Dissertations, and Problem Reports*. 1188.

<https://researchrepository.wvu.edu/etd/1188>

This Dissertation is protected by copyright and/or related rights. It has been brought to you by the The Research Repository @ WVU with permission from the rights-holder(s). You are free to use this Dissertation in any way that is permitted by the copyright and related rights legislation that applies to your use. For other uses you must obtain permission from the rights-holder(s) directly, unless additional rights are indicated by a Creative Commons license in the record and/ or on the work itself. This Dissertation has been accepted for inclusion in WVU Graduate Theses, Dissertations, and Problem Reports collection by an authorized administrator of The Research Repository @ WVU. For more information, please contact researchrepository@mail.wvu.edu.

**Predicting Habitat Suitability For American Woodcock and Landscape-
level Assessment of Habitat in West Virginia**

By

Ann Klein Steketee

Dissertation Submitted to
The College of Agriculture and Forestry
at West Virginia University
In partial fulfillment of the requirements
for the degree of

Doctor of Philosophy
in
Forest Resource Management

Petra B. Wood Ph.D. Chair
John G. Bruggink Ph.D.
Jack I. Cromer
David E. Samuel Ph.D.
Charles Yuill

Division of Forestry
West Virginia University
Morgantown, West Virginia

2000

ABSTRACT

Predicting Habitat Suitability For American Woodcock and Landscape-level Assessment of Habitat in West Virginia

Ann K. Steketee

The objectives of this study were to 1) develop models to predict potential habitat suitability for woodcock over large geographic areas in West Virginia (Chapter 4), 2) quantify and describe the local and landscape structural components and spatial patterns of woodcock habitat in the state (Chapter 3), and 3) to determine the current suitability and fate of woodcock habitat that was available in the mid-1970's (Chapter 5).

Differences between 165 woodcock flush points and 165 randomly generated points for proportion of 12 land-cover types and 4 metrics describing landscape composition and pattern were compared within 3 elevation groups and 8 spatial scales. Habitat variables were determined from the Multi-Resolution Land Cover database and FRAGSTATS spatial analysis program. Logistic regression was used to quantify relationships between woodcock use sites and available habitat. Standard reclassification statistics were used to evaluate modeling efficiency and model results were extrapolated to the entire study area. Developed models were generally better at classifying use points than nonuse points. Predicted habitat suitability for the study area ranged from $P = 0.0$ to 0.96 . The two best indicators of woodcock habitat suitability were distance to the nearest wooded wetland and degree of slope. Six habitat variables differed by scale for at least one group of flush points, no variable around random points varied by scale. No habitat variable was important to woodcock at all elevations and most differences occurred in low- and mid-elevations.

Using a combination of singing male counts, dog-assisted searches and other means, 5,115 ha of habitat that had been field-checked in the 1970's were resurveyed. Twenty-five (408 ha) resurveyed sites were classed as definitely not woodcock habitat and 28 sites (173 ha) were classed as unlikely woodcock habitat. Forty-two sites (1040 ha) were classed as possible woodcock habitat; 16 sites (451 ha) were probably woodcock habitat and woodcock were found on 15 sites (3,042 ha). Original classification was a good predictor of status in the 1990's. The majority (83.0 % of sites, 65.6 % of area) of the sites currently classified as unsuitable (definitely not or unlikely) were originally rated as poor or fair habitat. The majority (48.3 % of sites, 93.0 % of area) of the sites currently rated as definite woodcock habitat were originally rated good or exceptional habitat. Reasons for habitat loss included suburban and industrial development, flooding due to dams, conversion to agricultural use (e.g. open fields, pastures, or row crops) and seral advancement of forest vegetation beyond what was suitable for woodcock.

PREDICTING HABITAT SUITABILITY FOR AMERICAN WOODCOCK AND A LANDSCAPE-LEVEL ASSESSMENT OF HABITAT IN WEST VIRGINIA

Table of Contents	iii
List of Figures	vi
List of Tables.....	viii
Acknowledgements	xi
 CHAPTER 1. INTRODUCTION	
Introduction	1
Study Area.....	3
Methods and Data Sources.....	6
Locating Current Habitat.....	6
Woodcock Use.....	7
Habitat Sampling	9
Digital Data Sources	10
 CHAPTER 2. LOCATION AND CHARACTERISTICS OF WOODCOCK HABITAT IN WEST VIRGINIA	
Introduction	15
Study Area.....	16
Methods	16
Locating Current Habitat.....	16
Woodcock Use.....	17
Habitat Sampling	18
Results.....	20
Current Habitat	20
Flush Site Vegetation	21
Discussion	21
Current Habitat	21
Vegetation Characteristics.....	23
 CHAPTER 3. HABITAT PATTERNS AROUND AMERICAN WOODCOCK FLUSH SITES IN WEST VIRGINIA	
Introduction	30
Study Area.....	31
Methods	33
Flush Sites and Random Points	33
Landscape Structure and Spatial Characteristics	34
Statistical Analysis.....	36
Comparisons of Non-scale Dependent Variables	38
Results.....	38
Effects of Scale	38
Comparisons of Elevation and Use Type	39
Differences in Non-scale Variables	40
Discussion	41
Effects of Elevation.....	41

CHAPTER 4. USING LOGISTIC REGRESSION AND BROAD-SCALE DATA TO PREDICT POTENTIAL
HABITAT SUITABILITY FOR AMERICAN WOODCOCK IN THE HIGH ALLEGHENY REGION OF
WEST VIRGINIA

Introduction	62
High Allegheny Study Area	64
Methods	64
Data Collection	64
GIS Analysis	65
Model Development and Evaluation	67
Model Extrapolation	68
Model Extrapolation to the Entire State	69
Results	69
Model Development	69
Model Testing	71
Model Extrapolation	71
Extrapolation to the Entire State	72
Discussion	72
Habitat Relationships	72
Model Performance	74
Model Extrapolation	76
Management Implications	77
Using the Predictive Models	78

CHAPTER 5. CHANGES IN QUALITY AND QUANTITY OF AMERICAN WOODCOCK HABITAT IN
WEST VIRGINIA FROM THE 1970'S TO THE 1990'S

Introduction	89
Methods	91
Summary of Previous Work	91
Data Transfer	92
Determining Current Status	92
Determining Current Status from Developed Predictive Model	94
Results	95
Current Status of Sites Field-checked in the 1970's	95
Current Status Determined from Predictive Model	96
Discussion	97
Limitations of the Studies	99

APPENDIX 1

Public Land	112
Private Land	115
LITERATURE CITED	117

LIST OF FIGURES

Figure 2-1. State of West Virginia showing the locations of 301 areas searched for woodcock presence during 1995-1997.	25
Figure 2-2. State of West Virginia showing the locations of 165 woodcock flush points that occurred during 1995-1997 and the location of the High Allegheny Study Area.....	26
Figure 3-1. The state of West Virginia showing the location of the High Allegheny Study Area and the locations of the 165 woodcock flush points that occurred during 1995-1997.	44
Figure 3-2. The state of West Virginia showing the location of the High Allegheny Study Area and the locations of the 165 randomly generated points.	45
Figure 3-3. Mean proportion of woody wetland measured within each buffer distance for woodcock flush points and random points in each elevation group. The line formed by the mean proportion of woody wetlands around mid-elevation flush points was significantly different from those of all random points and low- and high-elevation flush points.	46
Figure 3-4. Mean proportion of deciduous forest measured within each buffer distance for woodcock flush points and random points in each elevation group. The lines formed by the mean proportion of deciduous forest around mid- and low-elevation flush points were significantly different from those of all random points and high-elevation flush points.	47
Figure 3-5. Mean proportion of transitional land measured within each buffer distance for woodcock flush points and random points in each elevation group. The lines formed by the mean proportion of transitional around high-elevation flush points was significantly different from those of all random points and mid- and low-.....	48
Figure 3-6. Mean proportion of row crops measured within each buffer distance for woodcock flush points and random points in each elevation group. The lines formed by the mean proportion of row crops around low-elevation flush points was significantly different from those of all random points and mid- and high-elevation flush points.	49
Figure 3-7. Mean proportion of mixed pasture/low-intensity agriculture measured within each buffer distance for woodcock flush points and random points in each elevation group.	50
Figure 3-8. Mean fractal dimension within each buffer distance for woodcock flush points and random points in each elevation group.	51
Figure 3-9. Mean proportion of woody wetlands, emergent wetlands, water, and patch richness in the 450-m buffer. Like letters over bars indicate that means are not significantly different	52
Figure 3-10. Mean proportion of deciduous, mixed, and coniferous forest, and developed land, mixed pasture/ low intensity agriculture, row crops, and hay/pasture/grass in the 450-m buffer. Like letters over bars indicate that means are not significantly different.....	53

Figure 3-11. Mean proportion of hay/pasture/grass, row crops, mixed pasture/low intensity agriculture, and barren land in the 450-m buffer. Like letters over bars indicate that means are not significantly different.	54
Figure 3-12. Means of diversity index and contagion index in the 450-m buffer. Like letters over bars indicate that means are not significantly different.	55
Figure 4-1. The High Allegheny Study Area and locations of Canaan Valley, the 134 random points and the 134 woodcock flushes that occurred during 1995-1997. The inset shows the location of the study area within West Virginia	80
Figure 4-2. Predicted probability of woodcock habitat suitability in West Virginia's High Allegheny Study Area. The inset shows the location of Canaan Valley and the study area within West Virginia. The largest contiguous amount of area predicted to be highly suitable occurred within Canaan Valley..	81
Figure 5-1. Location of the High Allegheny Study Area and 1970's habitat inventory sites that occurred in the study area.....	101
Figure 5-2. Area given each woodcock habitat quality rating by Fenwood (1976) and Webb (1978) and area in each category resurveyed. A disproportionate amount of excellent habitat was resurveyed.....	102
Figure 5-3. Current quality categories showing proportion of area in each original (1970's) quality classification. Each column represents one of 5 current quality ratings. The first column represents areas that are definitely no longer habitat; 19 % of the area was originally listed as poor (pink), 40 % was fair (green), none of it was exceptional. Conversely, of the area currently classed as definitely woodcock habitat, (the last column) 95 % of it was originally characterized as exceptional (blue) and none of it was poor.	103
Figure 5-4. Original (1970's) quality categories showing proportion of area in each current quality classification. Each column represents one of 4 1970's quality ratings. The first column represents areas originally classed as poor habitat; it still contains the largest proportion of unsuitable habitat (pink and green). Half of it is possible habitat; only 6% is probable habitat and none if it is definite habitat. The majority of last column, areas originally rated as exceptional habitats, is currently definite habitat and the rest is probable or possible habitat.	104

LIST OF TABLES

Table 1-1. Land-use/land-cover classes used with Multi-Resolution Land Cover data to obtain habitat variables associated with woodcock presence in West Virginia.....	14
Table 2-1. Quality rating given to areas identified as potential woodcock habitat after field checking.	27
Table 2-2. Woodcock habitat areas in West Virginia with the greatest number of flushes per dog-hour during 1995-1998.	28
Table 2-3. Means of vegetation data collected at 87 points state-wide where woodcock had been flushed in 1995-1997 and 28 points within areas that had been unsuccessfully searched for woodcock with dogs in 1997.	29
Table 3-1. Land-use/land-cover classes used with Multi-Resolution Land Cover data to obtain habitat variables associated with woodcock presence in West Virginia.....	56
Table 3-2. Analysis of variance (ANOVA) models used for analyzing habitat patterns around woodcock flush sites in West Virginia.....	57
Table 3-3. Results of ANOVA comparisons for effect of scale. Where ANOVAs were significant ($P < 0.05$) separate comparisons were made for flush and random points to determine where scale differences existed. All scale differences occurred around flush points.	58
Table 3-4. Results of a series of significant analysis of variance tests comparing proportion of each land-cover type within a 450-m buffer around 6 use type/elevation groups. The last six columns show the mean value of each habitat variable and the result of the Tukey least square means test. Use-type/elevation combinations with the same letter were not significantly different.	59
Table 3-5. Results ($P > F$) of ANOVA comparisons of non-scale dependent variables. The model column shows the ANOVA 'F' and probability, the next three columns give the means and the results of the Tukey least square means multiple comparisons. Groups with the same letter are not significantly different ($\alpha = 0.05$).....	60
Table 4-1. Land-use/land cover classes used with Multi-Resolution Land Cover data to obtain habitat variables associated with woodcock presence in West Virginia.....	82
Table 4-2. Results (G value) of univariate logistic regression for each habitat variable for each buffer distance using mid-elevation points. An 'x' indicates variables that were not used for further analysis for that buffer distance because $G > 0.25$. A '-' indicates variables deleted after correlation analysis.	83
Table 4-3. Results (G value) of univariate logistic regression for each habitat variable for each buffer distance using high-elevation points. An 'x' indicates variables that were not used for further analysis for that buffer distance because $G \geq 0.25$. A '-' indicates variables deleted after correlation analysis.	84
Table 4-4. Habitat variables identified by a series of logistic regression models as important to woodcock presence in West Virginia's High Allegheny study area. Minus sign	

indicates a negative association with woodcock presence; plus sign indicates a positive association.....	85
Table 4-5. Number of 31 woodcock flush points that occurred during June 1998 classified into 4 groups of potential habitat suitability by the ‘best’ logistic regression models developed to predict habitat suitability for woodcock in the High Allegheny study area. The best mid-elevation model was developed using habitat variables measured within a 450 m buffer. The best high-elevation models were developed using habitat variables measured within 150 m and 1050 m buffers. Both mid- and high-elevation models performed better at classifying points within the same elevation group.	86
Table 4-6. Number of 31 woodcock flush points that occurred outside of the study area classified into 4 groups of potential habitat suitability by the ‘best’ logistic regression models developed to predict habitat suitability for woodcock in the High Allegheny study area. The best mid-elevation model was developed using habitat variables measured within a 450-m buffer. The best high-elevation models were developed using habitat variables measured within 150 m and 1050 m buffers. Both mid- and high-elevation models performed better at classifying points within the same elevation group.	87
Table 5-1. Quality categories for American woodcock habitat in West Virginia as determined by Fenwood (1976) and Webb (1978).	105
Table 5-2. Quality ratings given in 1995-1997 to woodcock habitat sites originally classified by Fenwood (1976) and Webb (1978) in the mid-1970’s.	106
Table 5-3. Current and original woodcock habitat quality classification of a sample of sites originally field-checked, classified during the 1970’s study, and reclassified during 1995-1997. Number of sites is given with area (in hectares) in parentheses.....	107
Table 5-4. Number of sites and amount of habitat reclassified as unsuitable and reasons for its current unsuitability. Number of sites is given with area (in hectares) in parentheses.	108
Table 5-5. Current and original quality classification of a sample of sites categorized solely from aerial photograph during the 1970’s study and reclassified during 1995-1997. Number of sites is given with area (in hectares) in parentheses.	109
Table 5-6. Current quality classification and mean predicted probability of woodcock occurrence for sites within the High Allegheny Region that had been field-checked in the 1970’s and resurveyed during 1995-1997.....	110
Table 5-7. Number of sites, area, and original quality classification for sites in the High Allegheny Region predicted to be suitable woodcock habitat (probability of woodcock occurrence $P > 0.50$) and unsuitable habitat (probability of woodcock occurrence of $P < 0.50$).....	111
Table A-1. Number of all points (134 flush and 134 random points) and mid-elevation points (80 each) classified into each of 4 groups of potential habitat suitability by logistic regression models developed to predict habitat suitability for woodcock in the High Allegheny study area.	122

Table A-2. Number of all points (134 flush and 134 random points) and high-elevation points (54 flush and 54 random points) classified into each of 4 groupings of potential habitat suitability by logistic regression models developed to predict habitat suitability for woodcock in the High Allegheny study area.	123
---	-----

ACKNOWLEDGEMENTS

This project would not have been possible without the help, support, and guidance of many people. A few brief lines here can not begin to repay the debts I owe.

First, I am thankful for the support of my husband, partner, and KSI charter member Jerry. Without him I would not have even gotten started; how do you say *thanks for everything*? Thanks to my kids Hannah and Jack, you are the ones who make it all worthwhile. This story is for you, thanks for going woodcocking with me.

My advisor and committee chair Dr. Petra Wood was everything I could want in an advisor. I am thankful for her guidance, advice, and patience during my entire time at WVU. I appreciated her low-key, relaxed style and open door. I will always be grateful to her for understanding and respecting my role as a mommy as well as my role as a graduate student.

I would also like to thank the rest of my committee for their time and patience and the numerous reviews of proposals, manuscripts, and thesis drafts. Thank you to Dr. John Bruggink in his second term as my committee member. I appreciated your thorough reviews and constructive comments.

Thank you to Walter Lesser for his willingness to share his expert knowledge of woodcock habitat in the state. Thanks to my fellow scolopaxologists Pam Denmon and Ian Gregg and to the field-assistants who did the real work: Erica Zimba, Kathy Huffman, Robert Oxendorfer, and Natasha Diamond. I am particularly grateful to Roger Anderson for loaning his setter 'Bubba' to the project and to Ken Lynch and his German shorthairs who came from New York to show me how to really find woodcock. They flushed more birds in 2 months of work than I did in three summers. Thanks to all the dogs and their people who spent days 'hunting' woodcock for the project including Walter Lesser, Kay Pierce, Frank Jezero, Bruce Brenneman, and Tom Dotson.

Many fellow graduate students helped academically and more importantly helped to keep me sane. Ree Brannon has my unending thanks for her patient help when I was first learning GIS. I have tried to repay her by passing along this help. I am grateful for the friendship and camaraderie of Katie, Gary, Jeff, J.B. Julie, Dorothy, Cheryl, Joell, Brent, Jackie, Mike, and many others whom it was my pleasure to know and work with. And to Jeff and Tara, Brent and Liz, and Stuart and Beth, fellow students and fellow parents you helped show me that it could be done.

Finally, I am indebted to my parents, Bill and Ginny Klein, for their moral and financial support. They have always respected and supported my decisions, ideas, and goals. Thank you.

CHAPTER 1.

INTRODUCTION

The American woodcock (*Scolopax minor*) is a small, migratory, game bird belonging to the Order Charadriiformes, and the Family Scolopacidae, which contains the snipe (*Gallinago gallinago*), sandpipers, and woodcock. Although classified as a shorebird, woodcock are physically and behaviorally adapted to damp woodlands (Sepik et al. 1981). Typical American woodcock habitat is wet woodlands containing young forest and scattered openings (Sheldon 1967). Because it is listed as a game bird, the welfare and population status of the woodcock has been a concern to sports people and biologists for decades. Results from the U. S. Fish and Wildlife Service's (USFWS) North American Singing-ground Survey have indicated that woodcock populations in the eastern United States have declined since 1968 when monitoring began (Straw et al. 1994, Bruggink 1997). West Virginia is part of the USFWS's Eastern Region where short- (1987-1997) and long-term (1968-1997) trend analyses indicated that breeding populations have declined significantly by 3.6 % and 2.5 % per year, respectively. In West Virginia, long-term trend analyses indicated significant woodcock population declines of 2.1 % per year (Bruggink 1997).

Habitat loss throughout the breeding grounds is thought to be a primary factor contributing to woodcock population declines, and woodcock require several different habitat types throughout their annual cycle. On the breeding grounds alone, displaying, feeding, nesting, roosting and brood-rearing habitats have been described by biologists (Mendall and Aldous 1943, Sheldon 1967, Dunford and Owen 1973, Wenstrom 1973, Gregg 1984, Sepik and Dwyer 1982, Gutzwiller et al. 1983). Deficiencies in any one of these habitat types may limit the density or productivity of the population.

Habitat loss has occurred both directly through urbanization and industrialization, and indirectly as natural forest succession creates mature forest stands unsuitable for woodcock (Gutzwiller et al. 1980, Fenwood and Webb 1981). Fire control, intensive forest management techniques, a decrease in farm abandonment and limited regeneration of seedling-sapling stands also have resulted in a net loss of woodcock breeding habitat (Fenwood and Webb 1981, Sepik and Dwyer 1982, Gutzwiller et al. 1980, Dwyer et al. 1983, U. S. Fish and Wildlife Service 1990, Sauer and Bortner 1991, Straw et al. 1994).

Habitat use and selection by woodcock has been thoroughly studied at fine spatial scales. Yet, there has been little research exploring woodcock/habitat relationships at broad scales or over large geographical areas although several authors have recognized the need (U.S. Fish and Wildlife Service 1990, Straw et al. 1994). Such studies would facilitate a better understanding of how habitat availability and distribution affects woodcock abundance and would provide information on where and how to best manage woodcock habitat. Advances in remote sensing, and its associated image processing technology and software, provide access to spatial information on a planetary scale and have made large-scale habitat analysis possible. In recent years, wildlife biologists have used remotely sensed data within Geographic Information Systems (GIS) to predict and define wildlife/habitat relationships on a landscape level for many species including black bears (*Ursus americanus*; Clark et al. 1993), sage grouse (*Centrocercus urophasianus*; Homer et al. 1993), bobwhite quail (*Colinus virginianus*; Roseberry et al. 1994), wild turkeys (*Meleagris gallopavo*; Gustafson et al. 1994), and sandhill cranes (*Grus canadensis tabida*; Baker et al. 1995).

West Virginia contains over a million ha of public land (national forest and state game lands) in addition to 4 million ha of private forested land. The quality of woodcock

habitat in these areas is unknown. West Virginia currently contains areas of excellent woodcock habitat and many other areas have potential to become good woodcock habitat once critical factors are identified. The results from this study should identify areas suitable for woodcock or areas that may become so with proper management. This information has a variety of potential uses including periodic statewide assessment of habitat and predicting the effects of future land use and land cover trends, and could be used by land managers to develop strategies for woodcock conservation and management in West Virginia. This study began in January of 1995 with three major objectives:

1. To use remotely sensed data and other widely available digital data to develop models to predict potential habitat suitability for American woodcock over large geographic areas in West Virginia (Chapter 4).
2. To quantify and describe the local and landscape structural components and spatial patterns of woodcock habitat in the state (Chapter 3)
3. To determine the current suitability and fate of woodcock habitat that was available in West Virginia in the mid-1970's (Chapter 5).

STUDY AREA

The study area included the entire state of West Virginia; however, I focused on areas that contained the greatest proportion of woodcock habitat and/or the greatest amount of public or accessible land. These included Canaan Valley, Monongahela National Forest, land belonging to Westvaco and The Nature Conservancy (TNC) in south-central West Virginia, land leased by the Mountain Top Hunting Club near Davis, West Virginia, and most of the State's Wildlife Management Areas and Public Hunting and Fishing Areas

(Appendix 1). Searches were confined to public lands and private lands that were not posted, or for which written permission for access was obtained.

West Virginia is the southern-most state in the main breeding range of the woodcock (Sheldon 1967). Although the entire state is usually included in the breeding range, West Virginia is characterized by rugged and forested terrain; large patches of the shrubby lowland areas preferred by woodcock are uncommon. Suitable woodcock habitat areas are generally small, scattered, and patchy (Fenwood 1976, Webb 1978). Canaan Valley, a 100-km² basin in the northeastern portion of the High Allegheny Region, is the only exception. Canaan Valley has historically contained the best habitat and highest woodcock populations in the state (Goudy et al. 1970, Webb 1978, Webb and Samuel 1982) and is an important migration staging area for woodcock (U.S. Fish and Wildlife Service 1990).

West Virginia is an irregularly shaped state that contains wide variations in latitude and longitude within a relatively small (62,629 km²) area (Strausbaugh and Core 1977). The state also contains wide variations in elevation ranging from 73 m above sea level at Harper's Ferry to 1,482 m at the summit of Spruce Knob. The mean elevation of 504 m is greater than that of any other state in the eastern U. S. These altitudinal variations tend to obscure the differences in latitude and longitude and the lowest temperatures often occur in the central or southern part of the state (Strausbaugh and Core 1977).

West Virginia contains three main physiographic regions: the Western Hill Region, the Allegheny Mountain Region, and the Eastern Ridge and Valley Region. The Western Hill Region is the largest of the three regions and contains all or parts of 39 counties in western and southern West Virginia. This region is characterized by rounded rolling hills with moderate to strong relief. The stream pattern is dendritic with the small tributaries and

hills between them oriented randomly. The vegetation of the western hill region is classified as central hardwood forest but varies greatly in species composition (Strausbaugh and Core 1977). Generally, the forest associations as determined by The Nature Conservancy (TNC), are composed of oak (*Quercus* spp.) -pine (*Pinus* spp.) and oak-chestnut (*Castanae dentata*) alliances on drier sites, cove hardwoods and mixed mesophytic forest (sugar maple {*Acer saccharum*}, oaks, cherries {*Prunus* spp.}) on mesic sites, and flood plain (cottonwood {*Populus deltoids*}, box elder {*Acer negundo*}, river birch {*Betula nigra*}) communities in wetter areas (Strausbaugh and Core 1977, Sneddon et al. 1994).

The highest elevations in the state occur in the Allegheny Mountain Region. This region is located in the east-central part of the state and contains all or part of 11 counties. This area contains the largest proportion of public land in the state and includes the Monongahela National Forest. The mountains of the area are generally oriented in a northeast-southwest direction with deep valleys between. Rainfall averages 127-157 cm annually (Webb 1978). The vegetation of the Allegheny Mountain Region is classified as northern forest and is divided into northern evergreen and northern hardwood cover types (Strausbaugh and Core 1977). Red spruce (*Picea rubens*) is the most distinctive member of the northern evergreen forest in West Virginia; balsam fir (*Abies balsamea*) and red pine (*Pinus resinosa*) also are common. Some of the species alliances in the northern hardwood cover type include maple-hemlock (*Tsuga canadensis*)-yellow birch (*Betula allegheniensis*) in deep hollows and on north facing slopes; maple-yellow birch-beech (*Fagus grandifolia*) at higher elevations; black cherry-poplar (*Populus* spp.) -basswood (*Tilia americana*), often associated with pine; spruce and/or fir at higher elevations; and hawthorn (*Crataegus*) associated with crabapple (*Prunus* spp.), locust (*Robina* spp.) and sumac (*Rhus* spp.);

Sneddon et al. 1994). The last group contains species often associated with good woodcock habitat.

The Ridge and Valley Region occupies all or part of the eight easternmost counties. It consists of wide, level, lowland valleys above which rise longitudinal ridges. The drainage is of the trellis type; vegetation consists of oak-hickory-pine, although the original vegetation was probably dominated by American chestnut (Strausbaugh and Core 1977, Sneddon et al. 1994).

METHODS AND DATA SOURCES

Locating Current Habitat

Potential habitat was initially located by a combination of ‘expert opinion’, resurveying habitat sites from the 1970’s survey, and by examining aerial photographs. Methods for aerial photograph analysis closely followed those used by Fenwood (1976) and Webb (1978). Potential habitat in Monongalia, Tucker, and Randolph counties was located by examining stereo pairs of 23 x 23-cm, black and white, 1:20,000 scale aerial photographs with a stereoscope to identify lowland shrubby areas and other suitable habitat. Photographs for each county were available at the Natural Resources Conservation Service (NRCS) office in the county; the most recent photographs available were from the early 1990’s. Most images were taken before leaf drop in late summer or early fall. An approximate outline of the site was transferred to the appropriate 7.5’ U. S. Geological Survey (USGS) topographical map before field checking.

Aerial photograph analysis was used only at the beginning of the project in 1995. It was a slow process and was replaced by the expert opinion method as a pool of experts was

identified. State wildlife biologists, land managers, hunters, and others knowledgeable about woodcock in the state provided expert opinion on sites potentially suitable for woodcock.

Additional woodcock use sites were obtained by incidental flush reports provided by West Virginia Division of Natural Resources (WVDNR) personnel, West Virginia University (WVU) graduate students, and others who flushed woodcock while not intentionally searching for them. This information was usually forwarded to me as coordinates of the location of the flush.

Woodcock Use

Sites identified as potential habitat were field-checked for the presence of woodcock or their sign. Woodcock use was determined by a variety of methods including searches with trained pointing or flushing dogs. Each site was given a subjective quality rating (Table 2-1) based on a number of factors, including degree of vegetation maturation and/or human influence, shrub density, site size and land-use and the presence of woodcock or their sign.

Singing male counts were conducted between the middle of April and end of May in 1995-1997. They were used to evaluate areas of private property that could not be accessed on foot, and as a preliminary means of evaluating woodcock use. With the landowner's permission, counts were conducted at a single point at or near the center of the site for a period of 5 minutes. Otherwise, counts followed established protocol for the USFWS singing-ground surveys as closely as possible; i.e., they were conducted between 20 and 40 minutes after sunset when wind, rain, and temperature conditions were acceptable for the latitude and longitude of the site (Bruggink 1997). Sites where woodcock were heard were searched with dogs later if permission was obtained from the landowner.

Habitat use by woodcock was confirmed by searches with trained pointing and flushing dogs; techniques for using dogs to locate woodcock were given by Ammann (1981). In general, a dog-assisted search consisted of 1-3 human searchers walking slowly through an area with 1-3 bird dogs covering the area between searchers. Each flush was noted and a Global Positioning System (GPS) was used to record the position the bird occupied immediately before flushing, allowing an exact use point to be input into a GIS. The same pointing dog was provided to the project for seasonal use each year by Roger Anderson of the West Virginia Division of Natural Resources (WVDNR). Additional dogs, accompanied by their owner/handlers were used as available. Dog-assisted searches were conducted from May-September 1995 and May-August in 1996 and 1997. Search intensity was calculated by using flushes per dog-hour, i.e., two dogs searching for 1.5 hours equaled three dog-hours. Standardizing for the use of different individual dogs or different scenting conditions was not possible (Gutzwiller 1990).

Several areas identified by expert opinion or from the 1970's statewide survey were searched by walking systematically through them, without a dog, looking for woodcock or their sign. Due to the secretive habits of the woodcock, this method was unlikely to be successful and no woodcock or signs of their use were found during foot searches. Areas that looked promising were searched later with dogs.

A final means of evaluating potential habitat was a roadside evaluation. In a roadside evaluation, the quality of a site was judged from the road without accessing the site. This method was used only when reevaluating sites identified during the 1970's habitat inventory and only when the site was obviously no longer suitable habitat due to human use or development, flooding, or conversion to open, grassy animal pasture.

Habitat Sampling

When woodcock were found, habitat data including vegetation type, percent canopy closure, land use, and soils characteristics were collected at the flush point and immediately surrounding area. When possible, data were collected immediately after the flush; the longest interval between a flush and data collection at that site was 21 days (mean = 1.3 days). Collected data included characteristics considered to be important to woodcock: height of herbaceous vegetation, percent of herbaceous ground cover and litter cover, canopy and shrub cover, shrub stem density, and soil moisture, texture, and compaction (Gutzwiller et al. 1983, McCoy 1987). In addition to flush site vegetation, data were collected at 28 randomly selected sites that had been searched with dogs without finding woodcock. A point was selected at the center of the searched area and vegetation characteristics were collected there and at a point 25 m directly west of the center point. Characteristics for the two points were averaged to obtain a single value for each variable for the site.

In general, methods described by James and Shugart (1970) were used with slight modification. A 0.04-ha plot was established around each flush site with a radius of 11.28 m and sampling points located every 2.26-m in each cardinal direction (20 sampling points per plot). At each of the 20 sampling points and the actual flush site, the observer imagined a straight vertical line to the ground using the cross hairs of a sighting tube. Leaf litter and herbaceous ground cover were recorded as 'present' or 'absent' based on whether or not the imagined line would intersect them. If a herbaceous plant was present, its height was recorded. If more than 7 days had passed between the flush and the collection of vegetation data, herbaceous height was not measured because significant changes may have occurred

during the interval between flush and collection. The observer then repeated the process for vegetative canopy at 0-1 m, 1-3 m, 3-6 m, 6-9 m and > 9 m above the ground. Each 'present' represented 5 % coverage for a particular variable. The sum gives an estimate of percent cover for that variable for the 0.04-ha plot. Shrub and tree stem densities were obtained by counting each woody plant intersected along each transect with a Biltmore stick. Woody plants with a DBH of < 5 cm were considered shrubs.

Soil characteristics were estimated at the exact flush point (as judged by the presence of a dropping). Soil moisture was qualitatively judged as moist, medium, or dry. Soil texture was qualitatively judged as coarse, medium, or fine, and soil compaction was qualitatively judged as difficult, medium, or easy to penetrate based on the force needed to insert a pencil-sized rod into the ground.

Digital Data Sources

The primary goal of this project was to use GIS technology with widely and publicly available digital data for habitat analysis and model development. The process and resulting model can then be updated as often as the availability of new data or land-use changes make updating desirable. Digital data used in this study included the Multi-Resolution Land Cover (MRLC), National Wetlands Inventory (NWI), State Soil Geographic database (STATSGO), Digital Elevation Models (DEMs), and human population data.

The MRLC is a land-cover database generated as a generalized and consistent land-use/land-cover data layer for Environmental Protection Agency (EPA) Region III that includes the states of Pennsylvania, Maryland, Delaware, Virginia, and West Virginia. The primary source of the data set was leaves-on (summer) Land Remote Sensing Satellite

(Landsat) Thematic Mapper (TM) data acquired in 1991, 1992, and 1993. Volgemann et al. (1996) provides a full description of data sources and methods. Data were in raster format; all features and land-use categories were described by 30 x 30-m squares. This minimal mapping unit omitted long, narrow tracts including utility rights-of-way, roads, and lower order rivers and streams and all features smaller than 30-x 30 m.

Personnel at the Natural Resource Analysis Center (NRAC) at West Virginia University modified the MRLC for the state of West Virginia by incorporating NWI data and major roads and interstate highway information. The database was further modified by reclassing 'row crops' that occurred on slopes greater than 20 degrees and areas classed as 'probable row crops' to 'low intensity agriculture'. We further modified the data set by combining 2 wetland classes and 2 developed land classes and used 12 classes for analysis (Table 1-1).

The NWI database was compiled by the U. S. Fish and Wildlife Service to describe and inventory wetlands nationally. There are 44,276 polygons for wetlands in West Virginia. Polygons are records of wetland locations and classification as defined by the USFWS (Cowardin 1979). All photo-interpretable wetlands were mapped using a minimum mapping unit of 1-3 acres depending on the wetland type and the scale of the source aerial photography.

NWI maps were compiled through manual photo interpretation of NHAP (National High Altitude Photography) or NAPP (National Aerial Photographs) aerial photography supplemented by Soil Surveys and field checking of wetland photo signatures. Delineated wetland boundaries were manually transferred from interpreted photos to USGS 7.5-minute topographic quadrangle maps and then manually labeled. Attribute accuracy was tested by

manual comparison of the source with hard copy printouts and/or symbolized display of the digital wetland data on an interactive computer graphic system. Further descriptions of NWI data are provided by the NWI National Center in St. Petersburg, FL.

STATSGO is a digital general soil association map developed by the National Cooperative Soil Survey and designed primarily for regional or large-scale resource planning, management, and monitoring. STATSGO consists of a broad-based inventory of soils and non-soil areas that occur in a repeatable pattern on the landscape and can be cartographically shown at the scale mapped. The soil maps for STATSGO were compiled by generalizing more detailed soil survey maps. Where more detailed soil survey maps were not available, data on geology, topography, vegetation, and climate were assembled, together with Landsat TM images. Soils of like areas were studied, and the probable classification and extent of the soils were determined.

This data set consisted of geo-referenced digital map data and computerized attribute data. The map data were collected in 1- by 2-degree topographic quadrangle units, merged, and distributed as statewide coverages. The soil map units were linked to attributes in the Map Unit Interpretations Record relational database that give the proportionate extent of the component soils and their properties.

The approximate minimum area delineated was 625 hectares, which is represented on a 1:250,000-scale map by an area approximately 1 cm x 1 cm. Linear delineations are not less than 0.5 cm in width. The number of delineations per 1:250,000 quadrangle typically is 100 to 200, but may range up to 400. Delineations depict the dominant soils making up the landscape. Other dissimilar soils, too small to be delineated, are present within a delineation.

The STATSGO coverage for West Virginia included 380 polygons containing soil characteristics for pH and percent hydric soils that were averaged across the polygon. Although STATSGO data were intended for broad scale use, I included these data in my analyses because it was the only soil database available for the entire state.

A statewide grid depicting elevation was created from the 498 USGS Digital Elevation Models (DEMs) that contain data for West Virginia. DEMs were developed by the U.S. Geological Survey and are available on-line. The elevation grid consisted of 30 x 30m cells coded with the average elevation of that cell. I generated grids depicting aspect and degree of slope from the elevation grid using Arc/Info GRID functions.

A digital human population density data set for the state of West Virginia was derived at the NRAC lab from 1990 U.S. Census block point data. It was converted to polygons using the Arc/Info Thiessen command and then clipped with a state boundary polygon. Population density was calculated by dividing population by area for each of the 71,252 polygons. Areas covered by rivers or lakes were eliminated.

[go back](#)

Table 1-1. Land-use/land-cover classes used with Multi-Resolution Land Cover data to obtain habitat variables associated with woodcock presence in West Virginia.

Land-use/Land-cover Class	Description
Water	Open water and rivers.
Developed Land	Areas less than 50 % covered by vegetation and 50-100 % covered by constructive materials (asphalt, concrete, buildings etc).
Hay/Pasture/Grass	Areas covered by grasses or other vegetation regularly mowed for hay and/or grazed by livestock.
Row Crops	Areas regularly tilled and planted.
Mixed Pasture/Low Intensity Agriculture	Areas covered by non-woody vegetation and areas classed as row crops that occurred on slopes > 20 degrees.
Conifer Forest	Areas more than 70 % covered by coniferous tree species
Mixed Forest	Areas with both coniferous and deciduous tree species present.
Deciduous Forest	Areas more than 70 % covered by deciduous tree species
Woody Wetlands	Wetland areas with substantial amount of woody vegetation and those areas defined by NWI as wooded wetlands.
Emergent Wetlands	Non-woody wetlands and those areas defined by NWI as unwooded wetlands.
Barren: Quarries/Mine	Quarry and coal mine areas.
Barren: Transitional	Areas likely to change to other land-cover classes, including clear-cut areas

CHAPTER 2.

LOCATION AND CHARACTERISTICS OF AMERICAN WOODCOCK HABITAT IN WEST VIRGINIA

Abstract: American woodcock (*Scolopax minor*) habitat in West Virginia was located using singing male counts, dog-assisted searches, and aerial photograph analysis during 1995-1997. More than 300 sites were searched, 195 of them with trained pointing or flushing dogs. Woodcock or their signs were found on 80 sites statewide with 188 woodcock flushed. The majority of woodcock flushes and the best habitat were found in the Allegheny Region. Habitat characteristics at flush sites varied greatly but were generally similar to those measured in other parts of the woodcock's range. Flush points had greater canopy closure at 0-1 m above the ground ($P < 0.01$) and less canopy closure > 9 m above the ground ($P = 0.03$) than did areas searched unsuccessfully with dogs. Flush sites also had greater soil moisture ($P < 0.01$), less soil compaction ($P = 0.02$) and fewer tree stems ($P = 0.03$). There was no significant difference between flush site characteristics between years except for percentage of leaf litter cover ($P = 0.05$), which was greater in 1995 and 1997 than 1996.

INTRODUCTION

Woodcock habitat in West Virginia is unique. West Virginia is on the southern edge of the major breeding range of the American woodcock and is characterized by rugged terrain and steep slopes. The primary breeding range of the woodcock extends south into northern and eastern West Virginia (Sheldon 1967), and the winter range may extend northward into the state during milder winters, particularly along the Ohio and Kanawha Rivers (Hall 1983). Statewide woodcock populations have always been relatively low

compared with other areas in the northern breeding range, and suitable woodcock habitat is scattered, patchy, and probably non-existent in parts of the state. However, West Virginia does contain areas of excellent woodcock habitat and woodcock occur throughout the state. The consensus of those in the state familiar with the woodcock is that they probably breed in all counties and are locally common in summer (Webb and Samuel 1982, Hall 1983). The objective of this study was to locate and describe woodcock habitat available in West Virginia.

STUDY AREA

The study area included the entire state of West Virginia; however, I focused on areas that contained the greatest proportion of woodcock habitat and/or the greatest amount of public or accessible land (Fig. 2-1). These included Canaan Valley, Monongahela National Forest, land belonging to Westvaco and The Nature Conservancy (TNC) in south-central West Virginia, land leased by the Mountain Top Hunting Club near Davis, West Virginia, and most of the State's Wildlife Management Areas and Public Hunting and Fishing Areas (Appendix 1). Searches were confined to public lands and private lands that were not posted or for which written permission to access was obtained.

METHODS

Locating Current Habitat

Potential habitat was initially located by a combination of 'expert opinion', resurveying habitat sites from the 1970's survey, and by examining aerial photographs. Potential habitat in Monongalia, Tucker, and Randolph counties was located by examining

stereo pairs of 23 x 23 cm, black and white, 1:20,000 scale aerial photographs with a stereoscope to identify lowland shrubby areas and other suitable habitat.

Aerial photograph analysis was used only at the beginning of the project in 1995. It was a slow and tedious process and was replaced by the expert opinion method as pools of experts were identified. State wildlife biologists, land managers, hunters, and others knowledgeable about woodcock in the state provided expert opinion on sites potentially suitable for woodcock.

Additional woodcock use sites were obtained by incidental flush reports provided by West Virginia Division of Natural Resources (WVDNR) personnel, West Virginia University (WVU) graduate students, and others who flushed woodcock while not intentionally searching for them. This information was usually forwarded to me as coordinates of the location of the flush.

Woodcock Use

Sites identified as potential habitat were field-checked for the presence of woodcock or their sign. Woodcock use was determined by a variety of methods including searches with trained pointing or flushing dogs. Each site was given a subjective quality rating (Table 2-1) based on a number of factors, including degree of vegetation maturation and/or human influence, shrub density, site size and land-use and the presence of woodcock or their sign.

Singing male counts were conducted between the middle of April and the end of May in 1995-1997. They were used to evaluate areas of private property that could not be accessed on foot, and as a preliminary means of evaluating woodcock use. With the landowner's permission, counts were conducted at a single point at or near the center of the

site for a period of 5 minutes. Otherwise, counts followed established protocol for the USFWS Singing-ground surveys as closely as possible; they were conducted between 20 and 40 minutes after sunset when wind, rain, and temperature conditions were acceptable for the latitude and longitude of the site. Sites where woodcock were heard were searched with dogs later if permission was obtained from the landowner.

Habitat use by woodcock was confirmed by searches with trained pointing and flushing dogs; techniques for using dogs to locate woodcock are given by Ammann (1981). In general, a dog-assisted search consisted of 1-3 human searchers walking slowly through an area with 1-3 bird dogs covering the area between searchers. Each flush was noted and a Global Positioning Unit (GPS) was used to record the position the bird occupied immediately before flushing, allowing an exact use point to be input into a GIS. The same individual pointing dog was used each year, additional dogs, accompanied by their owner/handlers were used as available. Dog-assisted searches were conducted from May-September 1995 and May-August in 1996 and 1997. Search intensity was calculated by using flushes per dog-hour, i.e., two dogs searching for 1.5 hours equaled three dog-hours. Standardizing for the use of different individual dogs or different scenting conditions was not possible (Gutzwiller 1990).

Habitat Sampling

When woodcock were found, habitat data including vegetation type, percent canopy closure, land use, and soils characteristics were collected at the flush point and immediately surrounding area. When possible, data were collected immediately after the flush; the longest interval between a flush and data collection at a site was 21 days. Collected data

included characteristics considered to be important to woodcock: height of herbaceous vegetation, percent of herbaceous ground cover and litter cover, canopy and shrub cover, shrub stem density, and soil moisture, texture, and compaction (Gutzwiller et al. 1983, McCoy 1987). In addition to flush site vegetation, data were collected at 28 randomly selected sites that had been searched with dogs without finding woodcock. A point was selected at the center of the searched area and vegetation characteristics were collected there and at a point 25 m directly west of the center point. Characteristics for the two points were averaged to obtain a single value for each variable for the site.

In general, methods described by James and Shugart (1970) were used with slight modification. A 0.04-ha plot was established around each flush site with a radius of 11.28 m and sampling points located every 2.26-m in each cardinal direction (20 sampling points per plot). At each of the 20 sampling points and the actual flush site, the observer imagined a straight vertical line to the ground using the cross hairs of a sighting tube. Leaf litter and herbaceous ground cover were recorded as 'present' or 'absent' based on whether or not the imagined line would intersect them. If a herbaceous plant was present, its height was recorded. If more than 7 days had passed between the flush and the collection of vegetation data, herbaceous height was not measured because significant changes may have occurred during the interval between flush and collection. The observer then repeated the process for vegetative canopy at 0-1m, 1-3 m, 3-6 m, 6-9 m and > 9 m above the ground. Each 'present' represented 5 % coverage for a particular variable. The sum gives an estimate of percent cover for that variable for the 0.04-ha plot. Shrub and tree stem densities were obtained by counting each woody plant intersected along each transect with a Biltmore stick. Woody plants with a DBH of < 5 cm were considered shrubs.

Soil characteristics were estimated at the exact flush point (as judged by the presence of a dropping). Soil moisture was qualitatively judged as moist, medium, or dry. Moist soil was damp to the touch and dry soil could be blown easily off a cupped palm. Soil texture was qualitatively judged as coarse, medium, or fine based on the size of individual particles. Soil compaction was qualitatively judged as difficult, medium, or easy to penetrate based on the force needed to insert a pencil-sized rod into the ground.

Differences in habitat characteristics at flush sites and unsuccessfully searched sites were analyzed using analysis of variance (ANOVA) where each habitat variable was the independent variable and woodcock use (flush site or unsuccessfully searched site) was the dependent variable. Differences between characteristics at flush sites also were analyzed using ANOVAs. Where results were significant ($P < 0.05$) the Tukey-Kramer HSD test was used to determine which years differed.

RESULTS

Current Habitat

One hundred and ninety-five sites were searched with dogs (256 dog-hours) during 1995-1997 for signs of woodcock use (Fig. 2-1). Eighty sites statewide contained woodcock or signs of their use (Fig. 2-2). One hundred and eighty-eight woodcock were flushed on 71 different sites. Eleven sites contained the majority of woodcock flushes (Table 2-2). These sites had a mean of 1.04 flushes/dog-hour; the overall mean for all 71 sites was 0.7 flushes/dog-hour. On 4 of the 195 dog-searched sites, woodcock sign was found, but no birds were flushed. Woodcock also were flushed incidentally by DNR personnel and other WVU graduate students on 5 sites. These sites were not searched with dogs.

An additional 102 sites were evaluated through other methods including foot searches, singing male counts, and expert opinion. The majority of these sites were classified as unlikely or non-habitat. A summary of public and selected private lands searched is provided in Appendix 1.

Woodcock broods were found north of Davis, West Virginia, at 3 sites in the Monongahela National Forest, at McClintic WMA, at Cranesville Swamp in Preston County and at 2 sites in Canaan Valley. A nest was found in Preston County.

Flush Site Vegetation

Vegetation characteristics at woodcock flush sites and at sites that were searched unsuccessfully for woodcock varied greatly. Flush points had greater canopy closure at 0-1 m above the ground ($P < 0.01$) and less canopy closure > 9 m above the ground ($P = 0.03$) than did areas searched unsuccessfully with dogs (Table 2-3). Flush sites also had greater soil moisture ($P < 0.01$), less soil compaction ($P = 0.02$) and fewer tree stems ($P = 0.03$). There was no significant difference between flush site characteristics between years except for percentage of leaf litter cover ($P = 0.05$), which was greater in 1995 and 1997 than 1996.

DISCUSSION

Current Habitat

Woodcock habitat in the state is limited in both total amount and distribution. Because of the mountainous terrain of the state, there are virtually no large expanses of woodcock habitat, instead habitat patches tend to be small, isolated, and often irregularly shaped due to topography. However, the state does contain areas of excellent habitat and

relatively high woodcock densities. The best habitat was found in the High Allegheny Region; approximately 71 % of the woodcock flushes that occurred statewide in my study were in this region. Statewide surveys of woodcock habitat completed during the 1970's (Fenwood 1976, Webb 1978) also indicated that the majority of woodcock habitat (over 80 % of the approximately 17,000 ha identified) in the state was in the High Allegheny Region, which also contains the greatest proportion of undeveloped land in the state. Webb (1978) described the typical 'good' quality habitat site in West Virginia as...

'found in a gently sloping bottomland somewhere in the mountain region and was 18.2 ha in size. It had been used as pastureland sometime in the past but was now abandoned and shrubs were taking over; alder had come in along a small stream and hawthorn was present on the higher ground... The height of the shrub cover was variable, but centered between 3-6 m; canopy closure also was variable but averaged 60 %. Ground cover density was intermediate and moisture content of the soil was damp.'

This description is still applicable to West Virginia woodcock habitat. In addition, good but atypical habitat is found in the Monongahela National Forest in young, striped maple (*Acer penslyvanicum*) and hawthorn (*Crataegus* spp.) stands on flat benches and ridge tops.

The best habitat and highest populations continue to be found in Canaan Valley in the northeastern portion of the Mountain Region. Canaan Valley has historically contained West Virginia's highest woodcock densities (Goudy et al. 1970, Webb 1978, Webb and Samuel

1982) and still contains the best habitat in the state. Several sites along the Ohio River in the western portion of the state also contain good habitat although populations have probably been higher in the past. Shissler (1981), for example, reported much greater densities of woodcock on McClintic Wildlife Management Area than were evident during this study.

Vegetation Characteristics

When use sites were compared to unsuccessfully searched sites, woodcock were found to select areas with denser canopy closure near the ground, greater soil moisture, less soil compaction, and fewer tree stems. These preferences are consistent with the requirements of the species (McCoy 1987) and with research conducted elsewhere in the woodcock's range (Sepik et al. 1989, Straw et al. 1994).

The major exception was mean shrub stem density. The 2,055 stems/ha in this study were well below the 10,000-50,000 stems/ha that Straw et al. (1994) indicated were typical of most studies and the 7,533-115,665 stems/ha reported from other studies by Sepik et al. (1989). Because of these large differences between different studies, Sepik et al. (1989) stated that it is difficult to recommend a specific stem density but many sites in West Virginia probably contain sub-optimal shrub stem densities. The importance of shrub stem density is to moderate soil temperature and moisture for earthworms (Reynolds et al. 1977, Parris 1986) and to minimize herbaceous growth allowing woodcock to access worms (Sepik et al. 1989). They also serve to protect woodcock from predators.

The consensus of most researchers is that requirements of good woodcock habitat can be met by a variety of species and that structure is more important than species composition (Sepik et al. 1989). In Michigan, on an area with low shrub stem densities (2,400 stems/ha),

Steketee (1994) reported that bracken fern (*Pteridium aquilinum*) had substituted for high shrub stem densities and provided good overhead cover against potential predators and shade to minimize ground vegetation. In West Virginia, goldenrod (*Solidago* spp.) probably performs a similar function and several authors have reported woodcock use of goldenrod in the state (Goudy et al. 1970, Webb 1978).

[go back](#)

Figure 2-1. State of West Virginia showing the locations of 301 areas searched for woodcock presence during 1995-1997.

[go back](#)

Figure 2-2. State of West Virginia showing the locations of 165 woodcock flushes that occurred during 1995-1997 and the location of the High Allegheny Study Area.

[go back](#)

Table 2-1. Quality rating given to areas identified as potential woodcock habitat after field checking.

1. Definitely Not Woodcock Habitat:
a. Sites developed for human use, i.e., housing, industrial, or mining.
b. Sites permanently flooded due to dams.
c. Sites covered by open (grassy animal pasture or agricultural crops).
2. Unlikely Woodcock Habitat:
a. Sites containing mature forest cover and/or forest stands in advanced seral stages. These sites were characterized by few stems with high DBH, understory was sparse or nonexistent, and canopy cover was high (> 9 m).
b. Mostly wooded sites with a few scattered areas of human development.
c. Sparsely wooded animal pasture.
3. Possible Woodcock Habitat:
a. Undeveloped sites with some mature vegetation or undeveloped sites where the vegetation cover was not dense.
b. 'Spirea swamps'; these sites were often very wet and may have had standing water. They were often very thickly vegetated with persistent emergents such as <i>Juncus</i> spp. and <i>Typha</i> spp..
4. Probable Woodcock Habitat:
a. Sites undeveloped for human use and covered by early successional vegetation.
b. Animal pasture covered with shrubs or young woody vegetation.
c. Sites with reported use- 'expert opinion'.
5. Definite Woodcock Habitat:
a. Sites where woodcock were flushed during May-September 1995-1997.
b. Sites with evidence of woodcock use (probing, splashing, or singing males).

[go back](#)

Table 2-2. Woodcock habitat areas in West Virginia with the greatest number of flushes per dog-hour during 1995-1997.

Location	Dog Flushes	Dog Hours	Flushes/ Dog-hour ^a	Total Flushes ^b
Canaan Valley (all sites)	38	34.3	1.11	45
Westvaco/Rupert (all sites)	23	18.6	1.24	33
Middle Mt (MNF)	9	3.5	2.57	14
Spruce Knob Lake (MNF)	8	2.3	3.56	9
Davis Mine Site	7	2.8	2.55	7
McClintic WMA	6	13.0	0.46	6
Cunningham Knob (MNF)	5	16.0	0.31	5
Burnsville PHFA	4	7.0	0.57	7
Meadow River	3	0.4	7.50	3
Greenbottom WMA	3	1.0	3.00	3
Cassity Mine Site	3	3.3	0.90	3
Charles Town	1	0.5	2.00	1
Totals	110	105.4	1.04	136

^a Calculated from the number of dog flushes rather than total flushes.

^b Includes all incidental flushes and woodcock flushed without dogs.

[go back](#)

Table 2-3. Means of vegetation data collected at 87 points statewide where woodcock had been flushed in 1995-1997 and 28 points within areas that had been unsuccessfully searched for woodcock with dogs in 1997.

Variable	Flush Points		Searched Points		F	P
	Mean	Range	Mean	Range		
Soil Moisture ^a	1.61	1-3	1.90	1-3	7.00	< 0.01
Soil Texture ^b	2.03	1-3	2.10	1-3	0.61	0.44
Soil Compaction ^c	2.13	1-3	1.82	1-3	5.48	0.02
% Canopy 0-1m above ground	45.5	0-100	26.7	0-95	10.62	< 0.01
% Canopy 1-3m above ground	49.5	0-100	46.5	0-92	0.88	0.35
% Canopy 3-6m above ground	46.5	0-100	44.5	0-70	0.46	0.50
% Canopy 6-9m above ground	31.5	0-100	39.1	0-95	2.70	0.43
% Canopy > 9m above ground	14.9	0-60	30.4	0-90	5.13	0.03
Leaf Litter (%)	72.0	0-100	66.7	0-100	0.69	0.41
Herbaceous Coverage (%)	69.7	0-100	67.1	0-90	0.16	0.68
Herbaceous Height (cm)	34.9	1-91	35.8	7-113	0.01	0.96
Shrub Stem Density (stems/ha)	2,055	75-19,425	1,084	300-3,750	2.60	0.10
Tree Stem Density (stems/ha)	58.7	0-325	89.0	0-237	4.89	0.03
Tree Stem DBH (cm)	11.5	2-42.3	7.2	2-28.5	1.29	0.20

^a based on a scale of 1-3 where 1 = moist, 2 = medium, and 3 = dry

^b based on a scale of 1-3 where 1 = coarse, 2 = medium, and 3 = fine

^c based on a scale of 1-3 where 1 = difficult, 2 = medium, and 3 = easy

CHAPTER 3.

HABITAT PATTERNS AROUND AMERICAN WOODCOCK FLUSH SITES IN WEST VIRGINIA

Abstract: Annual indices of breeding American woodcock (*Scolopax minor*) continue to indicate significant declines in the breeding population. While these declines have been attributed to loss and degradation of habitat, few researchers have attempted to quantify the broad scale spatial or structural components of woodcock habitat. The objective of this study was to identify and quantify these components for woodcock habitat in West Virginia and to determine if habitat use differed by elevation. Differences between flush and random sites for proportion of 12 land-cover types and 4 metrics describing landscape composition and pattern were compared within 3 elevation groups. Differences due to scale were tested by comparing habitat variables within 8 concentric circles of increasing radii (150 m – 1200 m). Six habitat variables differed by scale for at least one group of flush points, no variable around random points varied by scale. No habitat variable was important to woodcock at all elevations and most differences that existed occurred in low- and mid-elevations.

INTRODUCTION

Effective management of a wildlife species depends on our ability to understand and predict relationships between a species and its habitat. Habitat use and selection by woodcock has been thoroughly studied at fine spatial scales and these studies have provided valuable information on requirements and preferences of the species at the forest stand level. However, wildlife managers should understand how a species habitat requirements change across spatial scales. There has been virtually no research exploring woodcock/habitat

relationships at broad scales and the relationships between habitat quality and woodcock survival at regional levels are poorly understood (Sepik et al. 1993). The development of broad scale models that can be used to inventory and monitor woodcock habitat quality over large geographical areas has been repeatedly identified as a need (U.S. Fish and Wildlife Service 1990, Straw et al. 1994). To develop broad scale models, researchers must understand how woodcock are affected by broad-scale habitat factors. Advances in technology (e.g., geographic information systems) and data (e.g., satellite imagery) have made quantitative study of large geographic areas possible. Studies of spatial patterns of habitat variables have been conducted for spotted owls (*Strix occidentaltus*, Lehmkuhl and Rahpael 1993), sandhill cranes (*Grus canadensis tabida*, Baker et al. 1995), black bears (*Ursus americanus*; Clark et al. 1993), and others.

The objectives of this project were to quantify and describe structural components and spatial patterns of woodcock flush points in West Virginia using broad-scale habitat data. Specifically, we wished to determine: (1) which broad-scale habitat variables were important to woodcock (i.e., used more than available) and (2) did selection have a scale component? (i.e., did selection vary by the scale at which it was measured). We also wished to determine if woodcock/habitat relationships varied by elevation. No other state in the breeding range contains the extremes of topography found in West Virginia, and preliminary analysis indicated that proportion of land-use-types around woodcock flush sites varied by elevation.

STUDY AREA

The study area included the entire state of West Virginia, which is the southern-most state in the main breeding range of the woodcock (Sheldon 1967). Although the entire state

is usually included in the breeding range, West Virginia is characterized by rugged and forested terrain and large patches of shrubby lowland areas preferred by woodcock are uncommon. Suitable woodcock habitat areas are generally small, scattered, and patchy (Fenwood 1976, Webb 1978).

West Virginia contains wide variations in altitude ranging from 73 m above sea level at Harper's Ferry to 1,482 m at the summit of Spruce Knob. The mean elevation of 504 m is greater than that of any other state in the eastern United States. There are three main physiographic regions: the Western Hill Region, the Allegheny Mountain Region, and the Eastern Ridge and Valley Region. The Western Hill Region is the largest of the three regions and is characterized by rounded rolling hills with moderate to strong relief. The stream pattern is dendritic with the small tributaries and hills between them oriented randomly. The vegetation of the western hill region is classified as central hardwood forest but varies greatly in species composition (Strausbaugh and Core 1977). Generally, the forest associations are composed of oak (*Quercus* spp.) -pine (*Pinus* spp.) and oak-chestnut (*Castanae dentata*) alliances on drier sites, cove hardwoods and mixed mesophytic forest on mesic sites, and flood plain communities in wetter areas (Strausbaugh and Core 1977, Sneddon et al. 1994).

The highest elevations in the state occur in the Allegheny Mountain Region. This region is located in the east-central part of the state and contains the largest proportion of public land in the state, including the Monongahela National Forest. The mountains of the area are generally oriented in a northeast-southwest direction with deep valleys between. The vegetation of the Allegheny Mountain region is classified as northern forest and is

divided into northern evergreen and northern hardwood cover types (Strausbaugh and Core 1977).

The Ridge and Valley Region occupies the easternmost portion of the state and consists of wide, level, lowland valleys above which rise longitudinal ridges. The drainage is of the trellis type; vegetation consists of oak-hickory-pine, although American chestnut probably dominated the original vegetation (Strausbaugh and Core 1977, Sneddon et al. 1994).

METHODS

Flush Sites and Random Points

Searches for woodcock with trained pointing dogs were used to define areas of woodcock use. The exact location the bird had occupied when discovered by a pointing dog was obtained with a global positioning system (GPS) and all flush points were entered into the Arc/Info geographic information system (GIS, Environmental Systems Research Institute, Inc., Redlands, Calif., USA). One hundred sixty-five woodcock use points were identified in the state during 1995-1997; 134 of them occurred in the Allegheny Mountain Region.

Because of the large variation in statewide elevation and corresponding variation in land-cover types, points were divided into 3 elevation groups by clustering flush point elevation with cluster analysis (SAS Institute Inc., 1997). Elevation was determined from a grid depicting elevation statewide created from USGS Digital Elevation Models (DEM) that contain data for West Virginia. Fifty-four 'high-elevation' flush points averaged 1,178 m above sea level (range 1,080-1,292 m), 80 'mid-elevation' flush points averaged 943 m

above sea level (735-1076 m), and 31 'low-elevation' points averaged 338 m above sea level (155-728 m). All mid- and high-elevation points occurred in the High Allegheny Mountain Region; low-elevation points were scattered statewide (Fig. 3-1). A corresponding number of random sites were created for each elevation group by randomly generating points within a GIS. Because we compared used and available sites (rather than used and unused), random sites were allowed to occur anywhere within the state within the elevation limits of the 3 groups even in areas of known woodcock habitat. Because of the elevation requirement, high- and mid-elevation random sites occurred only in the Mountain Region (Fig. 3-2). Random sites were never visited but were assumed to represent available habitat in the study area.

Landscape Structure and Spatial Characteristics

Habitat variables around flush sites (used) and random points (available) were compared at 8 spatial scales within 3 elevation groups using a GIS and digital data from various sources. Around each use and random point eight concentric circular buffers at 150-m intervals (150-1200 m) were constructed. Because of the 30- x 30-m resolution of Landsat TM data, 150 m was the smallest practical buffer distance. The upper distance was chosen because research suggests that woodcock make daily movements of up to 1 km (Sepik and Derleth 1993), and therefore may be affected by habitat composition within this distance.

FRAGSTATS spatial analysis program (McGarigal and Marks 1995) and the Multi-Resolution Land Characteristic (MRLC) database (Vogelmann et al. 1996) were used to quantify habitat variables for each buffer distance. The MRLC is a land-cover database for the entire mid-Atlantic region derived primarily from Landsat TM data. MRLC data has

30- x 30-m pixel resolution, and thus limits the identification of long, narrow tracts including utility rights-of-way, roads, lower order rivers and streams, and all features smaller than 30- x 30-m.

The portion of the MRLC pertaining to West Virginia was modified by personnel at the Natural Resource Analysis Center (NRAC) at West Virginia University by incorporating National Wetland Inventory data, and by reclassing row crops that occurred on slopes > 20 degrees and areas classed as 'probable row crops' as 'mixed pasture/low intensity agriculture'. The database was further modified for this study by combining 2 developed land categories and 2 wetland categories. A total of 12 land cover categories were used for analysis (Table 3-1).

Four landscape-level FRAGSTATS metrics- (Simpson's diversity index, contagion index, double log fractal dimension, and patch richness) also were used for analysis. Landscape was defined as the area within each circular buffer area around each flush or random point and was composed of patches of the 12 MRLC land cover categories. FRAGSTATS landscape metrics quantify landscape configuration or composition; composition refers to the presence and amount of each patch type but is not spatially explicit. Landscape configuration refers to the physical distribution of patches within the landscape.

Landscape composition was quantified by 2 landscape-level metrics (Simpson's diversity index and patch richness). Simpson's diversity index represents the probability that any 2 patches picked at random would be different types and thus, higher values indicate greater diversity. Because it is a probability, Simpson's diversity places more weight on common patch types and a single patch of a rare type will contribute relatively little to the diversity index. Patch richness, on the other hand, is sensitive to rare patch types. It is

simply the number of different land-cover types present within a buffer and provides no information on the number or size of patches. In general, both Simpson's diversity index and patch richness would be expected to have greater values within larger buffer distances.

Landscape configuration was quantified by contagion index and the double-log fractal dimension. Contagion is the sum of two probabilities: the probability that a given patch type belongs to type 'a' and that its neighbor belongs to type 'b'. Thus, it measures both the interspersion and dispersion of patch types. A landscape in which patch types were well interspersed would have a lower contagion than a landscape in which patch types were poorly interspersed. The double-log fractal dimension characterizes patch shapes using a perimeter-area method that quantifies the degree of complexity of patch shapes compared to a square, the simplest possible shape. Fractal dimension is relative and higher values represent more complex patch shapes.

Five additional variables used in analyses (distance to the nearest wooded wetland, distance to nearest stream, slope, percent hydric soil, and human population density) were not scale dependent and were measured at the point. Slope was obtained through manipulation of the elevation grid within a GIS, distance to the nearest wetland was measured from the NWI database, human population density was determined from the 1990 U.S. census, and proportion of hydric soils were computed using the West Virginia STATSGO database (Chapter 1).

Statistical Analysis

To test for effects of scale (changes in magnitude of habitat variables due to the buffer distance at which they were measured), the shapes of the line formed by plotting the

changes in each habitat variable measured at each scale were compared. A single value for each habitat variable for each point for all 8 buffer distances was obtained using linear orthogonal polynomials. Analysis of variance (ANOVA) comparisons were made to test whether the shape of the line remained constant for different use-type and elevation combinations. Each habitat variable was analyzed separately using the 6 use-type/elevation groups (i.e., high-elevation flush points, high-elevation random points, mid-elevation flush points, mid-elevation random points, low-elevation flush points, and low-elevation random points) as dependent variables (Table 3-2). When ANOVAs indicated significant ($P < 0.05$) differences between the use-type/elevation groups, additional ANOVA comparisons were made of flush and random points separately to determine which use-type differed.

To evaluate woodcock habitat selection and elevation differences, habitat variables (percent composition of land-cover types or magnitude of landscape metric) around each random and woodcock flush point were compared within the 450 m buffer. Tests were limited to a single buffer distance to avoid the problem of non-independence of concentric buffers and because preliminary analysis indicated scale effects for only a few habitat variables and use-type/elevation groups. The 450-m buffer was chosen for analysis because attempts to predict habitat suitability (Chapter 4) determined that models based on habitat variables within a 450-m buffer correctly classified the greatest number of flush and random points. Thus, 450 m may be the distance that best approximates the average area used by woodcock daily in West Virginia. ANOVA comparisons were made to test for interactions between differences in point type and elevation. Each habitat variable was analyzed separately using the habitat variables as independent variables and use-type/elevation groups as dependent variables (Table 3-2). When models were significant, Tukey's least squares

multiple comparisons of the least square means were used to compare flush and random points within each elevation and elevation within each use-type.

Comparisons of Non-scale Dependent Variables

Five variables used in analyses (distance to the nearest wooded wetland, distance to nearest stream, slope, percent hydric soil, and human population density) were not scale dependent and were measured at the point. ANOVA comparisons were made to test for interactions between differences in point type and elevation. Each variable was analyzed separately using the variable as independent variable and use-type/elevation group as dependent variables (Table 3-2). Tukey's least squares multiple comparisons were used where ANOVAs were significant ($P \leq 0.05$) to determine which groups differed.

RESULTS

Effects of Scale

Proportions of 5 land-cover variables (woody wetlands, transitional land, row crops, deciduous forest, and low intensity agriculture) and one landscape metric (double log fractal dimension) differed depending on the scale at which they were measured (Table 3-3) for at least one use-type/elevation group. Where differences due to scale existed, flush points rather than random points varied by scale. ANOVA comparisons by use-type showed that habitat compositions around random points were the same for woody wetlands ($P = 0.90$), transitional land ($P = 0.14$), row crops ($P = 0.70$), deciduous forest ($P = 0.26$), mixed pasture/low intensity agriculture ($P = 0.53$) and fractal dimension ($P = 0.11$). Proportion of woody wetlands around flush points (Fig. 3-3) decreased with increasing buffer distance.

Proportion of deciduous forest around low- and mid-elevation flush points (Fig. 3-4), proportion of transitional land around high-elevation flush sites (Fig. 3-5), and proportion of row crops around low-elevation flush points (Fig. 3-6) increased with increasing buffer distance. The proportions of mixed pasture/low intensity agriculture (Fig. 3-7) around mid-elevation flush points increased with increasing buffer size, while proportions around low-elevation flush points decreased with increasing buffer size. The fractal dimension (Fig. 3-8) increased with increasing buffer distance for all flush points.

Comparisons of Elevation and Use-type

No single variable was important to woodcock at all elevations (Table 3-4). Five variables (patch richness and proportion of emergent wetlands, woody wetlands, water, and deciduous forest) differed for one or two flush groups and two variables (proportion of coniferous forest and developed land) differed for a random group. Proportions of woody wetlands (Fig. 3-9) were greater at flush sites than at random sites at all elevations but the differences were significant only around mid-elevation flush points. Proportion of water (Fig. 3-9) was greatest around low-elevation flush points but did not differ for random points and mid- and high-elevation flush points. Patch richness and proportion of emergent wetlands (Fig. 3-9), were greatest at mid- and low-elevation flush points, and did not vary around random points and high-elevation flush points. Diversity (Fig. 3-12) also was greatest at mid- and low-elevation flush sites, however, flush and random points only varied at low-elevation sites.

Proportions of deciduous forest (Fig. 3-10) did not vary by elevation for random sites and were lower around low- and mid-elevation flush points than around random points or

high-elevation flush points. Proportion of coniferous forest (Fig. 3-10) was greatest at high-elevation random sites; proportion of developed land (Fig. 3-10) was greatest around low-elevation random sites. Proportions of coniferous forest, mixed forest, and developed land, did not vary by elevation around flush sites.

Proportions of hay/pasture/grass and row crops (Fig. 3-11) were greater at low-elevations for both flush and random points. Proportions of mixed pasture/low intensity agriculture (Fig. 3-11) were greatest at mid- and low-elevation flush points and lowest at flush and random high-elevation points.

Differences in Non-Scale Variables

The proportion of hydric soils at flush points was greatest at mid-elevation points and least at low-elevation points (Table 3-5). Only mid-elevation points differed between flush and random points with greater proportions of hydric soils at flush points. Human population density was greatest around low-elevation random points and did not differ between the other 5 use-type/elevation groups.

Flush points occurred on less steep slopes than did random points at all elevations and were significantly closer to woody wetlands than were random points at low- and mid-elevations (Table 3-5). Among flush points, mid-elevation points were closest to woody wetlands; distance to wetland was the same for high- and low-elevation flush points. Distance to nearest river or stream varied by elevation and streams were closer to points in the low elevations; flush points differed from random points in the low- and mid-elevations (Table 3-5).

DISCUSSION

Effects of Elevation

Variations in land-cover types due to elevation were important in explaining differences between woodcock flush points and random points in West Virginia. Differences in availability of land-cover types determined, in part, which habitat variables distinguished flush and random points for each of three elevation groups measured. For example, West Virginia is approximately 80 % forested (DiGiovanni 1990), but forested land was not distributed evenly throughout the state. High-elevation random sites were 92.2-93.6 % covered by forested land (coniferous, mixed, and deciduous forest), while low- (78.3-80.6 %) and mid-elevation (81.4-83.5 %) random sites contained lower proportions of forested land. Other differences in distribution of land-cover types existed; the greatest proportion of wetlands occurred around mid-elevation points, and the greatest amount of agricultural land occurred around low-elevation points. These differences in land-cover type were reflected in the differences between woodcock flush and random points for each elevation group. High-elevations contained the least amount of land-cover type diversity and the greatest amount of forest cover; forest cover types were the only land-cover types measured that differed between high-elevation flush and random points. Mid-elevations contained the greatest proportion of wetlands and all measured wetland variables differed between mid-elevation flush and random points. Wetland variables did not distinguish flush and random sites at high-elevations, probably because they were rare.

Two land-cover variables (proportion of coniferous and mixed forest) varied by elevation around random points but not around woodcock flush points, suggesting that use was determined by factors other than availability. Proportion of coniferous forest at random

sites (available) varied with elevation and was greatest at high-elevation sites and lowest at low-elevations sites. The proportions of coniferous forest at flush sites, however, was the same regardless of elevation or buffer distance at which it was measured, and thus, may represent a maximum level for woodcock. Most studies of diurnal habitat preferences have depicted a lack of use of coniferous vegetation by woodcock although some coniferous forest may be used. For instance, woodcock have been known to make use of coniferous forest during times of drought (Sepik et al. 1989) because these sites retained moisture and contained greater numbers of earthworms than hardwood stands. In my study, large contiguous tracts of coniferous forest indicated areas with low woodcock habitat suitability (Chapter 4).

The availability of 6 land-cover types (proportions of water, developed land, deciduous forest, barren and transitional land, and emergent wetlands) did not vary by elevation. Proportion of water was greatest around low-elevation sites. Although water obviously is not a land-cover type used by woodcock, water coverage is probably related to areas with increased soil moisture and high earthworm abundance. These soil types also are found associated with wetland areas, but, in West Virginia, low-elevation areas contained the lowest proportion of wetlands. In the absence of wetland areas, the land adjacent to water may be the best indication of hydric soils. Klute et al. (1999) detected a relationship between woodcock use of singing-grounds and coverage of water in the Ridge and Valley Province of Pennsylvania. The greater proportion of water at low-elevation woodcock flush sites also may be a factor of search intensity. Search efforts were concentrated on public lands and, in West Virginia, a large portion of state-owned lands occur near reservoirs and larger rivers.

The proportion of deciduous forest at woodcock flush sites varied by elevation while the availability of deciduous forest was the same regardless of elevation or scale. Deciduous forest use was greatest in the high elevations but rather than indicating a selection for deciduous forest, woodcock at high-elevations were probably avoiding coniferous and mixed forest types. In the high elevations, areas not covered by deciduous forest were composed mainly of coniferous and mixed forest, which are not generally suitable woodcock habitat. Mid- and low-elevations had the same proportion of deciduous forest present but the remaining areas were more equally distributed among other land types.

Distance to the nearest woody wetland, an indication of the spatial distribution of habitat components, also distinguished flush points from random sites. Flush points were significantly closer to woody wetlands than were random points at all elevations and 24.1% of flush points (2.4% of random points) occurred directly in woody wetlands, though this habitat comprised less than 1% of the total land area in the study area. Woodcock are known to make heavy use of wooded wetland areas, particularly those containing alder (Sheldon 1967, Liscinsky 1972, Sepik et al. 1989), probably because they contain the moist, rich soils that harbor high earthworm densities (Parris 1986). Woody wetlands were an important predictor of habitat suitability in West Virginia (Chapter 4).

[go back](#)

Figure 3-1. The state of West Virginia showing the location of the High Allegheny Study Area and the locations of the 165 woodcock flush points that occurred during 1995-1997.

[go back](#)

Figure 3-2. The state of West Virginia showing the location of the High Allegheny Study Area and the locations of the 165 randomly generated points.

[go back](#)

Figure 3-3. Mean proportion of woody wetland measured within each buffer distance for woodcock flush points and random points in each elevation group. The line formed by the mean proportion of woody wetlands around mid-elevation flush points was significantly different from those of all random points and low- and high-elevation flush points.

[go back](#)

Figure 3-4. Mean proportion of deciduous forest measured within each buffer distance for woodcock flush points and random points in each elevation group. The lines formed by the mean proportion of deciduous forest around mid- and low-elevation flush points were significantly different from those of all random points and high-elevation flush points.

[go back](#)

Figure 3-5. Mean proportion of transitional land measured within each buffer distance for woodcock flush points and random points in each elevation group. The line formed by the mean proportion of transitional land around high-elevation flush points was significantly different from those of all random points and mid- and low-elevation flush points

[go back](#)

Figure 3-6. Mean proportion of row crops measured within each buffer distance for woodcock flush points and random points in each elevation group. The lines formed by the mean proportion of row crops around low-elevation flush points was significantly different from those of all random points and mid- and high-elevation flush points.

[go back](#)

Figure 3-7. Mean proportion of mixed pasture/low-intensity agriculture measured within each buffer distance for woodcock flush points and random points in each elevation group.

[go back](#)

Figure 3-8. Mean fractal dimension within each buffer distance for woodcock flush points and random points in each elevation group.

[go back](#)

Figure 3-9. Mean proportion of woody wetlands, emergent wetlands, water, and patch richness in the 450-m buffer. Like letters over bars indicate that means are not significantly different.

[go back](#)

Figure 3-10. Mean proportion of deciduous, mixed, and coniferous forest and developed land in the 450-m buffer. Like letters over bars indicate that means are not significantly different.

[go back](#)

Figure 3-11. Mean proportion of hay/pasture/grass, row crops, mixed pasture/low intensity agriculture, and barren land in the 450-m buffer. Like letters over bars indicate that means are not significantly different.

[go back](#)

Figure 3-12. Means of diversity index and contagion index in the 450-m buffer. Like letters over bars indicate that means are not significantly different.

[go back](#)

Table 3-1. Land-use/land-cover classes used with Multi-Resolution Land Cover data to obtain habitat variables associated with woodcock presence in West Virginia.

Land-use/Land-cover Class	Description
Water	Open water and rivers.
Developed Land	Areas less than 50 % covered by vegetation and 50-100 % covered by constructive materials (asphalt, concrete, buildings etc).
Hay/Pasture/Grass	Areas covered by grasses or other vegetation regularly mowed for hay and/or grazed by livestock.
Row Crops	Areas regularly tilled and planted.
Mixed Pasture/Low Intensity Agriculture	Areas covered by non-woody vegetation and areas classed as row crops that occurred on slopes > 20 degrees.
Conifer Forest	Areas more than 70 % covered by coniferous tree species
Mixed Forest	Areas with both coniferous and deciduous tree species present.
Deciduous Forest	Areas more than 70 % covered by deciduous tree species
Woody Wetlands	Wetland areas with substantial amount of woody vegetation and those areas defined by NWI as wooded wetlands.
Emergent Wetlands	Non-woody wetlands and those areas defined by NWI as unwooded wetlands.
Barren: Quarries/Mine	Quarry and coal mine areas.
Barren: Transitional	Areas likely to change to other land-cover classes, including clear-cut areas

[go back](#)

Table 3-2. Analysis of variance (ANOVA) models used for analyzing habitat patterns around woodcock flush sites in West Virginia.

Effects of Scale	Model: shape of line = group		
	Class	Levels	Values
Independent Variables	Group	6	High-elevation flush points (N = 54) High-elevation random points (N = 54) Mid-elevation flush points (N = 80) Mid-elevation random points (N = 80) Low-elevation flush points (N = 31) Low-elevation random points (N = 31)
Dependant Variable	Linear Coefficients	1	Value representing line shape

Habitat Selection	Model: % variable = group		
	Class	Levels	Values
Independent Variables	Group	6	High-elevation flush points (N = 54) High-elevation random points (N = 54) Mid-elevation flush points (N = 80) Mid-elevation random points (N = 80) Low-elevation flush points (N = 31) Low-elevation random points (N = 31)
Dependant Variable	Habitat Variable	1	Habitat variable in 450 m buffer

[go back](#)

Table 3-3. Results of ANOVA comparisons for effect of scale. Where differences were significant ($P < 0.05$); separate comparisons were made for flush and random points to determine where scale differences existed. All scale differences occurred around flush points.

Land-cover Variables	Whole Model		Flush Points Only		Random Points Only	
	F	$P > F$	F	$P > F$	F	$P > F$
Barren Land	2.21	0.06				
Coniferous Forest	0.50	0.78				
Deciduous Forest	5.85	0.00 ^a	9.30	0.00	1.34	0.26
Developed Land	1.48	0.20				
Emergent Wetland	2.16	0.06				
Hay/Pasture/Grass	1.49	0.19				
Low Int. Agriculture	3.98	0.00	8.42	0.01	0.63	0.53
Mixed Forest	0.43	0.82				
Row Crops	2.51	0.03	5.06	0.01	0.36	0.70
Transitional Land	4.44	0.00	6.40	0.00	1.98	0.14
Water	1.39	0.23				
Woody Wetland	9.90	0.00	5.92	0.00	0.11	0.90
Landscape-level Variables						
Contagion	1.51	0.19				
Double Log Fractal Dim.	3.18	0.01	5.74	0.01	2.26	0.11
Patch Richness	1.29	0.27				
Diversity Index	1.10	0.36				

^a0.00 indicates a value < 0.01

[go back](#)

Table 3-4. Results of a series of significant analysis of variance tests comparing proportion of each land-cover type within a 450-m buffer around 6 use-type/elevation groups. The last six columns show the mean value of each habitat variable and the result of the Tukey least squares multiple comparison tests. Use-type/elevation combinations with the same letter were not significantly different.

Land-Cover Type	Model		Low-elevation		Mid-elevation		High-elevation	
	F	P > F	Flush	Random	Flush	Random	Flush	Random
Woody Wetlands	21.74	0.00 ^a	4.04 B	0.12 B	18.68 A	4.43 B	2.33 B	0.86 B
Emergent Wetlands	6.17	0.00	1.71 A	0.02 B	3.78 A	0.82 B	0.12 B	0.43 B
Water	9.01	0.00	8.31 A	0.32 B	0.66 B	1.15 B	0.84 B	0.27 B
Patch Richness	17.55	0.00	7.00 A	5.32 B	7.00 A	5.65 B	4.80 B	4.54 B
Mixed Forest	4.12	0.00	10.52 AB	7.60 B	12.11 AB	14.06 A	8.96 AB	14.09 A
Coniferous Forest	9.41	0.00	2.97 B	1.49 B	3.43 B	7.13 B	5.96 B	18.53 A
Deciduous Forest	13.96	0.00	44.15 B	71.31 A	42.72 B	60.91 A	77.30 A	60.88 A
Hay/Pasture/Grass	12.78	0.00	11.24 A	6.31 B	1.25 C	2.70 BC	0.23 C	0.63 C
Row Crops	7.82	0.00	5.14 A	2.79 B	1.21 CB	1.57 CB	0.80 C	0.41 C
Low Intensity Agric.	9.09	0.00	11.19 A	5.93 AB	11.44 A	5.52 AB	0.88 C	1.28 C
Barren Land	4.14	0.00	0.17 B	0.29 B	4.55 A	1.46 AB	0.74 AB	0.74 AB
Developed Land	2.35	0.04	0.37 AB	3.46 A	0.04 B	0.14 B	0.01 B	0.03 B
Landscape metrics								
Contagion	10.01	0.00	48.39 D	65.24 BA	49.93 D	54.92 DC	66.98 A	59.07 BC
Diversity Index	16.45	0.00	0.59 A	0.35 CD	0.59 AB	0.46 BC	0.31 D	0.37 CD

^a0.00 indicates a value < 0.01

[go back](#)

Table 3-5. Results ($P > F$) of ANOVA comparisons of non-scale dependent variables. The model column shows the ANOVA 'F' and probability, the next 3 columns give the means and the results of Tukey's least squares multiple comparisons. Groups with the same letter are not significantly different ($\alpha = 0.05$).

Land-cover variables	Model		Low-elevation		Mid-elevation		High-elevation	
	F	$P > F$	Flush	Random	Flush	Random	Flush	Random
Percent Hydric Soils (%)	19.22	0.00 ^a	2.41 C	0.58 C	18.91 A	5.88 BC	11.50 B	11.52 B
Human Population Density	4.44	0.01	5.39 B	108.07 A	3.14 B	4.14 B	0.03 B	0.57 B
Slope (degree)	24.96	0.00	1.19 A	3.00 B	1.28 A	2.81 B	1.70 A	2.48 B
Distance to Woody Wetland (m)	19.35	0.00	753 C	2476 A	353 C	1742 AB	1541 BC	2039 AB
Distance to Stream (m)	18.62	0.00	104 CD	428 AB	231 D	397 ABC	603 A	528 A

^a0.00 indicates a value < 0.01

CHAPTER 4.

USING LOGISTIC REGRESSION AND BROAD-SCALE DIGITAL DATA TO PREDICT POTENTIAL HABITAT SUITABILITY FOR AMERICAN WOODCOCK IN THE HIGH ALLEGHENY REGION OF WEST VIRGINIA

Abstract: Since 1968, annual indices of breeding American woodcock (*Scolopax minor*) have indicated significant declines in the range-wide breeding population. Habitat loss in the breeding zone has been identified as an important factor in this decline and many authors have recognized the need for inventories of existing and potential woodcock habitat range-wide. The objective of my study was to develop a model to discriminate probable woodcock use sites in the state. Habitat variables were determined from the Multi-Resolution Land Cover database and FRAGSTATS spatial analysis program at 8 spatial scales and within two elevation groups. Logistic regression was used to quantify relationships between woodcock use sites and available habitat. Standard reclassification statistics were used to evaluate modeling efficiency and model results were extrapolated to the entire study area. Developed models were generally better at classifying use points than nonuse points. Predicted habitat suitability for the study area ranged from $P = 0.0$ to 0.96 . The two best indicators of woodcock habitat suitability were distance to the nearest wooded wetland and degree of slope. These two variables appeared in all models at all buffer distances and elevations. My study showed that habitat variables derived from broad-scale data can be used to predict woodcock habitat suitability over large geographical areas.

INTRODUCTION

Results from the U. S. Fish and Wildlife Service's North American Singing-ground Survey have indicated that American woodcock (*Scolopax minor*) populations in the eastern and central United States have been declining since 1968 when monitoring began (Bruggink 1997). Short-term (1987-1997) and long-term (1968-1997) trend analyses indicated that breeding populations had declined significantly in the Eastern region by 4.4 % and 1.7 % per year respectively. In West Virginia, long-term trend analysis indicated significant woodcock population declines of 2.1 % per year (Bruggink 1997).

Habitat loss throughout the breeding range has been identified as a primary factor contributing to woodcock population declines, and woodcock require several different habitat types throughout their annual cycle. Within the breeding range alone, displaying, feeding, nesting, roosting and brood-rearing habitats have been described by biologists (Mendall and Aldous 1943, Sheldon 1967, Dunford and Owen 1973, Wenstrom 1973, Gregg 1984, Sepik and Dwyer 1982, Gutzwiller et al. 1983). Deficiencies in any one of these habitat types may limit the density or productivity of the population.

Habitat loss has occurred both directly through urbanization and industrialization, and indirectly as natural forest succession creates mature forest stands unsuitable for woodcock (Gutzwiller et al. 1980, Fenwood and Webb 1981). Fire control, intensive forest management techniques, a decrease in farm abandonment, and limited regeneration of seedling-sapling stands also have resulted in a net loss of woodcock breeding habitat (Fenwood and Webb 1981, Sepik and Dwyer 1982, Gutzwiller et al. 1980, Dwyer et al. 1983, U. S. Fish and Wildlife Service 1990, Sauer and Bortner 1991, Straw et al. 1994).

Habitat use and selection by woodcock has been thoroughly studied at local spatial scales. Yet, there has been little research exploring woodcock/habitat relationships at broad scales or over large geographical areas, although several authors have recognized the need (U.S. Fish and Wildlife Service 1990, Straw et al. 1994). Such studies would facilitate a better understanding of how habitat availability and distribution affects woodcock abundance and would provide information on where and how to best manage woodcock habitat. Advances in remote sensing and its associated image processing technology and software provide access to spatial information on a planetary scale and have made analysis of habitat over large geographic regions possible.

West Virginia contains over one million ha of public land, national forest, and state game lands in addition to 4 million ha of private forested land. The quality of woodcock habitat in these areas is unknown. West Virginia currently contains several areas of excellent woodcock habitat and many other areas have potential to become good woodcock habitat with proper management once critical factors are identified. The results from this study should identify areas suitable for woodcock or areas that may become so with proper management. This information has a variety of potential uses including periodic statewide assessment of habitat, predicting effects of future land-use trends, and use by land managers to develop strategies for woodcock conservation and management in West Virginia. The objectives of this project were to use remotely sensed data and other widely available digital data to develop models to predict potential habitat suitability for American woodcock over large geographic areas in West Virginia.

HIGH ALLEGHENY STUDY AREA

West Virginia is a large and irregularly shaped state on the southern edge of the major breeding range of the woodcock. Although, I originally intended to develop a model for the entire state, most areas did not have enough known habitat (i.e., flushes) to create a model. Approximately 71 % of the woodcock flushes that occurred statewide during 1995-1997 occurred in the High Allegheny Mountain Region. Statewide surveys of woodcock habitat completed during the 1970's (Fenwood 1976, Webb 1978) also indicated that the majority of woodcock habitat (over 80 % of the approximately 17,000 ha identified) in the state was in the Mountain Region. This region contained the highest elevations in the state and the largest proportion of federal and state-owned land including a large portion of the Monongahela National Forest. Approximately 89 % of the area was covered by forested land roughly subdivided into northern evergreen and northern hardwood cover types (Strausbaugh and Core 1977). For model development and extrapolation, a study area was defined within the High Allegheny Mountain Region (Fig. 4-1).

METHODS

Data Collection

Searches for woodcock with trained pointing dogs were used to define areas of woodcock use. The exact location the woodcock had occupied when discovered by a pointing dog was obtained with a global positioning system (GPS) and all flush points were entered into an Arc/Info geographic information system (Environmental Systems Research Institute, Inc., Redlands, Calif., USA). One hundred thirty-four woodcock use points were identified in the study area during May-August 1995-1997; a corresponding number of

random points were created by randomly generating points within a GIS and then eliminating those outside the study area boundary. Because we compared used and available points (rather than used and unused), random sites were allowed to occur anywhere within the study area at elevations ≥ 735 m (the elevation of the lowest flush site), even in areas of known woodcock habitat. Random sites were never visited but were assumed to represent available habitat in the study area.

Because of the high variation in elevation and, consequently, land cover types on the study area, points were divided into 2 groups by clustering flush point elevation (SAS Institute Inc., 1997). Elevation was determined from a grid depicting elevation statewide created from U. S. Geological Survey (USGS) Digital Elevation Models (DEMs) that contain data for West Virginia. Fifty-four 'high-elevation' flush points averaged 1178 m above sea level (range 1080-1292 m) and 80 'mid-elevation' flush points averaged 943 m above sea level (735-1076 m).

GIS Analysis

A series of circular buffers were established around each flush and random point at 150 m intervals ranging from 150-1200 m. This resulted in 16 datasets, one for each buffer distance/elevation combination. Because of the 30 x 30-m resolution of Landsat TM data, 150 m was chosen as the smallest practical buffer distance. The upper distance was chosen because research suggests that woodcock make daily movements of up to 1 km (Sepik and Derleth 1993), and therefore, may be affected by and respond to habitat composition within this distance.

The Multi-Resolution Land Characteristic (MRLC) database (Vogelmann et al. 1996) and FRAGSTATS spatial analysis program (McGarigal and Marks 1995) were used to quantify habitat variables within each buffer distance for each point. The MRLC is a land cover database for the entire mid-Atlantic region derived primarily from Land Remote Sensing Satellite (Landsat) Thematic Mapper (TM) data. The MRLC data set has 30 x 30-m pixel resolution, and thus limits the identification of long, narrow tracts including utility rights-of-way, secondary roads, lower order rivers and streams, and all features smaller than 30-x 30 m.

The portion of the MRLC pertaining to the state of West Virginia was modified by personnel at the Natural Resource Analysis Center (NRAC) at West Virginia University by incorporating National Wetland Inventory (NWI) data and by reclassing row crops that occurred on slopes > 20 degrees and areas classed as 'probable row crops' as 'mixed pasture/low intensity agriculture'. The database was further modified for this study by combining 2 developed categories and 2 wetland categories resulting in 12 categories used for analysis (Table 4-1).

For model development, 4 landscape-level metrics (Simpson's diversity index, contagion index, double log fractal dimension, and patch richness), 12 land-cover variables (proportion of each of 12 land-cover types) and 2-class-level metrics (mean patch size for woody wetland and deciduous forest patches) were used. Additional variables were included for woody wetlands because of their importance to woodcock and for deciduous forest because it was the dominant land-cover type in the study area. Two additional variables used in analyses (distance to the nearest wooded wetland and degree of slope) were not scale dependent and were measured at the point. Slope was obtained through manipulation of the

elevation grid within a GIS (Chapter 1); distance to the nearest woody wetland was measured from the NWI database.

Model Development and Evaluation

To evaluate woodcock habitat selection and to determine habitat associations between the presence of woodcock and measured habitat variables, logistic regression models were constructed for each of the 8 spatial scales and 2 elevation groups following Hosmer and Lemeshow (1989). To limit the number of variables considered for each data set, a series of univariate logistic regression models were fit and likelihood ratio tests (G tests) were examined for each variable (PROC LOGISTIC; SAS Institute 1989) for each data set. Variables with $P < 0.25$ for G tests were retained for further analysis and were subjected to correlation analysis (PROC CORR; SAS Institute 1990) to detect co-linearity. Pairs of variables with $r > 0.50$ were considered for elimination. The decision of which variable to eliminate from each correlated pair was based on significance of the univariate G tests and the more significant variable was retained.

Sixteen stepwise multivariate logistic regression models (PROC LOGISTIC, SAS Institute Inc., 1990) were fit using the variables remaining in the data set after correlation analysis. Classes for logistic regression were defined by woodcock use and available habitat (flush or random points). Significant entry and retention levels of $P \leq 0.25$ were used for the regressions and the resulting models for all subsequent analyses.

Standard reclassification statistics were used to evaluate modeling efficiency. The probability of classifying a point as a use point (rather than a random point) can be predicted from the parameter estimates of the logistic regression equation and the calculated habitat

values at the point. The resulting probability is a relative measure based on comparisons with random locations and a sample of woodcock use points during a certain period (van Manen and Pelton 1997). To pick the 'best' buffer distance for each elevation group (i.e., the buffer distance for which calculated habitat variables resulted in a logistic regression model that correctly classifies the greatest number of points) reclassified points were placed into 4 categories ($P = 0.0-0.25$, $0.25-0.50$, $0.50-0.75$, or $0.75-1.0$). Contingency table analysis (likelihood ratio chi-square) was used to determine which model correctly classified the most flush ($P = 0.75-1.0$) and random points ($P = 0.0-0.25$). Developed models also were tested using 31 woodcock flushes that occurred on the study area during June 1998. Data from these flush points were not used in model development. Habitat variables around these points were determined using FRAGSTATS and the MRLC database and the parameter estimates from developed models were used to classify these points.

Model Extrapolation

After a suitable logistic regression model had been identified for each elevation group, the models were used to calculate the predicted probability of woodcock habitat suitability throughout the High Allegheny study area. A grid consisting of $450 \times 450\text{-m}^2$ cells was created for the study area and habitat variables were determined from the MRLC database and FRAGSTATS for each grid cell. Slope was determined by calculating the average for the cell. Distance to nearest wetland was calculated from the center point and thus represents a 'maximum-minimum' distance or the largest of the possible smallest distances to the nearest wetland. Parameter estimates from the developed logistic regression

models were used to calculate a predicted probability of woodcock habitat suitability in each grid cell.

Model Extrapolation to the Entire State

Thirty-one flushes occurred statewide outside of the High Allegheny study area during 1995-1997; 31 random points were generated within the state but outside of the High Allegheny study area. Parameters from developed models were used with the MRLC data set to classify these points to determine how well the model developed for the High Allegheny Study Area would perform in other parts of the state.

RESULTS

Model Development

Univariate analyses eliminated one land-cover variable (proportion of row crops) from inclusion in all mid-elevation buffer distance models (Table 4-2). Other variables were eliminated from some buffer distance datasets only. Univariate analyses eliminated 3 land-cover variables (proportion of hay/pasture/grass, proportion of transitional land, and mean patch size of woody wetlands) from all the high-elevation models (Table 4-3). Other variables were eliminated from some buffer distance datasets only. Correlation analysis eliminated mean size of deciduous forest and woody wetland patches, and Simpson's diversity index from all data sets and contagion and proportion of coniferous forest from the high-elevation data sets (Tables 4-2 and 4-3). Proportion of deciduous forest and patch richness were eliminated from mid-elevation data sets.

Sixteen stepwise logistic regressions were performed with the remaining variables, one for each spatial scale/elevation category combination. Two variables (distance to nearest woody wetland and degree of slope) were inversely associated with woodcock presence in all 16 models regardless of buffer distance or elevation (Table 4-4). Proportion of coniferous forest and hay/pasture/grass were inversely associated with woodcock presence in mid-elevation models developed with habitat variables with buffers ≤ 750 m; proportion of mixed forest was inversely associated with woodcock presence in 4 of 8 mid-elevation models. Among high-elevation models, deciduous forest was positively associated with woodcock presence in all models; patch richness and proportion of water were associated with woodcock presence in 3 of 8 high-elevation models. Proportion of mixed pasture/low intensity agriculture was inversely associated with woodcock presence in 5 of 8 high-elevation models.

Contingency table analysis determined that mid-elevation models based on habitat variables within the 450 m buffer performed the best overall for classifying both flush and random points for all points (Chi-square = 155.9, $P < 0.001$) and for mid-elevation points (Chi-square = 114.3, $P < 0.001$). For the high-elevation data sets, contingency table analysis determined that models based on habitat variables within 150 m of points correctly classified the greatest number of both flush and random points (Chi-square = 97.8, $P < 0.001$). Models based on habitat variables within 1050 m of points performed the best (Chi-square = 70.3, $P < 0.001$) for classifying high-elevation flush and random points.

Model Testing

Models were tested using 31 flush points that occurred on the study area during June 1998. Models were tested using habitat variables derived from buffering the 1998 flushes to the same distance as was used to derive the model being tested. For example, models developed from habitat variables derived with a 450-m buffer were tested using habitat variables for the 1998 flushes determined within 450 m of the points. The best mid-elevation model (450-m buffer) classified 19 of 31 (61.3 %) points (11 of 15 mid-elevation points, 73.3 %); the best high-elevation models (450-m buffer and 900-m buffer) classified 9 of 31 (29.0 %) points (Table 4-5 and 4-6). All three models were better at classifying points in the same elevation group than all points. The 900 m high-elevation model classified high elevation points better (7 of 16, 43.8 %) than the 450 m high-elevation model (5 of 16, 31.2 %).

Model Extrapolation

Values indicating probability of occurrence were calculated for each 450 x 450m cell in the study area using variable parameters from the logistic model derived from mid-elevation points for mid-elevation cells and the model derived from high-elevation points (1050 m model) for high-elevation cells. Probability of woodcock occurrence throughout the study area extrapolated from both the mid- and high-elevation models (Fig. 4-2) ranged from 0.00 to 0.97 with 2.3 % of the study area having a high ($P > 0.75$) probability of being suitable for woodcock. The majority of the study area (89.9 %) was predicted to be unsuitable for woodcock ($P < 0.25$).

Extrapolation to the Entire State

Models developed in the High Allegheny Study Area performed poorly when tested with points occurring throughout the rest of the state. The model developed with mid-elevation points correctly classified ($P > 0.75$) 6 of 31 (19.4 %) flush points outside the study area. It classified random points ($P < 0.25$) much better (26 of 31, 83.9 %) than flush points (45.2 %). The model developed with high-elevation points correctly classified 56.5 % of all points outside the study area. It also classified random points much better (90.3 %) than flush points (22.6 %).

DISCUSSION

Habitat Relationships

Class level variables were important in predicting woodcock presence but the single best predictor described the spatial distribution of a habitat element: distance to woody wetland. Flush points were significantly closer to woody wetlands than were random points at all elevations and 26.1 % of flush points (2.9 % of random points) occurred directly in woody wetlands though this habitat comprised less than 1 % of the total land area in the study area. Distance to woody wetlands was a significant variable in all models developed in the study area at all spatial scales and elevations. It was a better predictor of woodcock presence than was the proportion of woody wetlands. A univariate model developed with this variable alone correctly classified 63.8 % of all points in the High Allegheny Study Area. Woodcock are known to make heavy use of wooded wetland areas, particularly those containing alder, (Sheldon 1967, Liscinsky 1972, Sepik et al. 1989) probably because they contain the moist, rich soils that harbor high earthworm densities (Parris 1986). In heavily

forested, mountainous areas like the High Allegheny Study Area, these soil types are largely limited to wetlands, riparian areas, and small, scattered seeps. Most stream banks and riparian areas in the study area were, however, covered with forest vegetation rather than shrubs, and may not be used by woodcock (Webb and Samuel 1982). Woodcock in West Virginia are occasionally associated with seeps or other damp areas too small to map with aerial photographs (Webb 1978) or satellite imagery but woody wetlands remain the best indicator of woodcock occurrence in West Virginia.

Degree of slope also was a good predictor of woodcock habitat suitability with suitable habitat occurring exclusively on level to gently sloping land. Steep slopes are often too dry to support the type of soils needed by earthworms, the primary prey item of the woodcock. Degree of slope is not generally a variable mentioned in the literature to describe woodcock habitat suitability probably because no other state in the breeding zone contains the extremes of topography found in West Virginia.

Proportion of deciduous forest was the only land-cover variable to appear in all high-elevation models. Proportion of deciduous forest was greater around high-elevation flush sites than random sites at all buffer distances measured ($P < 0.01$). Deciduous forest was the dominant land cover type on the study area and proportion of deciduous forest available (58.6-62.5 %) was the same regardless of elevation ($P = 0.31$). High-elevation flush sites had greater proportion of deciduous forest than did mid-elevation flush sites probably because areas not covered by deciduous forest were composed mainly of coniferous (16.0-19.6 %) and mixed forest (13.7-14.6 %), which are not generally suitable woodcock habitat. In the mid-elevations, areas not covered by deciduous forest were more equally distributed

among other land types. Rather than indicating a preference for deciduous forest, woodcock at high-elevations were probably avoiding coniferous and mixed forest habitats.

The proportion of water was associated with woodcock presence for 5 of 8 high-elevation models. While water is obviously not suitable habitat for woodcock, it may be an indicator of moist soils and increased earthworm abundance particularly in the high elevations where wetlands are limited. The mid-elevations contain proportionally more woody wetlands than do the high elevations and water was not an important predictor in any mid-elevation model.

Proportion of mixed pasture/low intensity agriculture measured at buffer distances above 450 m was inversely associated with woodcock presence at high-elevations. Most of these areas in the high elevations were open and grassy, sheep or cattle pasture. These areas may be used as singing grounds or night roosting fields but are unlikely to be used as diurnal habitat.

Model Performance

Results indicated that probability of woodcock occurrence in West Virginia's High Allegheny Study Area could be predicted using widely available digital data to obtain broad-scale habitat variables. Klute (1999) showed that in Pennsylvania a logistic regression model developed to predict habitat suitability associated with singing-ground survey stops correctly predicted low probability for areas of very low suitability and high probability for areas of high suitability. Areas with marginal habitat suitability had moderate predicted probabilities and were the most frequent causes of classification errors. This was true of the models developed in this study; the models correctly predicted the extremes (i.e., areas of very high suitability

and areas of very low suitability) and most of the misclassification errors occurred with the mid-range points.

Model misclassification error may have several causes. Random points were not visited but were assumed to be representative of available habitat rather than to be nonuse areas. It is possible that some random points misclassified as flush points by the model would have had woodcock present had they been searched. Insufficient sample size, poor choice of habitat variables or model error may also have caused point misclassification. Any modeling approach assumes that the variables being measured are the variables that the species of interest responds to; in reality, they may have been approximations of the true habitat variables to which woodcock respond. The modeling process also was limited by the 30 x 30-m resolution of the MRLC data. It was not possible, for instance, to determine forest age or differentiate shrubby species from tree species. These variables probably would have allowed finer distinctions between use and nonuse areas possible as the woodcock's preference for shrubby areas and young forest stands has been well documented (Godfrey 1974, Hudgins et al. 1985, Sepik et al. 1989). The spatial resolution of the MRLC also could not distinguish small seeps and other damp areas that may provide important habitat areas in brushy 'benches' and ridge tops (Webb and Samuel 1981).

Finally, locating woodcock with pointing dogs gives a 'snapshot view' of the species daily movements and habitat use. It offers no information about the amount of time that the bird spent in the habitat where it was found. Some birds may have been encountered in sub-optimal habitat or habitat where they normally spend very little time. Conversely, birds may not have been encountered in suitable habitat because of imperfect detection by dogs or because not all suitable habitat is occupied by woodcock every year. Sepik et al. (1989)

caution that without considering habitat quality, researchers may be measuring woodcock use of the best available habitat rather than the best habitat. If this is true, modeling efforts that rely on variables from best available sites may be modeling sub-optimal habitat.

Overall, models developed using mid-elevation points performed better than models developed with high-elevation points. Models predicted same-elevation points better than points from the other elevation group but models developed using mid-elevation points performed better when classifying all 268 points, indicating that mid-elevation models classified high-elevation points better than high-elevation models classified mid-elevation points.

Model Extrapolation

Woodcock habitat in West Virginia is unique. The study area is on the southern edge of the major breeding range and characterized by rugged terrain and steep slopes. Woodcock probably never were abundant in the state before Europeans arrived; their numbers increased somewhat after colonization as agricultural and lumbering activities created more suitable areas (Kletzly 1976). Large variations in elevation and consequent variations in land-cover types provide a unique challenge to modeling efforts. Extrapolation of developed models to the High Allegheny region cannot distinguish specific points of woodcock occurrence. They do, however indicate areas where habitat variables are consistent with areas in which woodcock do occur and where woodcock may have a high probability of occurrence. This potential habitat is scattered and patchy but the study area contains areas of excellent habitat and relatively high woodcock population densities. The best habitat (judged by number of flushes) continues to be found in Canaan Valley, which has consistently contained West

Virginia's highest woodcock densities (Goudy et al. 1970, Webb 1978, Webb and Samuel 1982). In the 1970's, Canaan Valley contained approximately 40 % of all woodcock habitat identified statewide and 100 % of the habitat classed as 'exceptional' (Fenwood 1976, Webb 1978). However, most of the Valley floor and the best woodcock habitat is privately or industrially owned and is in danger of becoming lost by conversion to vacation homes and other recreational development. Habitat areas within the Monongahela National Forest, while protected from development, may become lost to woodcock through forest succession or maturation. There are currently no areas in West Virginia that are actively managed for woodcock and continued declines in woodcock populations can be expected as habitat loss continues.

Management Implications

This study suggests that widely available broad scale data derived from satellite imagery can be used to identify areas of varying woodcock suitability across large geographic areas. The extremes (i.e., areas of relatively high and relatively low suitability) in particular, were discernable with broad scale data. Areas of very low suitability included steep slopes, urban and developed areas, and areas with high proportions of coniferous and mixed forest. This information has a variety of potential uses including regional assessment of habitat and predicting the effects of future land use and land cover trends. Models developed for this study were based on variables that represent a certain period (i.e., 1993 Landsat image and woodcock use data collected during 1995-1997) and as such, they predict relative probability of woodcock occurrence based on conditions that may change over time. However, the coefficients identified in this study should remain constant and could be

applied to new images as they become available or as land use changes make updating desirable. It also is possible to use the developed models to simulate the effects of land use changes by manipulating the land use data set to reflect anticipated changes and then applying the model.

Couture et al. (1993) suggested that the size of the woodcock population may be proportional to the amount of available habitat and that it should be possible to derive an index of the total population for different parts of its range by measuring the amount of available habitat. Results from this study and a similar study conducted in the same area by (Klute et al. 1999) support this possibility within West Virginia's mountain region.

Using the Predictive Models

With the logistic regression equation of the 'best' model, the probability of classifying an area for woodcock habitat suitability can be predicted from the habitat characteristics of that area:

$$Y = B_0 + B_1X_1 + B_2X_2 \dots + B_nX_n$$

$$P = 1/(1 + \exp. (Y))$$

The 'B's are the parameter estimates from the logistic equation and the 'X's are the values of the habitat variables in the area of interest. The second equation uses the natural exponent of the result of the first equation (Y) and will result in a number between 0 and 1. This number is the predicted suitability of the area as woodcock habitat. Numbers closer to 1 represent more suitable habitats and numbers closer to 0 represent less suitable. The user has

to decide on a cut off probability for suitability. In other words, pick a higher probability to increase the likelihood that the area actually is suitable.

The model was developed using a 450-m buffer and gives a single suitability rating for the entire area. Few 450 m² areas are uniform throughout however, and the best use of the model may be to judge the relative suitability of two or more areas or as an initial screening process to identify potential areas for management.

[go back](#)

Figure 4-1. The High Allegheny Study Area, Canaan Valley, the 134 random points, and the 134 woodcock flushes that occurred during 1995-1997. The inset shows the location of the study area and Canaan Valley within West Virginia.

[go back](#)

Figure 4-2. Predicted probability of woodcock habitat suitability in West Virginia's High Allegheny Study Area. The inset shows the location of Canaan Valley and the Study Area within West Virginia. The largest contiguous amount of area predicted to be highly suitable occurred within Canaan Valley.

[go back](#)

Table 4-1. Land-use/landcover classes used with Multi-Resolution Land Cover data to obtain habitat variables associated with woodcock presence in West Virginia.

Land-use/Landcover Class	Description
Water	Open water and rivers.
Developed Land	Areas less than 50 % covered by vegetation and 50-100 % covered by constructive materials (asphalt, concrete, buildings etc).
Hay/Pasture/Grass	Areas covered by grasses or other vegetation regularly mowed for hay and/or grazed by livestock.
Row Crops	Areas regularly tilled and planted.
Mixed Pasture/Low Intensity Agriculture	Areas covered by non-woody vegetation and areas classed as row crops that occurred on slopes > 20 degrees.
Conifer Forest	Areas more than 70 % covered by coniferous tree species
Mixed Forest	Areas with both coniferous and deciduous tree species present.
Deciduous Forest	Areas more than 70 % covered by deciduous tree species
Woody Wetlands	Wetland areas with substantial amount of woody vegetation and those areas defined by NWI as wooded wetlands.
Emergent Wetlands	Non-woody wetlands and those areas defined by NWI as unwooded wetlands.
Barren: Quarries/Mine	Quarry and coal mine areas.
Barren: Transitional	Areas likely to change to other landcover classes, including clear-cut areas

[go back](#)

Table 4-2. Results (G value) of univariate logistic regression for each habitat variable for each buffer distance using mid-elevation points. An 'X' indicates variables that were not used for further analysis for that buffer distance because $G > 0.25$. A '-' indicates variables deleted after correlation analysis.

Habitat Variable	Buffer Distance (m)							
	150	300	450	600	750	900	1050	1200
Water	X	X	X	X	X	X	0.16	0.07
Developed Land	0.17	0.14	0.15	0.22	X	X	X	X
Hay/Pasture/Grass	0.05	0.10	0.06	0.10	0.18	X	X	X
Row Crops	X	X	X	X	X	X	X	X
Mix Past./Low Int. Agriculture	X	0.12	0.01	0.00 ^a	0.00	0.00	0.00	0.00
Coniferous Forest	0.05	0.03	0.04	0.04	0.07	0.13	0.21	0.25
Mixed Forest	X	X	0.20	0.08	0.09	0.09	0.15	X
Deciduous Forest	-	-	-	-	-	-	-	-
Barren Land	0.11	0.08	0.06	0.04	0.05	0.07	0.10	0.14
Transitional Land	X	X	X	X	X	X	0.21	0.20
Wooded Wetlands	-	-	0.00	0.00	0.00	0.00	0.00	0.00
Emergent Wetlands	0.23	0.05	0.01	0.01	0.01	0.01	-	-
Mean Patch Size Decid. Forest	-	-	-	-	-	-	-	-
Mean Patch Size Wetland	-	-	-	-	-	-	-	-
Patch Richness	-	-	-	-	-	-	-	-
Diversity Index	-	-	-	-	-	-	-	-
Double Log Fractal Dimension	X	X	X	X	-	-	-	-
Contagion Index	X	0.02	0.05	0.04	-	-	-	-

^a all 0.00 values are ≤ 0.01

[go back](#)

Table 4-3. Results (G value) of univariate logistic regression for each habitat variable for each buffer distance using high-elevation points. An 'x' indicates variables that were not used for further analysis for that buffer distance because $G \geq 0.25$. A '-' indicates variables deleted after correlation analysis.

Habitat Variable	Buffer Distance (m)							
	150	300	450	600	750	900	1050	1200
Water	X	X	0.20	0.10	0.08	–	0.04	–
Developed Land	X	X	X	0.15	0.03	X	X	X
Hay/Pasture/Grass	X	X	X	X	X	X	X	X
Row Crops	X	X	0.23	X	X	X	0.08	0.02
Mixed Pasture/Low Agriculture	X	X	X	0.21	0.15	0.11	0.09	0.11
Coniferous Forest	–	–	–	–	–	–	–	–
Mixed Forest	0.02	0.01	–	–	–	–	–	–
Deciduous Forest	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Barren Land	X	X	X	X	0.20	0.11	0.04	0.01
Transitional Land	X	X	X	X	X	X	X	X
Wooded Wetlands	X	0.23	X	X	X	X	X	X
Emergent Wetlands	X	X	0.16	X	X	X	X	–
Mean Patch Size Decid. Forest	–	–	–	–	–	–	–	–
Mean Patch Size Wetland	X	X	X	X	X	X	X	X
Patch Richness	X	X	X	0.09	–	0.01	–	0.08
Diversity Index	–	–	–	–	–	–	–	–
Double Log Fractal Dimension	–	–	–	–	–	–	X	–
Contagion Index	–	–	–	–	–	–	–	–

[go back](#)

Table 4-4. Habitat variables identified by a series of logistic regression models as important to woodcock presence in West Virginia's High Allegheny study area. Minus sign indicates a negative association with woodcock presence; plus sign indicates a positive association.

	Buffer distance (m)							
Mid-elevation models	150	300	450	600	750	900	1050	1200
Model r^2	0.48	0.46	0.52	0.49	0.48	0.43	0.41	0.42
Distance to Woody Wetland	-	-	-	-	-	-	-	-
Degree of Slope	-	-	-	-	-	-	-	-
Developed land	-	-	-	-				
Hay/Pasture/Grass	-	-	-	-	-			
Coniferous Forest	-	-	-	-	-			
Mixed Forest			-	-	-	-		
Low Intensity Agriculture						-		
Emergent Wetlands						-		
Barren land	+							

	Buffer distance (m)							
High-elevation models	150	300	450	600	750	900	1050	1200
Model r^2	0.35	0.27	0.42	0.43	0.43	0.46	0.49	0.48
Distance to Woody Wetland	-	-	-	-	-	-	-	-
Degree of Slope	-	-	-	-	-	-	-	-
Row Crops			+				+	+
Low Intensity Agriculture				-	-	-	-	-
Deciduous Forest	+	+	+	+	+	+	+	+
Patch Richness				+		+		+
Water				+	+		+	+
Emergent Wetland			-					-

[go back](#) Table 4-5. Number of 31 woodcock flush points that occurred during June 1998 correctly classified into 4 groups of potential habitat suitability by the ‘best’ logistic regression models developed to predict habitat suitability for woodcock in the High Allegheny study area. The best mid-elevation model was developed using habitat variables measured within a 450-m buffer. The best high-elevation models were developed using habitat variables measured within 150-m and 1050-m buffers. Both mid- and high-elevation models performed better at classifying points within the same elevation group.

Model	<i>P</i>				%
	< 0.25	0.25-0.50	0.50-0.75	> 0.75	Correct
Mid-elevation/450 m					
All 31 Points	2	0	10	19	61.3
15 Mid-elevation Points	0	0	4	11	73.3
High-elevation/150 m					
All 31 points	10	4	8	9	29.0
16 High-elevation Points	2	2	7	5	31.3
High-elevation/1050 m					
All 31 points	16	0	6	9	29.0
16 High-elevation Points	3	0	6	7	43.8

[go back](#)

Table 4-6. Number of 31 woodcock flush points that occurred outside of the study area classified into 4 groups of potential habitat suitability by the ‘best’ logistic regression models developed to predict habitat suitability for woodcock in the High Allegheny study area. The best mid-elevation model was developed using habitat variables measured within a 450-m buffer. The best high-elevation models were developed using habitat variables measured within 150 m and 1050 m buffers. Both mid- and high-elevation models performed better at classifying points within the same elevation group.

	<i>P</i>				%
Model	< 0.25	0.25-0.50	0.50-0.75	> 0.75	Correct
Mid-elevation/450 m					
Flush Points	12	9	4	6	19.4
Random Points	26	1	2	2	83.9
High-elevation/150 m					
Flush Points	0	9	13	9	29.0
Random Points	22	4	2	3	71.0
High-elevation/1050 m					
Flush Points	9	2	0	20	64.5
Random Points	20	2	5	4	64.5

CHAPTER 5.

CHANGES IN QUALITY AND QUANTITY OF AMERICAN WOODCOCK HABITAT IN WEST VIRGINIA FROM THE 1970'S TO THE 1990'S

Abstract: Since the U. S. Fish and Wildlife Service began monitoring populations in 1968, the American woodcock (*Scolopax minor*) has experienced significant population declines. Loss of suitable habitat through urbanization and forest stand maturation has been cited as the probable cause of this decline. In the 1970's, a study was initiated to inventory and categorize diurnal woodcock habitat in the state. Approximately 12,300 ha of habitat were identified statewide; approximately 50 % were categorized as good or excellent habitat. The objective of my study was to determine the 1990's status of habitat that was available in the 1970's and determine the fate of lost habitat. Using a combination of singing male counts, dog-assisted searches and other means, 5,115 ha of habitat that had been field-checked in the 1970's were resurveyed. Twenty-five (408 ha) resurveyed sites were classed as definitely not woodcock habitat and 28 sites (173 ha) were classed as unlikely woodcock habitat. Forty-two sites (1040 ha) were classed as possible woodcock habitat; 16 sites (451 ha) were probably woodcock habitat and woodcock were found on 15 sites (3,042 ha). Original classification was a good predictor of status in the 1990's. The majority (83.0 % of sites, 65.6 % of area) of the sites currently classified as unsuitable (definitely not or unlikely) were originally rated as poor or fair habitat. The majority (48.3 % of sites, 93.0 % of area) of the sites currently rated as definite woodcock habitat were originally rated good or exceptional habitat. Reasons for habitat loss included suburban and industrial development, flooding due

to dams, conversion to agricultural use (e.g. open fields, pastures, or row crops) and seral advancement of forest vegetation beyond what was suitable for woodcock.

INTRODUCTION

West Virginia is on the southern edge of the major breeding range of the American woodcock (*Scolopax minor*) and is characterized by rugged terrain and steep slopes. The primary breeding range of the woodcock extends south into northern and eastern West Virginia (Sheldon 1967), and the winter range may extend northward into the state during milder winters, particularly along the Ohio and Kanawha Rivers (Hall 1983). Statewide woodcock populations have always been relatively low compared with other areas in the northern breeding range, and suitable woodcock habitat is scattered, patchy, and probably nonexistent in parts of the state (Chapter 4). However, West Virginia does contain areas of excellent woodcock habitat and woodcock occur throughout the state. The consensus of those in the state familiar with the woodcock is that it probably breeds in all counties and is locally common in summer (Webb and Samuel 1982, Hall 1983). Before the 1970's, no reliable estimate of woodcock habitat in West Virginia existed although it was known to be limited. In the early 1970's, a study was initiated by the West Virginia Division of Natural Resources (WVDNR), West Virginia University, and two West Virginia University graduate students to inventory and categorize diurnal woodcock habitat in the state (Fenwood 1976, Webb 1978). Although it represents only one of several habitat types required by the species, availability of diurnal habitat was determined to be the most limiting to West Virginia's woodcock populations and the type most readily identifiable on aerial photographs (Webb 1978). Diurnal habitat was defined as a dense, low, shrubby canopy often associated

with a meandering stream; alder (*Alnus* spp.) was generally the most important shrub species present (Webb 1978, Webb and Samuel 1982).

Fenwood (1976) and Webb (1978) identified and categorized approximately 17,000 ha of woodcock habitat and potential woodcock habitat statewide using aerial photographs and site visits. The best habitat was in the Canaan Valley in the eastern portion of the state but suitable areas were located statewide. Although identified habitat amounted to less than 1 % of the total land area of the state, Fenwood and Webb predicted a decrease in amount of woodcock habitat available in West Virginia over the two decades following their studies. Other researchers in West Virginia (Kletzly 1976, Fenwood and Webb 1981, Webb and Samuel 1982) noticed and commented on an apparent decline of suitable habitat areas in the state due, in part to human developments.

Long term trend analysis (1968-1997) from the U. S. Fish and Wildlife Service's North American singing-ground survey indicated significant long-term (1968-1997) declines in woodcock populations have occurred in West Virginia and throughout the entire Eastern Region (Bruggink 1997). This range-wide decline has been attributed to habitat loss that has occurred both directly through urbanization and industrialization, and indirectly as natural forest succession created mature forest stands unsuitable for woodcock (Gutzwiller et al. 1982, Fenwood and Webb 1981). However, no quantitative information exists as to how much habitat has been lost, and how (or if) new habitat is created. The presence of the 1970's statewide habitat inventory provides a unique opportunity to investigate the fate of woodcock habitat in West Virginia. This study had two objectives: to determine the current suitability of woodcock habitat that was available in West Virginia in the mid-1970's and to determine the fate of woodcock habitat that has been lost since the 1970's.

METHODS

Summary of Previous Work

Fenwood (1976) and Webb (1978) initially located potential habitat by examining stereo pairs of 23 x 23 cm, black and white, 1:20,000 scale aerial photographs to identify lowland shrubby areas and other suitable habitat. Only sites on level or almost level ground were recorded since steep slopes were likely to be too dry for woodcock. Approximate area of the site was obtained with a dot grid and the site outline was transferred to the appropriate 7.5 or 15' United States Geological Survey (USGS) topographical map. Approximately half of the sites were field-checked for signs of woodcock presence (probings, splashes, or flushed birds). Field-checked sites were subjectively placed into one of four quality categories (Table 5-1) based on presence of woodcock or their sign, site size, percent ground cover, percent shrub density, soil moisture, land use and reported use ('expert opinion'). Non-field-checked sites were qualitatively rated as 'questionable', 'possible', or 'probable' woodcock habitat based on interpretation of the aerial photographs. These categories roughly corresponded to the 'poor', 'fair', and 'good' ratings given to field-checked sites (Fenwood 1976).

Statewide, 1,331 potential woodcock habitat sites (about 17,000 ha) were identified; 659 of these comprising approximately 12,300 ha were field-checked. Only 124 sites (5,944 ha) were rated as good or exceptional habitat (Table 5-2). This represented 19 % of the number of sites and 48 % of the area surveyed. All exceptional sites (10 sites, 3114 ha) were located in the Canaan Valley. An additional 602 sites (4629 ha) were identified on aerial photographs but not field-checked. Only 160 sites (27 %) containing 1,298 ha (28 %) of non-field-checked areas were classified as possible or probable woodcock habitat.

Data Transfer

The data files and topographic maps from the 1970's statewide woodcock habitat inventories were obtained for this study. Site outlines were digitized into a Geographic Information System (Environmental Systems Research Institute, Inc., Redlands, Calif.) and all descriptive data except site name codes were imported into a spreadsheet for manipulation and analysis. Original site outlines and name codes were recorded on approximately 450 7.5' and 15' USGS topographical maps. Using the Universal Transverse Mercator (UTM) coordinates listed for each site and the original USGS topographic maps, sites were transferred onto new 7.5' USGS topographic maps for digitizing. This transfer was necessary before digitizing because the original maps were bound together, of different scales (i.e., some 7.5' and some 15' quadrangles), and many were folded or wrinkled from fieldwork. Additionally, most maps had been revised by the USGS since the previous study and the more current maps were used. Because some discrepancies existed between sites listed in the digital files and sites outlined on the topographic maps, only 1,243 of the 1,331 sites identified by Fenwood and Webb were used for my study.

Determining Current Status

The current status of a sample of the original sites (Table 5-2) was determined during May-August of 1995-1997 by various methods, including dog searches, aerial photograph analysis and singing male counts. A dog-assisted search consisted of 1-3 human searchers walking slowly through an area with 1-3 bird dogs covering the area between searchers (Ammann 1981). The same individual pointing dog was used each year and additional dogs accompanied by their owners/handlers were used as available.

Singing male counts were conducted between mid-April and the end of May in 1995-1997 to evaluate areas of private property that could not be accessed on foot, and as a preliminary means of evaluating woodcock use. When possible, sites where woodcock were detected were searched with dogs later. Counts were conducted at a single point at or near the center of the site for a period of 5 minutes. Otherwise, counts followed established protocol for the USFWS singing-ground surveys as closely as possible; i.e., they were conducted 20-40 minutes after sunset when wind, rain, and temperature conditions were acceptable for the latitude and longitude of the site (Bruggink 1997).

Methods for aerial photograph analysis closely followed those of Fenwood (1976) and Webb (1978). Stereo pairs of 23 x 23-cm, black and white, 1:20,000 scale aerial photographs were used to identify lowland shrubby areas and other suitable habitat; the most recent photographs available were from the early 1990's. All sites that looked like possible habitat were field-checked; only sites with strong evidence of human influence (i.e., development, agricultural use, or flooding) were classified through aerial photograph analysis alone.

A final means of evaluating potential habitat was a roadside evaluation. In a roadside evaluation, the quality of a site was judged from the road without accessing the site. This method was used only when the site was obviously no longer woodcock habitat due to human influence.

Fenwood and Webb sites were chosen for resurveying in a nonrandom manner based on proximity to sites that were surveyed during a concurrent project; however, the quality classification given to a site during the 1970's study was not known when the sites were resurveyed. Status of each resurveyed site was placed into one of five general categories

(Table 5-3). Like the Fenwood and Webb's study, rating the current quality of sites was subjective but a number of factors were considered, including degree of vegetation maturation and/or human influence, shrub stem density, site size and land use. Sites where woodcock or their sign were found were considered definite woodcock habitat.

The area of each potential site was originally estimated with a dot grid; minor fluctuations in scale inherent in aerial photographs, rough topography, and lack of definite site boundaries precluded exact measurements (Fenwood 1976). Minor errors in transferring site outlines to the new maps and digitizing errors may have occurred. Thus, the area recorded in the 1970's data and the area determined by digitizing the site outlines do not completely agree. Areas reported in this manuscript are from the original study and are given only as approximations; they should not be considered definitive. Additionally, sites were rated as a whole although the quality of the site may not have been uniform throughout. Some larger sites may have had unsuitable portions and still be rated as better habitat if the majority of the site was suitable or if woodcock were found on a portion of the site. Finally, a disproportionate amount of habitat originally rated as good or excellent was resurveyed (Table 5-2). This occurred because sites were resurveyed concurrently with a project whose objectives included locating current woodcock habitat and because no effort was made to determine the quality rating previously given to a site before the site was resurveyed.

Determining Current Status from Developed Predictive Model

In a related study of woodcock habitat in the state, a predictive model was constructed to quantify the potential for woodcock occurrence in portions of the High Allegheny Region of West Virginia (Chapter 4). The model was developed using logistic

regression and broad-scale habitat variables derived from the Land-sat data. Because I could not revisit all of the 1970's sites, a model (mid-elevation/450 m) was used to determine the predicted probability of occurrence of woodcock on 1970's habitat inventory sites. Current (1993) habitat variables were determined from the MRLC database for each site and parameter estimates from the developed logistic regression model were used to calculate predicted probability of woodcock presence for each site.

RESULTS

Current Status of Sites Field-Checked in the 1970's

The current status of 126 (5,114 ha) of 636 (11,286 ha) sites that had been field-checked by Fenwood or Webb was determined during 1995-1997 (Table 5-2). Twenty-five (408 ha) resurveyed sites were classed as definitely not woodcock habitat (Table 5-3) and 28 sites (173 ha) were classed as unlikely woodcock habitat. Forty-two sites (1040 ha) were classed as possible woodcock habitat; 16 sites (451 ha) were probably woodcock habitat and woodcock were found on 15 sites (3,042 ha).

The majority (83.0 % of sites, 65.6 % of area) of the sites currently classified as unsuitable (definitely not or unlikely) were originally rated as poor or fair habitat. The majority (48.3 % of sites, 93.0 % of area) of the sites currently rated as definite woodcock habitat were originally rated good or exceptional habitat (Fig 5-4). Most (56.0 % of sites, 40.3 % of area) of the sites originally listed as poor habitat were still unsuitable for woodcock; only 2 sites (8.0 %) containing 20 ha (6.3 %) of habitat originally classed as poor were reclassified as probable and none were classed as definite. Likewise, almost all of the

sites (90.0 % of sites, 95.1 % of area) originally classed as exceptional were still good woodcock habitat (probable or definite); none was reclassified as unlikely (Fig 5-3).

Of the 53 (581 ha) sites currently classed as unsuitable habitat, 40 (469 ha) had originally been classed as fair or good habitat and thus may be considered 'lost' for woodcock use. Reasons for habitat loss included suburban and industrial development, flooding due to dams, conversion to agricultural use (e.g. open fields, pastures, or row crops) and seral advancement of forest vegetation beyond what was suitable for woodcock (Table 5-4).

Sixteen sites containing 260 ha of habitat originally classed as poor or fair and currently classed as probable or definite may be considered 'gained' for woodcock use (Table 5-4). This represents 12.6 % of resurveyed sites and 5.1 % of resurveyed area. Twenty-eight (399 ha) of 602 (4629 ha) sites categorized by Fenwood and Webb from aerial photograph analysis, but not field-checked were resurveyed during 1995-1997 (Table 5-6). Woodcock were found on a single site and 14 sites (50.0 %) were considered unsuitable for woodcock.

Current Status Determined from Predictive Model

Two hundred and fifty-one sites (5,551 ha) that had been field-checked during the 1970's occurred in an area for which a predictive habitat model had been developed (Fig. 5-1). Sixty-five of these sites (3,216 ha) had been resurveyed during 1995-1997. The mean probability of woodcock occurrence determined by the predictive model on these sites was consistent with the subjective quality rating given after resurveying during 1995-1997 (Table

5-6). Sites classified as probable or definite had the highest mean probability of woodcock occurrence. However, in all categories the ranges of probabilities were high.

The predicted probability of woodcock occurrence on all 251 sites in the High Allegheny study area ranged from 0-0.94 (Table 5-7). One hundred and forty-four sites (4,305 ha) had a predictive value greater than 0.50 suggesting that they were suitable woodcock habitat, while 107 sites (1246 ha) had a predictive value of $P < 0.50$ suggesting that they were unsuitable woodcock habitat. More than one third (35.9 %) of the sites (19.4 % of the area) predicted to be unsuitable had originally been classified as good or fair habitat; none had originally been classified as excellent. Almost half (46.3 %) of the sites (24.4 % of the area) originally classed as fair or poor were predicted to be suitable habitat.

DISCUSSION

Woodcock require wet woodlands containing young forest with scattered openings and this type of habitat is apparently declining range-wide. Several researchers have associated this loss with increasing amounts of urban/developed land and mature forest stands and limited regeneration of seedling-sapling stands (Coulter and Baird 1982, Gutzwiller et al. 1982, Dwyer et al. 1983, U. S. Fish and Wildlife Service 1990).

Results from the habitat re-inventory indicated that 35.9 % of resurveyed sites and 19.4 % of resurveyed area was lost to woodcock since the mid-1970's because of forest stand succession and/or human use (development, agricultural use or flooding). Application of the predictive model indicated slightly higher amounts of lost habitat (40.5 % of sites and 27.9 % of area). The predictive model was expected to give a more conservative estimate of habitat loss than the statewide re-inventory. Its use was restricted to sites that occurred in the High

Allegheny Region, which contains most of the state's National Forest land and thus, the region of the state least influenced by human activities.

Conversion to agricultural uses (crops, open fields, and animal pasture) accounted for half of the number of resurveyed sites lost and 57.3 % of the amount of area lost. Lowlands and flood plains provide not only prime woodcock covers but also an inviting location for urban or agricultural development. This is especially true in West Virginia where such lands are limited and therefore at a premium (Kletzly 1976) and humans have diverted much of this land for their own use (Webb 1978).

Forest stand maturation and urban development was responsible for 20.9 % of lost resurveyed sites and 10.9 % of lost area. Several authors have connected forest stand succession and urbanization with a decrease in woodcock habitat. In Pennsylvania, Gutzwiller et al. (1982), determined that increases in the amount of mature forest (sawtimber one half or more of trees with DBH > 27.9 cm) and urban areas were consistent with the apparent decline in woodcock populations in the state. Dwyer et al. (1983) analyzed habitats along SGS routes in the northeastern United States and concluded that declines in woodcock numbers were related to increases in human developments. Earlier researchers in West Virginia (Kletzly 1976, Fenwood and Webb 1981) noticed and commented on a trend of human encroachment into woodcock habitat; a trend that has continued as human developments intrude into woodcock habitat in the state. Forest stand succession also is a factor in woodcock habitat loss in the state; West Virginia's forests have become increasingly mature since the last major cutting cycle at the turn of the century (DiGiovanni 1990).

Application of the developed predictive model indicated that approximately 1073 ha (19.4 %) of habitat available in the 1970's in the High Allegheny Region had become unsuitable. The majority of these sites were not re-inventoried and thus reasons for this change could only be inferred from proportion of land cover types on the site determined by the MRLC data set. Proportion of hay/pasture/grass areas and urban/developed land were inversely associated with woodcock presence in the model and unsuitable sites had higher proportions of these landcover variables than did sites predicted to be suitable for woodcock.

Fenwood and Webb recognized that some sites classified as poor or fair would become more suitable over time. This study indicated that 12.6 % of resurveyed sites (5.1 % of the resurveyed area) originally classified as poor or fair was currently probable or definite woodcock habitat. While this gain does not balance the apparent loss in habitat, it does mitigate it somewhat.

On all reclassified sites, previous classification was a good predictor of current status. Almost two thirds (65.6 %) of area classed as poor or fair by Fenwood and Webb is currently unsuitable (definitely not or unlikely) woodcock habitat, while most (80.8 %) of the rechecked area originally classed as good or exceptional is currently probable or definite habitat. This may indicate that good and exceptional habitat areas are more likely to remain suitable over time, while marginal habitat areas are more likely to be lost to other uses.

Limitations of the Studies

Many errors are possible in subjective, descriptive, studies like this study and the 1970's studies. For instance, aerial photograph analysis cannot locate small seeps and damp areas often associated with woodcock presence; Fenwood and Webb undoubtedly missed

many habitat sites because of this limitation. Additionally, some photographs were of limited usefulness because of their age (Fenwood 1976). Changes in land cover that occurred between the times some photographs were taken and when they were used to locate potential habitat allowed some sites to be mislabeled. Field checking also introduced potential errors. Woodcock are a secretive species usually located with the aid of dogs, however, dogs were not used in the 1970's studies. Woodcock probably occurred on many sites where their use was not noted because they were searched without the aid of a trained dog. Field checking during the 1970's studies occurred throughout the year and thus may have included sites used primarily by migrating rather than breeding birds. Finally, the quality rating was subjective and based in part, on subjective values of other estimated variables (Webb 1978). However, the earlier authors felt that most errors were made in judging poor and fair sites and that good and exceptional sites were seldom rated too high (Webb 1978). Because of these potential errors, the amount of habitat reported to be available in the 1970's was probably an underestimate but the degree of error is unknown.

My study would have been improved with a larger sample size that more equally represented the original classification ratings. Site quality was judged subjectively but like the earlier study, the mid-quality sites probably produced the most classification errors.

A trend of decreasing woodcock populations and decreasing amounts of suitable habitat has been repeatedly reported. This study provides further evidence that woodcock habitat areas continue to be lost and that these losses outweigh the gains. Concerns for the continued welfare of the species are justified.

[go back](#)

Figure 5-1. Location of the High Allegheny Region Study Area and 1970's habitat inventory sites that occurred in the study area.

[go back](#)

Figure 5-2. Area given each woodcock habitat quality rating by Fenwood (1976) and Webb (1978) and area in each category resurveyed. A disproportionate amount of excellent habitat was resurveyed.

[go back](#)

Figure 5-3. Current quality categories showing proportion of area in each original (1970's) quality classification. Each column represents one of 5 current quality ratings. The first column represents areas that are definitely no longer habitat; 19 % of the area was originally listed as poor (pink), 40 % was fair (green), none of it was exceptional. Conversely, of the area currently classed as definitely woodcock habitat, (the last column) 95 % of it was originally characterized as exceptional (blue) and none of it was poor.

[go back](#)

Figure 5-4. Original (1970's) quality categories showing proportion of area in each current quality classification. Each column represents one of 4 1970's quality ratings. The first column represents areas originally classed as poor habitat; it still contains the largest proportion of unsuitable habitat (pink and green). Half of it is possible habitat; only 6% is probable habitat and none if it is definite habitat. The majority of last column, areas originally rated as exceptional habitats, is currently definite habitat and the rest is probable or possible habitat.

[go back](#)

Table 5-1. Quality categories for American woodcock habitat in West Virginia as determined by Fenwood (1976) and Webb (1978).

Field-Checked Sites	Description
Exceptional	Site factors ideal for woodcock. Habitat would produce large resident populations.
Good	Ground cover, vegetative structure, and soil moisture were suitable. Habitat probably supported a small population of resident woodcock.
Fair	Areas were unsuitable due to a number of factors including vegetative structure, soil moisture, or ground cover. Habitat may or may not have produced resident woodcock.
Poor	Most of these sites were deficient in shrub cover but may have had future potential with succession. Habitat produced few, if any, resident woodcock.
Non-Field-Checked Sites	
Questionable	Sites did not appear promising, if field-checked many would have been eliminated or classified as fair or poor.
Possible	Sites appeared more promising, if field-checked many would have been classified as fair or good.
Probably	Sites appeared very promising, if field-checked most would have been classified as good.

[go back](#)

Table 5-2. Quality ratings given in 1995-1997 to woodcock habitat sites originally classified by Fenwood (1976) and Webb (1978) in the mid-1970's.

1) Definitely Not Woodcock Habitat:
a) Sites developed for human use, i.e., housing, industrial, or mining.
b) Sites permanently flooded due to dams.
c) Open (grassy) animal pasture or agricultural crops.
2) Unlikely Woodcock Habitat:
a) Sites with forest stands in advanced seral stages that no longer provide suitable woodcock cover. These sites were characterized by fewer stems with greater DBH; understory was sparse or nonexistent and canopy cover was high (> 9 m).
b) Mostly wooded sites that had a few scattered areas of human development.
c) Sparsely wooded animal pasture.
3) Possible Woodcock Habitat:
a) Undeveloped sites with some mature trees or undeveloped sites on which the vegetation cover is not dense.
b) 'Spirea swamps'; sites that were often very wet and may have standing water, often very thickly vegetated with persistent emergents such as <i>Juncus</i> spp. and <i>Typha</i> spp..
4) Probable Woodcock Habitat:
a) Sites undeveloped for human use, and covered by early successional vegetation.
b) Animal pasture covered with shrubs or young woody vegetation.
c) Sites with reported use 'expert opinion'.
5) Definite Woodcock Habitat:
a) Sites on which woodcock were seen during April-August 1995-1997 by Woodcock Project personnel or others.
b) Sites with evidence of woodcock use (probings, splashing, or singing males).

[go back](#)

Table 5-3. Current and original woodcock habitat quality classification of a sample of sites originally field-checked, classified during the 1970's study, and reclassified during 1995-1997. Number of sites is given with area (in hectares) in parentheses.

Current Habitat Quality Classification	1970's Habitat Quality Classification				Totals
	Poor	Fair	Good	Exceptional	
Definitely Not	4 (78)	15 (162)	6 (168)	0	25 (408)
Unlikely	10 (50)	15 (91)	3 (32)	0	28 (173)
Possible	9 (169)	21 (303)	11 (416)	1 (152)	42 (1040)
Probable	2 (20)	8 (140)	5 (222)	1 (69)	16 (451)
Definite	0	6 (100)	1 (49)	8 (2893)	15 (3042)
Totals	25 (317)	65 (796)	26 (887)	10 (3114)	126 (5114)

[go back](#)

Table 5-4. Number of sites and amount of habitat reclassified as unsuitable and reasons for its current unsuitability. Number of sites is given with area (in hectares) in parentheses.

	Number of sites currently classed as Unsuitable	Amount classed as unsuitable that was previously classed as Fair or Good	Percent of all resurveyed Fair or Good Habitat Lost
Flooded	1 (16)	1 (16)	1.1 (1.0)
Developed	9 (154)	6 (93)	6.6 (5.5)
Forest Stand Maturation	20 (126)	13 (91)	14.3 (5.4)
Converted to Agriculture	25 (291)	20 (269)	22.0 (16.0)
Totals	55 (587)	40 (469)	44.0 (27.9)

[go back](#)

Table 5-5. Current and original quality classification of a sample of sites categorized solely from aerial photograph during the 1970's study and reclassified during 1995-1997.

Number of sites is given with area (in hectares) in parentheses.

Current Habitat Quality Classification	1970's Habitat Quality Classification	
	Questionable	Possible
Definitely Not	6 (85)	3 (35)
Unlikely	4 (33)	1 (26)
Possible	5 (75)	2 (30)
Probable	6 (102)	0
Definite	0	1 (13)
Totals	21 (295)	7 (104)

[go back](#)

Table 5-6. Current quality classification and mean predicted probability of woodcock occurrence for sites within the High Allegheny Region that had been field-checked in the 1970's and resurveyed during 1995-1997.

Current Classification	No. Sites	Total in Ha	Mean probability of woodcock occurrence
Definitely Not	14	149	0.38 (0.00 - 0.86)
Unlikely	10	60	0.52 (0.06 - 0.90)
Possible	20	450	0.61 (0.11- 0.91)
Probable or Definite	21	2558	0.71 (0.17 - 0.88)
Totals	65	3216	0.57 (0.00 - 0.91)

[go back](#)

Table 5-7. Number of sites, area, and original quality classification for sites in the High Allegheny Region predicted to be suitable woodcock habitat (probability of woodcock occurrence $P > 0.50$) and unsuitable habitat (probability of woodcock occurrence of $P < 0.50$).

Original classification of sites predicted to be suitable habitat	No. Sites	Total In Ha	Mean probability of woodcock occurrence	Percent of sites (area) in High Allegheny Region predicted to be suitable
Excellent	7	2164	0.81 (0.72 - 0.88)	2.8 % (38.9 %)
Good	21	786	0.72 (0.59 - 0.93)	8.4 % (14.2 %)
Fair	92	1095	0.75 (0.53 - 0.94)	36.7 % (19.7 %)
Poor	24	260	0.73 (0.53 - 0.88)	9.6 % (4.7 %)
Total	144	4305	0.75 (0.53 - 0.94)	57.5 % (77.5 %)
Original classification of sites predicted to be unsuitable habitat	No. Sites	Total In Ha	Mean probability of woodcock occurrence	Percent of sites (area) in High Allegheny Region predicted as unsuitable
Good	12	297	0.29 (0.00 - 0.49)	4.8 % (5.4 %)
Fair	78	776	0.20 (0.00 - 0.50)	31.1 % (14.0 %)
Poor	17	172	0.21 (0.00 - 0.50)	6.8 % (3.1 %)
Total	107	1246	0.20 (0.00 - 0.50)	42.7 % (22.5 %)

APPENDIX 1.

A DESCRIPTION OF PUBLIC AND PRIVATE PROPERTIES IN WEST VIRGINIA FIELD-CHECKED FOR WOODCOCK PRESENCE DURING 1995-1997

Public Land

Pleasant Creek Wildlife Management Area. A single singing male was heard on the west end of the area in early May 1995. No woodcock were found when the area was revisited with pointing dogs in mid-June 1995. A singing male was heard on the east end of the area in May 1997; again no woodcock were found during dog-assisted searches that year.

Hillcrest Wildlife Management Area. Several areas of likely diurnal cover and several singing ground areas were identified by the wildlife biologist of the Area. These areas were searched without a dog in May 1995 and again with a dog in mid-September 1995 however, no woodcock or woodcock sign were found. It is likely that because of the unusually dry summer, woodcock were not present in areas where they may be found in wetter years. These areas were re-searched with dogs in June 1997 and no woodcock were found.

Castleman's Run Public Fishing Area. This area is reported by the Wildlife Biologist to contain singing grounds in the spring. The area was searched in May 1995 without a dog and no woodcock or woodcock sign were found.

Bear Rocks Public Fishing Area. This area also is reported to have singing males in the spring and contains some likely cover. It was searched in May 1995 without a dog and in August 1996 with a dog but no woodcock were found.

Burnsville Lake Public Hunting and Fishing Area. The Burnsville Lake area contains some good woodcock habitat; at least 4 areas containing woodcock were identified through searches with dogs. Additional sites were identified on U. S. Geological Survey topographical maps by a local hunter and by the Wildlife Biologist for the area. Several of these areas were rechecked with a dog in mid-September 1995. No woodcock were found in areas that contained birds in June, perhaps because the site was very dry due to the lack of rain. Additional woodcock were flushed on the area in 1996.

Elk River Public Hunting and Fishing Area. This area also contains some good woodcock habitat, 3 areas were identified by searches with dogs in early June 1995. Additional sites were identified on maps by a local hunter.

Hughes River Wildlife Management Area. This area was briefly searched in June 1996 with a dog. Most of the area was upland forest unsuitable for woodcock and no woodcock or their sign was found.

Lewis Wetzel Wildlife Management Area. Singing males were reported at the campground and along Buffalo Run by the area Wildlife Biologist. No woodcock were found during a search with a dog in early September 1995, however the area was very dry.

Stonewall Jackson Lake Wildlife Management Area. Probe holes and droppings were found by a dog in an area around the Vandalia Access Site, however most of this area is unsuitable for woodcock as it consists of upland forest. The Vandalia site was searched with a dog in August 1996 and no woodcock were located.

Coopers Rock State Forest (Trout Pond). Migrating woodcock are reported to use the area in the fall, but no birds were flushed by a dog during a visit in mid-August 1995 or in July 1997.

Monongahela National Forest. The Monongahela National Forest contains many areas of good woodcock cover. Several likely areas were identified on topographical maps by Walt Lesser of the WVDNR; many of these areas have been field checked with great success. Many of the best woodcock sites identified statewide were in the Monongahela National Forest; 2 of the 6 brood sightings were located within the Forest.

Handley Wildlife Management Area. Handley contains some alder thickets and some likely cover, however no woodcock were found during a search with a dog in June 1996.

Sherwood Lake. Woodcock are reported to use the area below the lake and along Meadow River. These areas were searched unsuccessfully with a dog in June 1996.

McClintic Wildlife Management Area. Woodcock have been present on McClintic Wildlife Management Area in large numbers in the past (Shissler 1981), however much of the area has matured beyond suitable cover. Two woodcock were flushed on the area in May 1996; 4 more were flushed in different locations on the area in 1997.

Bluestone Wildlife Management Area. Several areas along Crump's Bottom and Indian Creek were searched with a dog in June 1996. One woodcock was flushed at Crump's Bottom. The area had been severely flooded in the weeks before my visit and heavy evidence of the flood remained. There are probably more suitable areas at Bluestone than my searches would indicate.

Greenbottom Wildlife Management Area. Three woodcock were flushed in a narrow strip of cover between the swamp and river behind the historic house. An additional bird was flushed along Guyan Creek to the northeast of the main management area.

Dolly Sods. Woodcock were flushed on Dolly Sods near the picnic area and at the Red Creek campground in both 1997 and 1998.

Private Land

Westvaco lands. Some of the highest densities of woodcock were found on reclaimed mine lands owned by Westvaco near Rupert, WV. Seven woodcock were found on three sites in late May 1995. Five additional sites that hold woodcock (at least in the fall) were identified by Bruce Brenneman of Westvaco. Two of these sites were searched in mid-September 1995 and no woodcock were found, however they were very dry. These sights were rechecked in June 1996 and woodcock were flushed on one of them. Woodcock were also found at several sites on Westvaco lands near Cassidy, WV.

The Nature Conservancy lands along the Meadow River. Woodcock are reported to use the area along the Meadow River west of Rupert; however, none were found by a dog in 1995. Three woodcock were flushed in the area in June 1997 and 4 more near Sam Black Church in 1998.

The Nature Conservancy lands at Cranesville Swamp. Cranesville was searched unsuccessfully with a dog in June of 1997 but a brood was located there during a dog-assisted search in June 1998.

Mount Storm Lake. Several woodcock were flushed on coal company lands on the east side of Mount Storm Lake in June 1998.

Davis Power Company and Others in Canaan Valley. Canaan continues to contain the best woodcock habitat in the state. Thirteen woodcock were flushed in less than 4 hours (12 dog-hours) along the Blackwater River and the North Branch of the Blackwater. Woodcock were also found in the Canaan Valley State Park, Blackwater Falls State Park and

along the Camp 70 road. A brood was located north of the Blackwater River, east of Davis, WV.

Mountain Top Hunting Club lands north of Davis and near Leadmine. Lands leased by the Mountain Top Hunting Club contain some very nice woodcock habitat. Two broods were located on their lands.

LITERATURE CITED

- Ammann, G. A. 1981. A guide to capturing and banding American woodcock using pointing dogs. Ruffed Grouse Society, Coroapolis, Pennsylvania, USA. 30pp.
- Baker, B. W., B. S. Cade, W. L. Mangus, and J. L. McMillen. 1995. Spatial analysis of sandhill crane nesting habitat. *Journal of Wildlife Management* 59(4):752-758.
- Bruggink, J. G. 1997. American woodcock harvest and breeding population status, 1997. U.S. Fish and Wildlife Service, Laurel Maryland, USA.
- Coulter, M. W., and J. C. Baird. 1982. Changing forest land uses and opportunities for woodcock management in New England and the Maritime Provinces. Pages 75-85 in T. J. Dwyer and G. L. Storm, technical coordinators. *Proceedings of the Seventh Woodcock Symposium*. U.S. Fish and Wildlife Research Report 14. Washington D.C., USA.
- Couture, R., M. Babin, and S. Perras. 1993. Survey of woodcock habitat with Landsat: possibilities and limitations of remote sensing. Pages 50-56 in J. R. Longcore and G. F. Sepik, editors. *Proceedings of the Eighth American Woodcock Symposium*, U.S. Fish and Wildlife Service Report 16.
- Cowardin L., V. Carter, F. Golet, and E. Laroe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service. Office of Biological Services FWS/OBS-79/31. 103.
- Clark, J. D., J. E. Dunn, and K. G. Smith. 1993. A multivariate model of female black bear habitat use for a geographic information system. *Journal of Wildlife Management* 57:519-526.
- DiGiovanni, D. M. 1990. Forest Statistics for West Virginia 1975 and 1989. U.S. Department of Agriculture, Forest Service Resource Bulletin NE114.
- Dunford, R. D., and R. B. Owen, Jr. 1973. Summer behavior of immature radio-quipped woodcock in central Maine. *Journal of Wildlife Management* 37:462-469.
- Dwyer, T. J., D. G. McAuley, and E. L. Derleth. 1983. Woodcock singing-ground counts and habitat changes in the northeastern United States. *Journal of Wildlife Management* 47:772-779.
- Environmental Systems Research Institute, Inc. (ESRI). 1996. The Arc/Info Geographic Information System, Version 7.1. Redlands, California, USA.
- Fenwood, J. D. 1976. An inventory of woodcock habitat in southern West Virginia. M.S. Thesis, West Virginia University, Morgantown, West Virginia, USA. 110pp.
- Fenwood, J. D., and L. O. Webb. 1981. An aerial photo inventory of woodcock habitat in West Virginia. *Wildlife Society Bulletin* 9:306-307.
- Godfrey, G. A., 1974. Behavior and ecology of American woodcock on the breeding range in Minnesota. Ph.D. Thesis, University of Minnesota, Minneapolis, Minnesota, USA.

- Goudy, W. H., R. C. Kletzly, and J. C. Rieffenberger. 1970. Characteristics of a heavily hunted woodcock population in West Virginia. Transactions of the North American Wildlife and Natural Resources Conference 35:183-195.
- Gregg, L. E. 1984. Population ecology of woodcock in Wisconsin. Technical Bulletin 144 Wisconsin DNR. 50pp.
- Gustafson, E. J., G. R. Parker, and S. E. Backs. 1994. Evaluating spatial pattern of wildlife habitat: A case study of the wild turkey (*Meleagris gallopavo*). American Midland Naturalist. 131(1) 24-33
- Gutzwiller, K. J. 1990. Minimizing dog-induced biases in game bird research. Wildlife Society Bulletin 18:351-356.
- Gutzwiller, K. J. and J. S. Wakely. 1980. Differential use of woodcock singing grounds in relation to habitat characteristics. Pennsylvania Agriculture Experimental Station Paper 61-71.
- Gutzwiller, K. J., G. L. Storm, W. M. Tzilkowski, and J. S. Wakeley. 1983. Relative value of vegetation structure and species composition for identifying American woodcock breeding habitat. Journal of Wildlife Management 47:535-539.
- Hall, G. A. 1983. West Virginia Birds. Special Publication of the Carnegie Museum of Natural History, Pittsburgh, Pennsylvania, USA. 188pp.
- Homer, C. G., T. E. Edwards, R. D. Ramsey, and K. P. Price. 1993. Use of remote sensing methods in modeling sage grouse winter habitat. Journal of Wildlife Management 57:78-84.
- Hosmer, D. W., Jr., and S. Lemeshow. 1989. Applied Logistic Regression. John Wiley and Sons, Inc., New York, New York, USA.
- Hudgins, J. E., G. L. Storm, and J. S. Wakeley. 1985. Local movements and diurnal habitat selection by male American woodcock in Pennsylvania. Journal of Wildlife Management 49:614-619.
- James, F. C., and H. H. Shugart, Jr. 1970. A quantitative method of habitat description. Audubon Field Notes 24:727-736.
- Kletzly, R. C. 1976. American woodcock in West Virginia. West Virginia DNR Bulletin No. 8, Charleston, West Virginia, USA. 46pp.
- Klute, D. S. 1999. Modeling habitat relationships for American woodcock in Pennsylvania: effects of spatial autocorrelation and spatial scale. Ph.D. Thesis. Pennsylvania State University, University Park, Pennsylvania, USA.
- Klute, D. S., A. K. Steketee, and P. B. Wood. 1999. Using logistic regression and remotely sensed data to predict potential habitat suitability for American woodcock over large geographic areas in Pennsylvania and West Virginia. Report submitted to Webless Migratory Game Bird Program, Denver, Colorado, USA.
- Lehmkuhl, J. F., and M. G. Rapheal. 1993. Habitat pattern around Northern Spotted Owl locations on the Olympic Peninsula, Washington. Journal of Wildlife Management 57:302-315.

- McCoy, R. W. 1987. PAM HEP Habitat suitability index model for woodcock. U.S. Fish Wildlife Service 4pp.
- McGarigal, K., and B. J. Marks. 1995. FRAGSTATS: Spatial pattern analysis program for quantifying landscape structure. General Technical Report PNWGTR351. U.S. Department of Agriculture Forest Service, Pacific Northwest Research Station, Portland, Oregon, USA.
- Mendall, H. L., and C. M. Aldous. 1943. The ecology and management of the American woodcock. Maine Cooperative Wildlife Research Unit, University of Maine, Orono, Maine, USA. 201pp.
- Parris, R. W. 1986. Forest vegetation, earthworm, and woodcock relationships. Ph.D. Thesis, State University of New York, Syracuse, New York, USA. 240pp.
- Reynolds, J. W., W. B. Krohn, and G. A. Jordan. 1977. Earthworm populations as related to woodcock habitat use in central Maine. Pages 135-146 *in* D. J. Keppie and R. B. Owen, Jr., editors. Proceedings of the Sixth Woodcock Symposium. U.S. Fish and Wildlife Service Report.
- Roseberry, J. L., B. J. Richards, and T. P. Hollenhorst. 1994. Assessing the potential impact of Conservation Reserve Program lands on bobwhite habitat using remote sensing, GIS, and habitat modeling. Photogrammetric Engineering and Remote Sensing 60:1139-1143.
- SAS Institute, Inc. 1990. SAS/STAT User's guide, version 6, 4th edition, volumes 1 and 3. Cary, North Carolina, USA.
- Sauer, J. R., and J. B. Bortner. 1991. Population trends from the American woodcock singing-ground survey, 1970-88. Journal of Wildlife Management 55:300-312.
- Sepik, G. F., R. B. Owen, Jr., and M. W. Coulter. 1981. A landowners guide to woodcock management in the northeast. Maine Agriculture Experimental Station, University of Maine, Orono, Maine, USA.
- Sepik, G. F., and T. J. Dwyer. 1982. Woodcock response to habitat management in Maine. Pages 106-113 *in* T. J. Dwyer and G. L. Storm, technical coordinators, Proceedings Seventh Woodcock Symposium. U.S. Fish Wildlife Service Research Report 14.
- Sepik, G. F., R. B. Owen, Jr., and T. J. Dwyer. 1983. The effect of drought on a local woodcock population. Transactions of the Northeastern Fish and Wildlife Conference 40:18.
- Sepik, G. F., R. B. Owen, Jr., and M. W. Coulter. 1988. A landowner's guide to woodcock management in the northeast. U.S. Fish and Wildlife Service Miscellaneous Report 253 23pp.
- Sepik, G. F., D. G. McAuley, J. R. Longcore, and E. L. Derleth. 1989. Habitat requirements and management of woodcock in the Northeast: assessment of knowledge and needs. Pages 97-109 *in* J. C. Finley and M. C. Brittingham, editors. Timber management and its effects on wildlife. Proceedings of the 1989 Pennsylvania state forest resources issues conference, University Park, Pennsylvania, USA.

- Sepik, G. F., and E. L. Derleth. 1993. Habitat use, home range size, and patterns of moves of the American woodcock in Maine. Pages 41-49 *in* J. R. Longcore and G. F. Sepik, editors. Proceedings of the Eighth Woodcock Symposium U.S. Fish and Wildlife Service Biological Report 16.
- Sepik, G. F., D. G. McAuley, and J. R. Longcore. 1993. Critical review of the current knowledge of the biology of the American woodcock and its management on the breeding grounds. Pages 98-104 *in* Longcore and Sepik, editors. Proceedings of the Eighth American Woodcock Symposium. U.S. Fish and Wildlife Service Biological Report 16.
- Sheldon, W. G. 1967. Book of the American woodcock. University of Massachusetts Press, Amherst, Massachusetts, USA. 227pp.
- Shissler, B. P. 1981. The breeding biology of the American woodcock in West Virginia. M.S. Thesis, West Virginia University, Morgantown, West Virginia, USA. 193pp.
- Sneddon, L., M. Anderson, and K. Metzler. 1994. A classification and description of terrestrial community alliances in The Nature Conservancy's Eastern Region: First Approximation. The Nature Conservancy 97pp.
- Steketee, A. K. 1994. Population densities, singing ground characteristics and brood movements of American woodcock, and vegetation changes in a regenerating aspen stand. M.S. Thesis, Northern Michigan University, Marquette, Michigan, USA. 120pp.
- Strausbaugh, P. D., and E. L. Core. 1977. Flora of West Virginia. Seneca Books, Inc. Morgantown, West Virginia, USA. 1079pp.
- Straw, J. A., D. G. Krementz, M. W. Olinde, and G. F. Sepik. 1994. American woodcock. Pages 97-114 *in* T. C. Tacha and C. E. Braun, editors. Migratory shore and upland game bird management in North America. International Association of Fish and Wildlife Agencies, Washington, D.C., USA.
- U.S. Department of Agriculture, Soil Conservation Service. 1994. State Soil Geographic (STATSGO) database for West Virginia. U.S. Department of Agriculture Soil Conservation Service, Fort Worth, Texas, USA.
- U.S. Fish and Wildlife Service. 1990. American woodcock management plan. U.S. Fish and Wildlife Service, Washington, D.C., USA. 11pp.
- van Manen, F. T., and M. R. Pelton. 1997. A GIS model to predict black bear habitat use. *Journal of Forestry*. 95(8)6-12
- Vogelmann, J. E., S. M. Howard, and T. Sohl. 1996. Regional landcover characterization using multiple sources of intermediate scale data. Proceedings 1996 International Geoscience and Remote Sensing Symposium 1:246-247.
- Webb, L. O. 1978. Woodcock habitat inventory of northern West Virginia using aerial photographs. M.S. Thesis, West Virginia University, Morgantown, West Virginia, USA. 161pp.

- Webb, L. O., and D. E. Samuel. 1982. Woodcock habitat inventory and wetlands in Northern West Virginia. Symposium on Wetlands of the Unglaciaded Appalachian Region, Morgantown, West Virginia, USA.
- Wenstrom, W. P. 1973. Habitat utilization and activities of female American woodcock (*Philohela minor*) in northeastern Minnesota during spring and summer. Ph.D. Thesis, University of Minnesota, St. Paul, Minnesota, USA. 203pp.

Table A-1. Number of all points (134 flush and 134 random points) and mid-elevation points (80 each) classified into each of 4 groups of potential habitat suitability by logistic regression models developed to predict habitat suitability for woodcock in the High Allegheny study area.

		<i>P</i>				
All Flush Points (N=134)	Buffer	< 0.25	0.25-0.50	0.50-0.75	> 0.75	% > 0.75
	150	9	32	34	59	44.0
	300	27	16	29	62	46.3
	450	8	10	43	73	54.5
	600	5	19	43	67	50.0
	750	7	18	41	68	50.7
	900	5	34	34	61	45.5
	1050	6	41	28	59	44.0
	1200	15	30	30	59	44.0
All Random Points (N=134)						% < 0.25
	150	96	9	20	9	71.6
	300	91	18	16	9	67.9
	450	97	12	14	11	72.4
	600	90	13	19	12	67.2
	750	87	14	21	12	64.9
	900	84	19	10	21	62.7
	1050	80	23	12	19	59.7
	1200	81	22	14	17	60.4
Mid-elevation Flush Points (N=80)						% > 0.75
	150	4	4	18	54	67.5
	300	6	3	14	57	71.3
	450	5	2	13	60	75.0
	600	2	10	13	55	68.8
	750	3	8	13	56	70.0
	900	2	8	19	51	63.8
	1050	3	6	18	53	66.3
	1200	3	5	19	53	66.3
Mid-elevation Random Points (N=80)						% < 0.25
	150	57	5	12	6	71.3
	300	52	13	10	5	65.0
	450	63	3	9	5	78.8
	600	56	8	10	6	70.0
	750	55	7	11	7	68.8
	900	53	11	4	12	66.3
	1050	49	13	5	13	61.3
	1200	47	15	5	13	58.8

Table A-2. Number of all points (134 flush and 134 random points) and high-elevation points (54 flush and 54 random points) classified into each of 4 groupings of potential habitat suitability by logistic regression models developed to predict habitat suitability for woodcock in the High Allegheny study area.

		P				
All Flush Points (N=134)	Buffer	< 0.25	0.25-0.50	0.50-0.75	> 0.75	% > 0.75
	150	8	28	48	50	33.7
	300	5	37	52	40	29.9
	450	30	7	36	61	45.5
	600	56	11	22	45	33.6
	750	65	10	33	26	19.4
	900	55	7	25	47	35.1
	1050	48	13	18	55	41.0
	1200	35	20	25	55	41.0
All Random Points (N=134)						% < 0.25
	150	72	32	17	13	53.7
	300	54	432	24	13	40.3
	450	79	22	20	13	59.0
	600	89	18	10	17	66.4
	750	106	9	8	11	79.1
	900	91	19	11	13	67.9
	1050	97	11	10	16	72.4
	1200	91	14	6	23	67.9
High-elevation Flush Points (N=54)						% > 0.75
	150	2	8	28	16	29.6
	300	1	10	30	13	24.1
	450	2	3	24	25	46.3
	600	1	6	16	31	57.4
	750	7	5	26	16	29.6
	900	2	4	16	32	59.3
	1050	2	3	10	39	72.2
	1200	1	6	17	30	55.6
High-elevation Random Points (N=54)						% < 0.25
	150	28	13	7	6	51.9
	300	26	13	7	8	48.1
	450	32	9	9	4	59.3
	600	32	9	7	6	59.3
	750	39	6	5	4	72.2
	900	34	8	8	4	63.0
	1050	38	6	4	6	70.4
	1200	37	6	5	6	68.5