Proceedings of the Ninth American Woodcock Symposium

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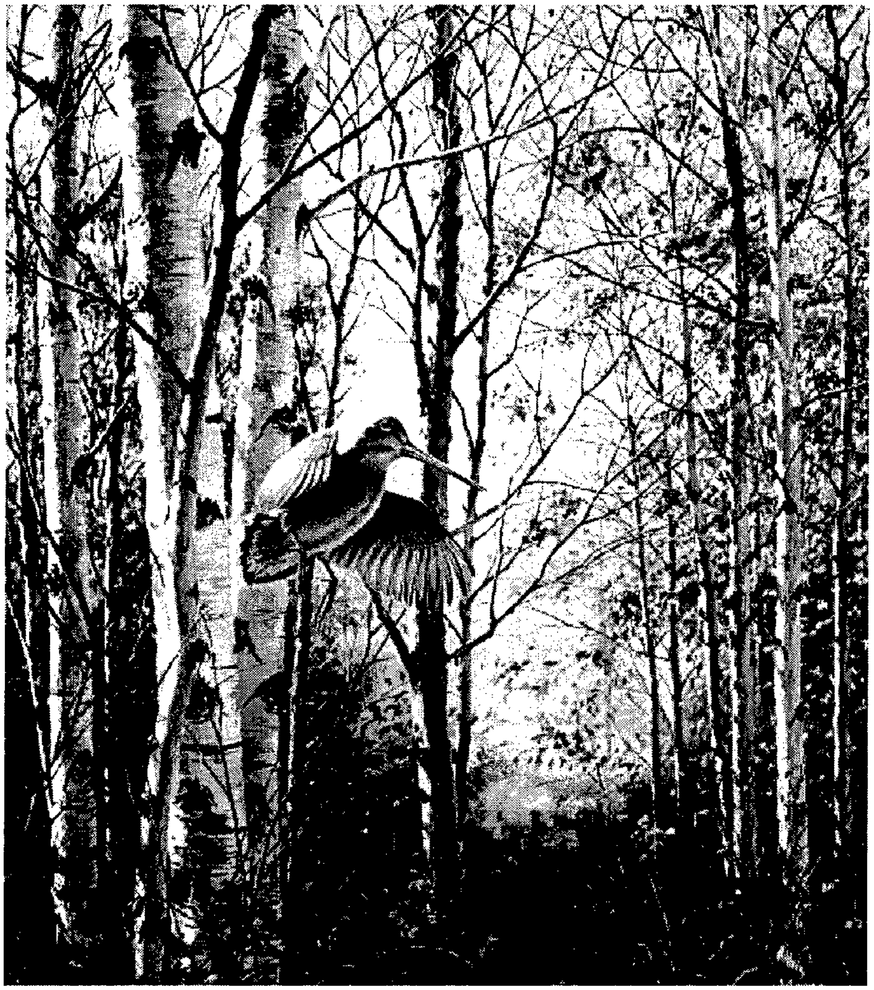

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Proceedings of the Ninth American Woodcock Symposium

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Dedication

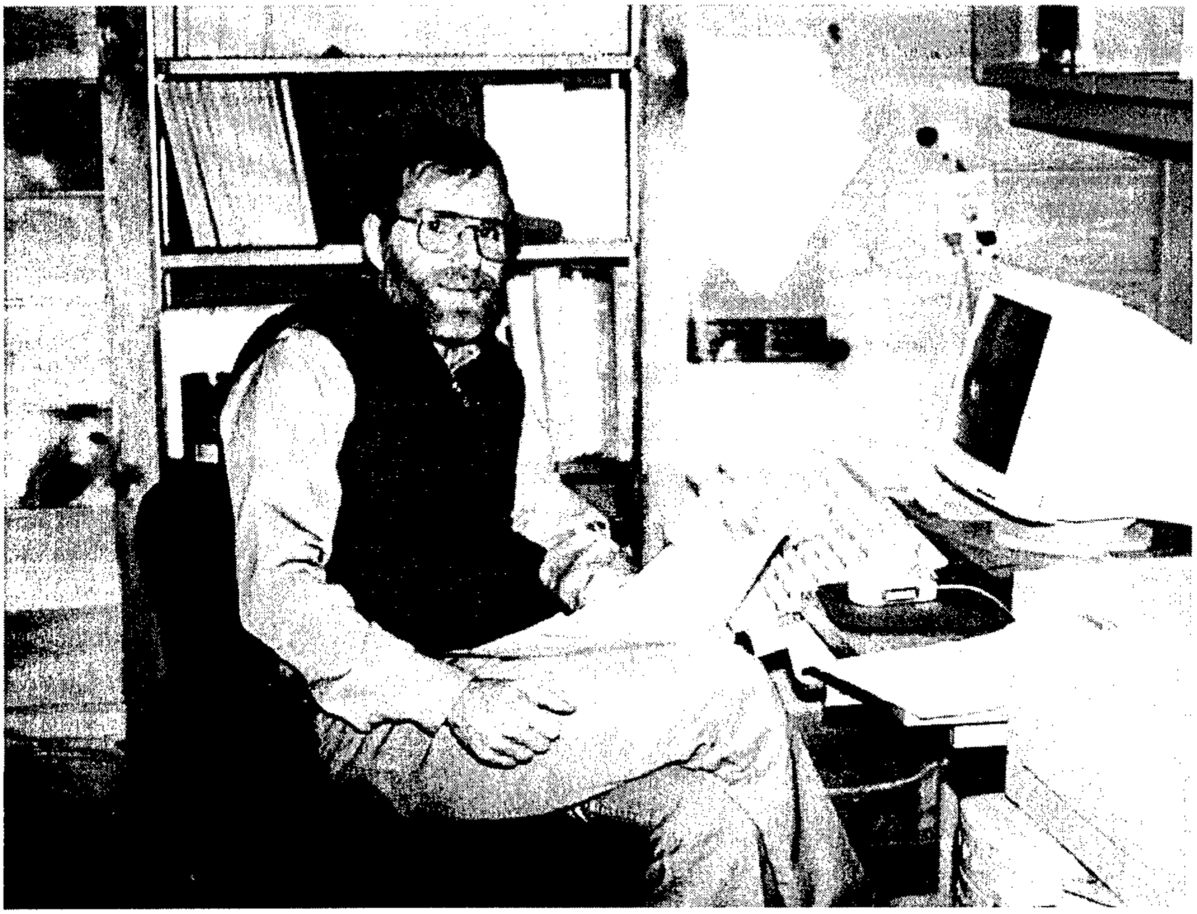
The Proceedings of the Ninth American American Woodcock Symposium is dedicated to Greg F. Sepik, whose untimely death on 28 May 1998 saddened friends and colleagues. At the time of his death, Greg was a Zone Biologist for Region 5 of the U.S. Fish and Wildlife Service and only 48 years old. He was stationed at Moosehorn National Wildlife Refuge (NWR), the only National Wildlife Refuge dedicated to research and management of the American Woodcock.

Greg was deeply involved in research and habitat management for woodcock during his entire career. His studies of woodcock at Moosehorn NWR began with graduate work in 1976 and continued professionally in 1979 when he was appointed refuge biologist at Moosehorn NWR. Eventually he was named the Woodcock Specialist for all of Region 5. Within the region he was a persistent advocate for managing some portion of each refuge for early successional habitat. Through his work on forest management at Moosehorn NWR, the refuge has become the premier showcase of how to manage habitat for woodcock and other early successional species. These management techniques were made available to the general public in 1981 with ***A Landowner's Guide to Woodcock Management in the Northeast***, of which Greg was the senior author.

Greg enjoyed working with people. He was always willing to talk to writers who were looking to do a story on woodcock or anyone just interested in the bird. Both graduate students and colleagues sought his advice on research. He always took the time to review their proposals and was quick to praise and encourage. Although he could dish out harsh criticism on a manuscript, he was always thoughtful and helpful with his critique. He was a competent research biologist with special insights into woodcock ecology who published the results of his work in scientific journals and symposia. The long-running symposia held on woodcock were a special time for Greg to challenge and inspire his colleagues. He contributed papers to the Proceedings of the sixth, seventh, eighth, and ninth symposia. He was a coeditor of the proceedings of the eighth woodcock symposium and this proceedings (ninth).

Greg was able to effectively communicate with the general public as well as professional resource managers. His easy going style, humor, and quick wit made him an effective speaker whether talking to sportsman's groups or at workshops for resource managers. Greg may have been most effective when he wrote his popular articles aimed at the general public. He was a regular contributor to the Ruffed Grouse Society (RGS) magazine, where his ***Woodcock's Way*** column was eagerly awaited by its readers. Paul Carson, RGS editor, said it well when he wrote "Greg talked and wrote about the woodcock in a way that captured the attention and gave life and immediacy to something that too often is rendered into graphs and statistical analyses. He knew....what should be done to help the woodcock, and he was able to effectively generate the interest necessary to change theory into actual habitat improvement gains."

The American woodcock lost a long-time advocate; those of us who continue to work with this fascinating bird have lost a dear friend and an irreplaceable colleague.



Greg Sepik at work in his office.

Contents

Preface

Symposia and workshops on the American Woodcock have been held periodically since 1966. The Ninth Woodcock Symposium was held January 26–28, 1997 in Baton Rouge, Louisiana. This was the second symposium held during the 1990s . These meetings bring together researchers, managers, and administrators to discuss and report current information on the ecology and management of this fine species. Papers presented at the Ninth Symposium ranged from philosophical and descriptive to highly technical and included several presentations by colleagues from Europe on *Scolopax rusticola.* Habitat use and factors affecting woodcock survival continue to be a research priority and this is reflected by the number of papers dealing with these issues. Continuing the precedent set by the Sixth Woodcock Symposium, manuscripts published in this proceedings went through a formal peer review process before being accepted.

Some very interesting things related to woodcock have developed since the publication of the Proceedings of the Eighth American Woodcock Symposium in 1993. The U.S. Fish and Wildlife Service, along with many state wildlife agencies, implemented the Harvest Information Program. This cooperative State–Federal program is designed to accomplish the goals of the migratory game bird stamp program called for by researchers back in the 1970s. It establishes a sampling base of migratory game bird hunters that will allow improved monitoring of the harvest of woodcock and other migratory game birds. In 1994 the Webless Migratory Game Bird Research Program was established to provide some much needed funding for research on woodcock and other nonwaterfowl migratory species; several of the studies reported in this symposium were supported, in part, by funding from this program. Finally, because of continuing declines in woodcock population indices, the Office of Migratory Bird Management of the U.S. Fish and Wildlife Service held a Woodcock Harvest Management Forum on January 29 following this symposium. This forum stimulated lively debate over appropriate hunting regulations for woodcock, and was the first in a series of discussions that resulted in harvest restrictions at the federal level in the fall of 1997.

The papers contained in this symposium enhance our knowledge of woodcock ecology and management. However, they also provide evidence that answers to some important questions continue to elude us. We hope these proceedings will help stimulate additional support for woodcock management and research among federal, state, and nongovernmental organizations, as well as individual citizens.

Many individuals, agencies and organizations contributed to the success of this symposium. The Steering Committee consisted of E. F. Bowers, J. G. Bruggink, D. R. Dessecker, F. G. Kimmel, D. G. Krementz, D. G. McAuley, M. W. Olinde and G. F. Sepik. The Program Committee consisted of R. A. Coon, D. G. Krementz and R. M. Whiting. The Conference Committee consisted of F. G. Kimmel and M. W. Olinde. Session moderators were J. G. Bruggink, R. A. Coon, D. G. Krementz, D. G. McAuley, and P. B. Wood.

The manuscript reviewers were J. G. Bruggink, J. B. Bortner, D. A. Clugston, R. A. Coon, D. R. Dessecker, L. Gregg, J. R. Kelley, W. L. Kendall, F. G. Kimmel, W. Krohn, D. G. Krementz, J. R. Longcore, D. G. McAuley, C. T. Moore, J. D. Nichols, M. W. Olinde, R. M. Pace III, D. L. Rabe, T. H. Roberts, W. L. Robinson, J. R. Sauer, G. F. Sepik, K. Sprankle, G. L. Storm, W. M. Vander Haegen, J. Wakeley, R. M. Whiting , P. B. Wood, and G. W. Wood.

The symposium was hosted and sponsored by the Louisiana Department of Wildlife and Fisheries. Other sponsors included Regions 3, 4, and 5 and the Office of Migratory Bird Management of the U.S. Fish and Wildlife Service, The Ruffed Grouse Society, The U.S. Forest Service, Kistachie National Forest, the Cajun Becasse Chapter of The Ruffed Grouse Society, and the Louisiana Chapter of The Wildlife Society.

Funding for publication of the proceedings was provided by the Louisiana Association of Professional Biologists, Region 4 of the U.S. Fish and Wildlife Service, The U.S. Forest Service, and the Ruffed Grouse Society.

Jerry Cox did the technical editing and formatting of the proceedings for publication. "Solitary Woodcock" by David A. Maass was provided courtesy of the artist and Wild Wings, Inc., Lake City, Minnesota 55041 (1-800-445-4833).

American Woodcock Management, Past, Present, and Future

by

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When Dan Dessecker asked if I would deliver this keynote address, I was both surprised and delighted. Surprised because there are so many talented wildlife biologists who have devoted all or a significant portion of their life's work to the American woodcock (*Scolopax minor*) who could perhaps jump start this symposium better than I. Delighted because it gives me the opportunity to interact with friends and colleagues with whom I do not have the chance to kibitz as often as I would like, and because I care deeply about the woodcock.

My interest stems from countless, glorious hours in woodcock coverts with my father, who worked over setters with considerable skill. Later I was exposed to great professionals such as Latham and Liscinsky when they were doing the scientific work that so piqued my interest. I am indebted to them all.

During my association with the Pennsylvania Game Commission, the Northeast Association of Fish and Wildlife Agencies, and in various capacities, the International Association of Fish and Wildlife Agencies, the plight and management of the American woodcock was never far from my mind. I believe, collectively, we were able to focus attention once again on this important natural resource in the late 1980s and 1990s.

In any event, I am indeed honored to be here among friends and professionals for whom I have the utmost respect and admiration. You will not get a long monologue in this presentation on past and present woodcock management in North America. Most of you, having been intimately involved with the subject for years, know more about it than I. What you will get is a clarion call for continued action on this important species. Although considerable work was accomplished between the publishing of Owen et al. (1977) and Straw et al. (1994), much remains to be done if we are to fulfill our professional and ethical responsibilities to this resource.

Even a cursory look at the literature on the American woodcock over the last 50 years indicates much solid scientific work has been initiated by a broad spectrum of wildlife biologists dedicated to improving management of the species. Yet, owing primarily to insufficient financial resources and, in some cases, a lack of persistence, we still do not have reliable estimates of population size, productivity, or harvest size and distribution. The scientists, for the most part, have given us a blueprint for managing the resource in the years ahead and, in the larger scheme of things, they have outlined a process that is affordable if accomplished in pre-determined increments. We must be certain, however, that we commit diligently to the task and hold wildlife managers accountable to the mandates and time frames.

As I view the challenge of woodcock management through the turn of the century, I concur with the recommendations outlined by Straw et al. (1994). In particular, I would emphasize the following:

1. The Migratory Shore and Upland Game Bird Committee of the International Association of Fish and Wildlife Agencies should pressure the U.S. Fish and Wildlife Service for comprehensive woodcock management. This committee should retain its full status and include acknowledged woodcock experts within its ranks.

2. The American Woodcock Management Plan, including the development and implementation of individual state and provincial management plans, should be implemented.

3. A vigorous marketing effort should be developed in each state to intensively manage and produce habitat on private land. Emphasis should be placed on economics and [on] recreational, ecosystem, and multiple species benefits. Land in key habitats (e.g., southern bottomland hardwoods) should be acquired as has been done on Cape May, New Jersey. This work should be augmented by taking full advantage of the Conservation Reserve Program and the Forest Stewardship Program.

4. There should be full implementation of the Migratory Bird Harvest Information Program. Target dates should not be allowed to slip. A suitable, consistent sampling framework must be established to accurately estimate national woodcock harvests.

5. Research needs must be addressed. Strong emphasis should be placed on remote sensing for habitat inventories and development of GIS [Geographic Information System] habitat models. We should insist that funding levels are increased to meet research needs. One hundred and fifty-thousand dollars from the U.S. Fish and Wildlife Service is a good start but it is inadequate. States must be willing to fund their share of research costs.

6. Managers should have the courage and will to adjust season length and bag limit frameworks when necessary. Until the implementation of the long-range plan, or if we should fail to meet our objectives, season lengths and bag limits are the only principal factors over which we have control.

It should continue to concern all of us that the long-term trends for woodcock hunting success in both the eastern and central regions are down. The long-term trend for woodcock heard on the Singing-ground Survey also is down in both regions. I realize that the data may be faulty, inadequate, or both, but they are all we have. We had better be prepared to get better data, or face dire consequences.

If it were up to the extraordinary individuals gathered here, there is not a doubt in my mind which path would be chosen. The proud tradition of your collective consciences will rise to the occasion once again to make certain that "old timberdoodle" survives and prospers.

In the final analysis, those outside these halls, yes, particularly politicians and high-level policy makers, will have perhaps more to say about the fate of *Scolopax minor* than you. Convincing them of the worthiness of the cause is our responsibility too, whether we like it or not. We can do it! We must do it!

References

Owen, R. B., Jr., J. M. Anderson, J. W. Artmann, E. R. Clark, T. G. Dilworth, L. E. Gregg, F. W. Martin, J. D. Newsom, and S. R. Pursglove, Jr. 1977. American woodcock (*Philohela minor* = *Scolopax minor* of Edwards 1974). Pages 149–186 *in* G. C. Sanderson, editor. Management of migratory shore and upland game birds in North America. International Association of Fish and Wildlife Agencies, Washington, D.C.

Straw, J. A., Jr., 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.

Current Population Status and Likely Future Trends For American Woodcock

by

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Abstract. Young forest habitats are declining throughout eastern North America, as are aspen communities (*Populus* spp.) in the Great Lakes Region. Declines in suitable habitats are a primary cause for declines in American woodcock (*Scolopax minor*) populations and those of various other wildlife species that require early-successional forest habitats. Habitat losses are exacerbated by societal attitudes largely not supportive of forest management. Demographic trends suggest that these negative attitudes toward active forest management will continue. Continued declines of American woodcock populations are likely unless the public better understands the role of forest management in the maintenance of components of biological diversity.

Keywords: Habitat, forest management, early-successional, societal attitudes.

Population Status

Data from the American woodcock (*Scolopax minor*) Singing-ground Survey (SGS) suggest that woodcock populations are declining across North America. Since 1968, woodcock populations in the Eastern and Central regions have declined by 2.5% and 1.7% per year, respectively (Bruggink 1997). Cumulative population declines for the period 1968–97 for the eastern and central regions are 52%, and 39%, respectively.

Habitat Status

Woodcock prefer habitats characterized by relatively high densities of woody stems (Bennett et al. 1982; Sepik and Dwyer 1982) such as recently regenerated forest stands. Although an imprecise index, inventory data that classify forest stands as seedling–sapling (size class) or <20 years old (age class) are available and can be used to identify gross trends in available woodcock habitat. In the northeastern United States, acreage of hardwood seedling–sapling stands has decreased by 26% during the past 2 decades (Frieswyk and Malley 1985a, 1985b; Dickson and McAfee 1988a, 1988b, 1988c; Alerich 1993; Alerich and Drake 1995; Griffith and Alerich 1996).

In the northern Great Lakes region, aspen forests provide important habitats for woodcock (Gregg 1984). Since the mid-1960s, the total area of aspen in Michigan, Minnesota, and Wisconsin has decreased by 21% (Stone 1966; Chase et al. 1970; Spencer and Thorne 1972; Spencer et al. 1988; Miles et al. 1995; Leatherberry and Spencer 1996).

Relation Between Habitat Trends and Woodcock Population Trends

Trends in the amount of seedling–sapling hardwood forest and trends of woodcock populations for most states within the primary breeding range of woodcock are negative (Table). However,

Table. Trends in forestland area classified as hardwood seedling–sapling and American woodcock populations in the northcentral and northeast United States.

State	Seedling–sapling trend (% change)	Interval	Population trend (% change)
Connecticut	-43	1972–1985	-76[a]
Maine	+34	1971–1995	-46
Massachusetts	-68	1972–1985	-58
Michigan	-20	1966–1993	-36
Minnesota	+23	1962–1990	-8
New Hampshire	-58	1973–1983	ns[b]
New York	-37	1980–1993	-26
Pennsylvania	-24	1965–1989	-72
Rhode Island	-80	1972–1985	ns
Vermont	-28	1973–1983	-32
Wisconsin	+3	1968–1996	-45

[a] Based on 1968–1997 population trend data (Bruggink 1997).

[b] ns = nonsignificant trend for interval or inadequate sample size to delineate trend.

correlation analysis of these data indicates no relation ($r = 0.45$, $P = 0.23$). Although seedling–sapling forests are declining throughout the woodcock's principal breeding range, Maine, Minnesota, and Wisconsin are exceptions to this general trend. The amount of seedling–sapling forest in these three states has increased, whereas data from the SGS indicate that their respective woodcock populations have decreased (Table). This lack of correlation between trends, potential woodcock habitat, and woodcock populations may be the result of one or a combination of factors such as the following:

- not all seedling–sapling forest is suitable woodcock habitat,
- SGS coverage may be incomplete or not representative of the surveyed landscape, and
- ongoing woodcock population declines may be independent of habitat availability.

Imprecise delineation of potential woodcock habitat may mask relations between habitat trends and woodcock population trends. Dwyer et al. (1983) found that in the northeastern United States, changes in three habitat types—urban–industrial, abandoned field, and alder—accounted for most of the variation in woodcock abundance as measured by the SGS. Habitat types associated with forest management activities (e.g., clearcut areas) were poorly represented in their sample, however, and not included in the analysis.

In Maine and Minnesota, substantial areas of forest have been regenerated through even–age silvicultural prescriptions in the past 10–15 years (Miles et al. 1995; Griffith and Alerich 1996). Much of this regeneration has occurred in areas where few roads existed when routes for the SGS were originally established in 1968. Timber harvest activities have accelerated in portions of northern New Hampshire and Vermont since the completion of the most recent forest inventory in 1983. Ongoing forest inventories will help to quantify the effects of these activities.

The North American Breeding Bird Survey (BBS) is a large-scale avian survey program that monitors the status and trends of more than 200 species of breeding birds throughout North America. Hagan et al. (1997) identified discrepancies between statewide trends in BBS data for Maine and estimated population trends for landbirds in a portion of northern Maine. They attributed these inconsistencies to poor BBS coverage in that portion of the state.

Godfrey (1975) stated that randomly selecting SGS routes each year might increase the accuracy of the survey. Straw et al. (1994) suggested that the distribution of existing routes be reviewed because of changes in the distribution of accessible roads since 1968. Periodic, partial or complete rerandomization of survey routes should be considered.

Status of Associated Wildlife Species

Askins (1993) used BBS data to document population trends (1966–91) for 16 shrubland specialist and 40 forest migrant birds in eastern North America. Askins defined shrubland specialists as "species that are primarily found in habitats with a dense shrub layer and little or no tree layer," and forest migrants as "species that primarily breed in closed canopy forest and spend the winter in the tropics." Of these 56 species, 6 shrubland specialists declined during the 25-year interval and 1 increased; 5 forest migrants declined and 10 increased. Likewise, Smith et al. (1993) found that in the eastern United States, 76% of the neotropical migrants experiencing significant population declines require early successional (grassland–shrubland) habitats. Further, Franzreb and Rosenberg (1997) analyzed BBS data (1966–94) by physiographic region and found that in the eastern United States an average of 27% of the forest birds, 46% of successional-shrub birds, and 70% of grassland birds were declining within each region.

The eastern towhee (*Pipilo erythrophthalmus*), a species commonly associated with recently disturbed forest stands, has declined 87% since 1966 when the BBS was initiated (Hagan 1993). The golden-winged warbler (*Vermivora chrysoptera*) exhibits habitat preferences similar to those of woodcock (i.e., shrub-dominated old fields and recently regenerated forest stands). The golden-winged warbler is declining throughout the eastern United States and is ranked as a high priority species on Partners in Flight draft prioritization lists for physiographic regions 16 and 20.

The geographic range of the New England cottontail (*Sylvilagus transitionalis*) has been reduced substantially as a result of maturing deciduous forests of the northeastern United States (Litvaitis and Villafuerte 1996). In 1989, this species was listed as a candidate for federal threatened or endangered status. These data do not suggest that species dependent upon early successional habitats warrant greater management attention than other species assemblages in the eastern United States. However, the continuing declines of many early successional species cannot be ignored.

Trends in Forest Disturbance

Historically, fire was the principal agent of forest disturbance throughout much of eastern North America (Little 1974; Heinselman 1981). Today, fires have been largely precluded from the landscape and commercial timber harvest has become the principal agent of forest disturbance. Unfortunately, commercial timber harvest is viewed by many within the general public as "a problem," rather than "a solution." This type of anti-management sentiment is partly the result of changing societal demographics. According to 1960 and 1990 census data, 63% of the United States population lived in what are termed "metropolitan" areas in 1960, and 80% lived there in 1990 (U.S. Department of Commerce 1998). Because of decreased interaction with, and a lack of understanding of natural systems, the general public may be increasingly unwilling to support habitat management activities (i.e., timber harvest operations) that are perceived as "destructive." Leopold (1949) recognized this phenomenon when he wrote "There are two spiritual dangers in not owning a farm. One is the danger of supposing that breakfast comes from the grocery, and the other that heat comes from the furnace."

Only 20% of the timberland within the principal breeding range of woodcock in the United States is in public ownership (Powell et al. 1993). Public land management agencies have responded to public concerns over active forest management by proposing significant reductions in levels of timber harvest and in the prescription of clearcut regeneration treatments (U.S. Forest Service 1995). Approximately 70% of the timberland within the principal breeding range of woodcock in the United States is in nonindustrial private (NIPF) ownership. Birch (1996) reported that privately owned forest tracts less than 40.0 ha in size increased from 12.3 million ha (26.7% of private forestland) in 1978, to 22.9 million ha (43.6% of private forestland) in 1994. As the size of NIPF tracts decrease, so does the likelihood of active forest management (Birch 1986; Roberts et al. 1986).

To provide habitat for many species of early successional wildlife, timber harvest should remove enough basal area from a stand to allow development of an understory. Timber harvest treatments commonly used in the eastern United States leave residual basal areas that exceed the levels necessary to allow development of quality understory habitat. During the interval between the two most recent forest inventories (early 1970s–mid-1980s), more than 60% of the basal area was removed from only 4% of the forest stands in West Virginia and from 8% of the stands in New England (Gansner et al. 1990; Birch et al. 1992). On most sites removal of only 60% of the basal area is not adequate to establish quality early successional habitat.

In Maine, data suggest that at least 80% of stand basal area has been removed from 13% of the timberland (1982–95; Thomas W. Birch, U.S. Forest Service, Northeast Forest Experiment Station, unpublished data). However, because the forest products industry owns 47% of Maine's timberland, harvest trends are not comparable to other states in the northeast.

As deciduous forests in the east continue to mature, they will increase in volume and in value. This could lead to increased harvest activity and, therefore, increased acreage of early successional forest habitats. However, because NIPF owners control most of the forestland in the east and these owners typically do not consider economic benefit from the sale of forest products as an important reason for forest ownership (Birch 1986; Carpenter et al. 1986; Roberts et al. 1986), timber harvesting may not increase from current levels on these lands.

Conclusions

American woodcock populations are declining throughout much of North America. These declines likely result from habitat loss. Negative societal attitudes towards active forest management must be altered if the long-term habitat needs of disturbance-dependent forest wildlife are to be met.

References

Alerich, C. L. 1993. Forest statistics for Pennsylvania–1978 and 1989. USDA Forest Service Resource Bulletin NE-126. Radnor, Pennsylvania. 246 pp.

Alerich, C. L., and D. A. Drake. 1995. Forest statistics for New York–1980 and 1993. USDA Forest Service Resource Bulletin NE-132. Radnor, Pennsylvania 255 pp.

Askins, R. A. 1993. Population trends in grassland, shrubland, and forest birds in eastern North America. Pages 1–34 *in* D. M. Power, editor. Current Ornithology, Volume 11. Plenum Press, New York.

Bennett, C. L., Jr., D. L. Rabe, and H. H. Prince. 1982. Response of several game species, with emphasis on woodcock, to extensive habitat manipulations. Pages 97–105 *in* T. J. Dwyer and G. L. Storm, technical coordinators. Woodcock ecology and management. U.S. Fish and Wildlife Service Wildlife Research Report 14. Washington, D.C.

Birch, T. W. 1986. Forest-land owners of Maine–1982. USDA Forest Service Resource Bulletin NE-90. Broomall, Pennsylvania. 83 pp.

Birch, T. W. 1996. Private forest-land owners of the northern United States–1994. USDA Forest Resource Bulletin NE-136. Radnor, Pennsylvania. 293 pp.

Birch, T. W., D. A. Gansner, S. L. Arner, and R. H. Widmann. 1992. Cutting activity on West Virginia timberlands. Northern Journal Applied Forestry 9:118–120.

Bruggink, J. G. 1997. American woodcock harvest and breeding population status, 1997. U.S. Fish and Wildlife Service. Laurel, Maryland. 14 pp.

Carpenter, E. M., M. H. Hansen, and D. M. St. John. 1986. The private forest landowners of Minnesota–1982. USDA Forest Service

Resource Bulletin NC-95. St. Paul, Minnesota. 55 pp.

Chase, C. D., R. E. Pfeifer, and J. S. Spencer, Jr. 1970. The growing timber resource of Michigan 1966. USDA Forest Service Resource Bulletin NC-9. St. Paul, Minnesota. 62 pp.

Dickson, D. R., and C. L. McAfee. 1988a. Forest statistics for Rhode Island–1972 and 1985. USDA Forest Service Resource Bulletin NE-104. Broomal, Pennsylvania. 96 pp.

Dickson, D. R., and C. L. McAfee. 1988b. Forest statistics for Massachusetts–1972 and 1985. USDA Forest Service Resource Bulletin NE-106. Broomal, Pennsylvania. 111 pp.

Dickson, D. R., and C. L. McAfee. 1988c. Forest statistics for Connecticut–1972 and 1985. USDA Forest Service Resource Bulletin NE-105. Broomal, Pennsylvania. 102 pp.

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.

Franzreb, K. E., and K. V. Rosenberg. 1997. Are forest songbirds declining? Status assessment from the southern Appalachians and northeastern forests. Transactions of the North American Wildlife and Natural Resources Conference 62:264–279.

Frieswyk, T. S., and A. M. Malley. 1985a. Forest statistics for New Hampshire–1973 and 1983. USDA Forest Service Resource Bulletin NE-88. Broomal, Pennsylvania. 100 pp.

Frieswyk, T. S., and A. M. Malley 1985b. Forest statistics for Vermont–1973 and 1983. USDA Forest Service Resource Bulletin NE-87. Broomal, Pennsylvania. 102 pp.

Gansner, D. A., T. W. Birch, S. L. Arner, and S. J. Zarnoch. 1990. Cutting disturbance on New England timberlands. Northern Journal of Applied Forestry 7:118–120.

Godfrey, G. A. 1975. A needed revision in the concept of surveying American woodcock populations. Biologist 57(3):89–103.

Gregg, L. 1984. Population ecology of woodcock in Wisconsin. Wisconsin Department of Natural Resources, Natural Resource Technical Bulletin 144. Madison, Wisconsin. 51 pp.

Griffith, D. M., and C. L. Alerich. 1996. Forest statistics for Maine–1995. USDA Forest Service Resource Bulletin NE-135. Radnor, Pennsylvania. 134 pp.

Hagan, J. M. 1993. Declines of the rufous-sided towhee in the eastern United States. Auk 110:863–874.

Hagan, J. M., P. S. McKinley, A. L. Meehan, and S. L. Grove. 1997. Diversity and abundance of landbirds in a northeastern industrial forest. Journal of Wildlife Management 61:718–735.

Heinselman, M. L. 1981. Fire intensity and frequency as factors in the distribution and structure of northern ecosystems. Pages 7–57 *in* H. A. Mooney, T. M. Bonnicksen, N. L. Christensen, J. E. Lotan and W. A. Reiners, editors. Fire regimes and ecosystem properties. USDA Forest Service General Technical Report WO-26. Washington, D.C.

Leatherberry, E. C., and J. S. Spencer, Jr. 1996. Michigan forest statistics–1993. USDA Forest Service Resource Bulletin NC-170. St. Paul, Minnesota. 144 pp

Leopold, A. 1949. A sand county almanac. Oxford University Press, London. 226 pp.

Little, S. 1974. Effects of fires on temperate forests: northeastern United States. Pages 225–250 *in* T. T. Kozlowski and E. E. Ahlgren, editors. Fire and Ecosystems. Academic Press, New York.

Litvaitis, J. A., and R. Villafuerte. 1996. Factors affecting the persistence of New England cottontail metapopulations: the role of habitat management. Wildlife Society Bulletin 24:686–693.

Miles, P. D., C. M. Chen, and E. C. Leatherberry. 1995. Minnesota forest statistics, 1990, revised. USDA Forest Service Resource Bulletin NC-158. St. Paul, Minnesota. 138 pp.

Powell, D. S., J. L. Faulkner, D. R. Darr, Z. Zhu, and D. W. MacCleery 1993. Forest resources of the United States–1992. USDA Forest Service General Technical Report RM-234. Fort Collins, Colorado. 132 pp.

Roberts, J. C., W. G. Tlusty, and H. C. Jordahl, Jr. 1986. The Wisconsin private non-industrial woodland owner: a profile. University of Wisconsin Cooperative Extension Service. Madison. 292 pp.

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. Woodcock ecology and management. U.S. Fish and Wildlife Service Wildlife Research Report 14. Washington, D.C.

Smith, C. R., D. M. Pence, and R. J. O'Connor. 1993. Status of neotropical migratory birds in the northeast: a preliminary assessment. Pages 172–188 *in* D.M. Finch and P.W. Stangel, editors. Status and management of neotropical migratory birds. USDA Forest Service General Technical Report RM-229. Fort Collins, Colorado. 422 pp.

Spencer, J. S. Jr., and H. W. Thorne. 1972. Wisconsin's 1968 timber resource– a perspective. USDA Forest Service Resource Bulletin NC-15. St. Paul, Minnesota. 80 pp.

Spencer, J. S., Jr., W. B. Smith, J. T. Hahn, and G. K. Raile. 1988. Wisconsin's fourth forest inventory–1983. USDA Forest Service Resource Bulletin NC-107. 158 pp.

Stone, R. N. 1966. A third look at Minnesota's timber. USDA Forest Service Resource Bulletin NC-1. St. Paul, Minnesota. 64 pp.

Straw, J. A., Jr., 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. Allen Press, Lawrence, Kansas.

U.S. Department of Commerce. 1998. Statistical Abstracts of the United States 1998. Bernan Press, Washington, DC. 1020 pp.

U.S. Forest Service. 1995. The Forest Service program for forest and rangeland resources: a long-term strategic plan. USDA Forest Service. Washington, D.C.

American Woodcock Use of Reclaimed Surface Mines in West Virginia

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Abstract. Twenty-nine West Virginia reclaimed mines of different ages and reclamation types were surveyed for singing and diurnal use by American woodcock (*Scolopax minor*). Six sites received both singing and diurnal use, five received diurnal use only, and four received singing use only. Singing use was more common on younger (<25 years old) or more open, mixed-age sites. Woodcock selected singing grounds open at ground level, with scattered woody plants ($\chi^2 = 28.32$, $P < 0.0001$), but selection was not strong ($R^2 = 0.25$). Singing male densities ($\bar{x} = 1.29$ males/100 ha, SE = 0.39) were lower than in other studies, but this likely reflects a surplus of suitable courtship habitat rather than low quality of courtship habitat. Diurnal use was concentrated on older (>25 years old) or mixed-age sites. Canopy cover averaged between 50 and 60% at flush points. Stem densities ($\bar{x} = 4{,}249$ stems/ha, SE = 745) were low and soil conditions and earthworm availability generally poor compared to those in unmined habitats. Flush rates ($\bar{x} = 1.04$ flushes/h, SE = 0.34) were comparable to those in other studies. Reclaimed sites may be the best available habitat in much of West Virginia but probably are not high-quality diurnal habitat. Newer reclaimed sites were characterized by better soil conditions and may provide higher quality woodcock habitat as succession produces the vegetation structure typical of older sites. Management activities that enhance development of suitable woody cover on such sites would improve habitat. Future research should compare the population dynamics of woodcock using reclaimed mines and unmined areas to assess the habitat quality of reclaimed sites. If habitat quality is acceptable, the early successional areas provided by widespread mining in West Virginia and other eastern states may be beneficial to woodcock, and offer opportunities for counteracting the widespread losses of other types of woodcock habitat by targeting reclamation to the needs of this species.

Keywords: American woodcock, habitat, reclamation, *Scolopax minor*, singing grounds, surface mining, West Virginia

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Loss of habitat has been cited as the major factor in the long-term decline of woodcock populations (Dwyer et al. 1983; Straw et al. 1994; Bruggink 1996). Human development is a major cause of woodcock habitat loss; however, activities such as timber harvesting and farm abandonment produce early successional stages suitable for woodcock. The U.S. Fish and Wildlife Service (1990) identified creation of new habitat as a research and management priority.

Historically, suitable habitat for woodcock was limited in West Virginia because of the mountainous terrain. Fenwood and Webb (1981), using aerial photos from 1959–1974, identified only 17,332 ha of suitable woodcock habitat. Since then, development and succession have reduced that amount. Thus, creation of woodcock habitat is a challenge for resource managers in West Virginia. Even-age timber harvest is the most common prescription for creating early successional habitat suitable for woodcock (U.S. Fish and Wildlife Service 1990); however, surface mine reclamation also creates early successional stages. About 100,000 ha of West Virginia has been mined in this century and about 2,000 ha is reclaimed annually (J. G. Skousen, West Virginia University, personal communication). Reclaimed mines are used by wild turkeys (*Meleagris gallopavo*; Anderson and Samuel 1980), ruffed grouse (*Bonasa umbellus*; Kimmel and Samuel 1978), and mourning doves (*Zenaida macroura*; Feierabend 1983), but little attention has been given to use by woodcock. Brenner et al. (1997) evaluated two scrub–shrub palustrine wetlands and an upland community on 10–12-year-old reclaimed mines in northwestern Pennsylvania and found that the reclaimed sites had higher woodcock use (in conjunction with higher stem densities and earthworm biomass) than a nearby natural shrub wetland. They concluded that reclaimed mines had promise as breeding and migration habitat for woodcock.

Our objectives were to quantify use of reclaimed surface mines in West Virginia by resident woodcock, measure habitat variables at point and site levels to identify important factors for predicting woodcock use, and develop recommendations regarding reclamation and management of surface mines as woodcock habitat.

Study Areas and Methods

We selected 29 sites in Monongalia ($n = 6$), Preston ($n = 3$), Grant ($n = 6$), Tucker ($n = 5$), Randolph ($n = 3$), and Greenbrier ($n = 6$) Counties, West Virginia. Eleven sites were selected as potential woodcock habitat based on suggestions by biologists and hunters. The remaining sites were chosen to provide a representative sample of ages (years since reclamation) and reclamation types. Sites were from 9 to 148 ha (*O* = 53 ha, SE = 8), with most between 40 and 80 ha. Time since reclamation ranged from 1 to 50 years (*O* = 17 yr, SE = 1). The Monongalia County sites were located in the Allegheny Plateau Section, with the rest of the sites in the Allegheny Mountain Section. Climate and topography of these sections were described by Strasbaugh and Core (1970).

We grouped sites into four categories (before 1971, 1971–77, after 1977, and mixed) based on when mining occurred. Coal companies, landowners, or the West Virginia Department of Environmental Protection provided the approximate year that mining or reclamation occurred.

Sites mined before 1971 ($n = 7$) received minimal or no reclamation, usually had steep highwalls and rolling spoil banks, and had low-pH soils made up mainly of coarse fragments. Vegetative cover was uneven and variable, but generally similar to surrounding vegetation. Species such as black birch (*Betula lenta*), red maple (*Acer rubrum*), black cherry (*Prunus serotina*), bigtooth aspen (*Populus grandidentata*), blackberry (*Rubus* sp.), and goldenrods (*Solidago* spp.) were common. At some sites planted black locust (*Robinia pseudoacacia*) and pines (*Pinus* spp.) were still present.

In 1971, West Virginia law required backfilling and regrading of sites, so highwalls, benches, and spoil banks were not present on 1971–77 sites ($n = 4$). Common plantings included tall fescue (*Festuca arundinacea*), black locust, and autumn olive (*Eleagnus umbellata*). Most of these sites also contained patches of poor soil where revegetation was ineffective. These areas remained barren or were colonized in patterns similar to pre-1971 sites.

In 1977, the federal Surface Mining Control and Reclamation Act (SMCRA) tightened reclamation requirements. Post-1977 sites ($n = 14$) were recontoured, and topsoil was replaced. Grasses and forbs were planted on these sites, with tall fescue, orchard grass *(Dactylis glomerata)*, redtop (*Agrostis gigantea*), birdsfoot trefoil (*Lotus comiculatus*), and red clover (*Trifolium pratense*) especially common. Black locust, autumn olive, pines, and black alder (*Alnus glutinosa*) also were planted on some sites. Mixed-age sites ($n = 4$) contained adjacent or interspersed pre-1971 and post-1977 reclamation resulting from separate mining operations.

We recorded woodcock use of singing grounds and summer diurnal cover. In 1995, we conducted singing ground surveys on five sites between 19 and 29 May. In 1996, we conducted surveys during the 15 April–5 May time period recommended for West Virginia Singing-ground Survey routes. When conducting surveys, we assumed a 320-m detection distance (Duke 1966) and followed a route that allowed total coverage of the site by the observer(s) during the 30-minute crepuscular period. We recorded all males seen or heard displaying on the site; the singing ground was located and flagged when possible. To compare numbers of singing males between sites, we calculated a standardized density of singing males by dividing the number of males by the size of the site (ha) and multiplying by 100.

To index diurnal use of habitat, we used a trained pointing dog to conduct systematic flush counts on 19 sites during August 1995, and on all 29 sites once each during June and August 1996. All woodcock flushed were recorded. We marked the point of flush if it could be located visually or by the presence of a dropping. To compare levels of diurnal use between sites, we calculated flushes-per-hour search time. Because sites differed considerably in density and structure of vegetative cover, the amount of area a dog could search per hour varied among sites. So that flush rates would be comparable between sites, the area (ha) searched per hour was calculated for each site and the percent deviation from the overall average computed. We adjusted the flush rate for a site upward (for sites with less area searched per hour than average) or downward (for sites with more area searched per hour than average) by the same percentage as that site's deviation from the average. We compared June and August flush rates using a Wilcoxon rank-sum test (SAS Institute 1989) to determine if differences existed between the two periods.

We collected habitat data at the point level and the site level. To compare habitat features between points used by woodcock and random points, we compared point-level (microhabitat) data for singing ground and flush points to random points. For each site, we calculated the number of points needed to produce at least one random point per eight hectares (minimum of five points per site). We delineated strata homogeneous in slope, aspect, and presence and density of woody cover and measured size with a dot grid on aerial photos (1:7,920). We randomly allocated sample points proportionately among strata (Noon 1981).

We measured vegetation on 0.04-ha circular plots during June through August 1995 and 1996. In each plot, we measured the diameter at breast height (dbh) of 5–6 stems closest to the center point and assigned 1 of 4 overstory size classes (after a habitat suitability index [HSI] model for the American woodcock [from an anonymous and unpublished manuscript]): class 1 had no overstory, class 2 had widely scattered saplings with average dbh less than 15 cm, class 3 had more than 25% cover of saplings with average dbh less than 15 cm, and class 4 had pole-sized timber 15–25 cm dbh. No stems larger than 25 cm dbh were present on the plots. Using methods similar to James and Shugart (1970), we also measured density of all woody stems at breast-height, percent canopy cover at 0–1, 1–3, 3–6, and 6–9 m, percent herbaceous cover, average herbaceous height, and percent litter cover.

Concurrently with vegetation measurements, we collected soil samples from the top 10 cm (the approximate depth that would be available to a probing woodcock; Sepik et al. 1981) using a trowel and a 2-cm diameter soil corer. Samples were air-dried and sieved to remove fragments greater than 2 mm. We determined soil pH with a Fisher Accumet 915 pH meter on a 1:1 soil:water paste (Sobek et al. 1978). Percent organic matter was determined from loss-on-ignition at 550° C (Blume et al. 1990). To determine the amount of available water in the soil, we calculated water retention difference (Soil Survey Staff 1984). A higher water retention difference reflects a larger amount of available water. Also, we assigned a qualitative compaction rating of 1–5 in the field based on the amount of effort required to penetrate the soil with a 0.6-cm diameter tent stake, with 1 being the least compacted (almost no effort required) and 5 the most compacted (nearly impossible to penetrate).

During September and October 1996, we collected earthworm samples from each point by hand-sorting a block of soil 0.5 m x 0.5 m x 0.1 m deep (Baker and Lee 1993). Worms were dried at 105° C for 48 hours and weighed.

We calculated site level values for the vegetation and soil parameters as the average of point-level values for the site. The age of each site was determined by when mining occurred (>15 yrs old = pre-1971; 19–15 yrs old = 1971–77; < 18 yrs old = post-1977; mixed). Size of each site was measured with a dot grid on 1988–92 aerial photographs (1:7,920). On aerial photographs, we also identified unmined areas with features typical of woodcock habitat and measured the distance from the nearest such area to the perimeter of each mine site. We traced each mine site and a 1-km buffer onto a transparency and determined the percentage of the buffer area comprised of unmined woodcock habitat using a dot grid. We measured the distance between the perimeter of the site and the edge of the nearest body of permanent water from topographic maps.

We used JMP software (SAS Institute 1989) for statistical analyses. On sites with use by singing males, we compared point-level variables between singing grounds and random points, and on sites with diurnal use we compared flush points to random points using Wilcoxon rank-sum tests. Singing ground versus random point comparisons included all soil variables, overstory size class, stems per hectare, and percent litter cover but excluded canopy cover, herbaceous cover, and herbaceous height because these variables probably changed between the time males selected singing grounds and the time we collected data. Comparisons of flush points to random points included all vegetation and soil variables, and we only used random points from sites with woodcock use. To ensure that variables potentially useful for predicting woodcock presence were not left out of further analyses, we initially retained all variables differing at $P \leq 0.25$. We computed Pearson product-moment correlations between each pair of independent variables, with pairs having correlation $|r| \geq 0.40$ and $P \leq 0.0001$ considered highly correlated. All possible sets of potentially important variables containing no highly correlated pairs were then identified. We used logistic regression to select the best set of variables for differentiating point types. Each set of variables was specified as a logistic regression model, with the threshold level for classifying points as used or random set at 0.5. The model resulting in the highest R^2 was considered the best predictor, and was used to classify the points from the original data set to test its effectiveness in discriminating between point types. To examine the possibility that different factors influenced use on the older, generally unreclaimed sites, we tested for significant differences between flush and random points 19 years old or older (pre-SMCRA) with a Wilcoxon rank-sum test. We also compared habitat at the point level between different ages of reclamation using Wilcoxon rank-sum tests.

At the site level, we used logistic regression analyses as described for point-level data. We compared singing male density and flush rate with each habitat variable using Pearson product-moment correlation. Correlations of $P \leq 0.25$ were considered potentially important. Pairs of independent variables with $|r| \geq 0.40$ and $P \leq 0.0001$ were considered highly correlated. All possible sets of potentially important variables that contained no highly correlated pairs were then identified. We used stepwise multiple regression (probability to enter set at 0.25 and probability to leave at 0.10) to develop a reduced model for each set. The reduced model with the highest adjusted R^2 (balancing predictive power with the number of variables) was selected as the best set of predictors of use. We also compared average densities of singing males, flush rates, and habitat parameters between the four reclamation ages using Wilcoxon rank-sum tests.

Results

Singing Use

Singing males (*n* = 28) were present on 10 of the 29 sites, including 7 of the 18 randomly selected sites, in 1995–96. Densities of singing males ranged from 0.7 to 6.4/100 ha on used sites. Densities were 1.1 males/100 ha (SE = 0.5) on sites less than 18 years old, 2.2 males/100 ha (SE = 1.3) on sites 19–25 years old, and 3.2 males/100 ha (SE = 1.5) on mixed-age sites. No singing males were found on sites greater than 25 years old. Only mixed sites and sites greater than 25 years old differed in singing male density (Z = 2.40, $P = 0.02$). There were no correlations between habitat characteristics and singing male density.

On sites with singing use the 22 points identified as singing grounds had less litter cover and lower soil pH ($P \leq 0.05$) than the 96 random points (Table 1). Stems per hectare, age of reclamation, soil compaction, and earthworm biomass were retained as potentially important. The best logistic regression model ($\chi^2 = 28.32$, $P \leq 0.0001$, $R^2 = 0.25$) was (variables in decreasing order of importance)

> point type (singing or random) = 6.921 - (0.037) (percent litter cover) - (0.653) (compaction) - (0.001) (stems/ha) - (0.482) (soil pH) - (0.038) (earthworm biomass).

The model correctly classified 101 of 118 (86%) observations. The model classified 11 points as singing grounds, 8 correctly. It incorrectly classified 14 singing grounds as random points.

At the site level, sites used by singing males were larger and had higher earthworm biomass than sites without singing males (Table 2). Average percent organic matter was retained as potentially important for predictive models. Only one logistic regression model was tested ($\chi^2 = 10.57$, $P = 0.01$, $R^2 = 0.28$).

> use by singing males (yes or no) = 7.443 - (0.029) (size) - (0.387) (average percent organic matter) - (0.210) (average earthworm biomass)

This model correctly classified 25 of 29 sites (86%). The model classified eight sites as having singing use, seven of which were used. One site was classified as used but was not used, and three sites classified as unused were used.

Diurnal Use

We flushed 35 woodcock during 1995–96 on 11 of the 29 sites, including 4 of the 18 randomly selected mines. In spring, singing males were detected on 6 of these 11 diurnal use sites. Flush rates did not differ (Z = -0.42, $P = 0.67$) between June (*0* = 1.1 flushes/h, SE = 0.4) and August (*0* = 1.1 flushes/h, SE = 0.8). Thus, data from both

Table 1. Characteristics of American woodcock singing grounds (*n* = 22) and random points (*n* = 96) on 10 reclaimed surface mines used by singing males in West Virginia, 1995–1996.

	Singing ground points			**Random points**				
Variable	***0***	**SE**	**Range**	***0***	**SE**	**Range**	***z***	***P*-value**[a]
Percent litter cover[b, c]	65.9	5.0	13–95	83.3	1.6	24–100	-3.36	0.0008
Stems per hectare[b, c]	257	79	0–1,130	904	149	0–7,458	-1.29	0.1976
Water retention difference (cm/cm)	0.16	0.01	0.06–0.26	0.17	0.01	0.001–0.36	-0.34	0.7323
Soil pH[b, c]	5.25	0.25	3.54–7.17	5.89	0.11	3.50–7.75	-2.32	0.0204
Soil organic matter-percent	11.6	1.0	6.8–26.0	11.7	0.4	5.8–32.2	-0.67	0.5004
Age since reclamation (yr)[b]	11.2	1.3	1–20	14.9	1.0	1–45	-1.48	0.1378
Earthworm biomass (g/m^2)[b, c]	2.86	1.20	0–24.61	3.80	0.48	0–25.44	-1.63	0.1040
Soil compaction (1 = least, 5 = most)[b, c]	3.2	0.2	1–5	3.6	0.1	1–5	-1.95	0.0506

[a] Wilcoxon rank-sum test, normal approximation; significant difference at $P \leq 0.05$ between singing grounds and random points

[b] Entered in testing of logistic regression models

[c] Included in best logistic regression model

Table 2. Characteristics of reclaimed mine sites used (n = 10) and unused (n = 19) by American woodcock singing males in West Virginia, 1995–1996.

	Singing use sites			Unused sites				
Variable	*0*	**SE**	**Range**	*0*	**SE**	**Range**	*z*	***P*-value**[a]
Average percent litter cover	80.8	2.3	70–94	81.9	1.2	74–94	-0.51	0.6126
Stems per hectare	1,187	333	34–3,541	1,521	264	0–4,294	-0.87	0.3833
Average water retention difference (cm/cm)	0.16	0.01	0.08–0.23	0.15	0.01	0.08–0.21	0.73	0.4628
Average soil pH	5.68	0.19	4.85–6.58	5.37	0.21	3.93–6.68	0.99	0.3239
Average soil organic matter percent[b,c]	12.5	1.0	10.0–18.4	11.2	0.6	7.9–17.2	1.17	0.2418
Average soil compaction (rank: 1 = least, 5 = most)	3.4	0.1	2.5–4.1	3.4	0.1	2.5–4.3	-0.21	0.8356
Average earthworm biomass (g/m^2)[b,c]	3.32	0.62	0.35–6.20	1.95	0.73	0–12.48	2.34	0.0193
Size (ha)[b,c]	77.2	15.3	20–148	39.6	8.1	9–142	2.27	0.0231
Distance to unmined habitat (km)	0.23	0.06	0.01–0.53	0.63	0.27	0.01–5.37	-1.13	0.2598
Percent unmined habitat within 1 km	3.6	1.0	0.3–10	3.0	0.8	0–14	0.69	0.4902
Distance to water (km)	0.40	0.08	0.05–0.83	0.34	0.08	0.02–1.12	0.80	0.4213

[a] Wilcoxon rank-sum test, normal approximation; significant difference at $P \leq 0.05$ between singing-use and non-singing-use sites
[b] Entered in testing of logistic regression models
[c] Included in best logistic regression model

periods were combined for each site. Diurnal use differed only between mixed-age sites and sites less than 18 years old ($Z = 2.28$, $P = 0.02$). The mean number of woodcock flushes per hour were 2.6 (SE = 1.4) at mixed sites, 2.5 (SE =1.5) at sites greater than 25 years old, 0.2 (SE = 0.1) at 19–25-year-old sites, and 0.1 (SE = 0.1) at sites less than 18 years old.

The 25 points from which we flushed woodcock had more stems per hectare, larger overstory size class, and correspondingly higher percentages of canopy cover in the 1–3 m, 3–6 m, and 6–9 m categories than the 88 random points on sites with diurnal use (Table 3). Herbaceous cover, canopy cover at 0–1 m, and soil compaction were lower at flush points; organic matter and age of reclamation

Table 3. Characteristics of American woodcock flush points (n = 25) and random points (n = 88) on 11 reclaimed surface mines with woodcock diurnal use in West Virginia, 1995–1996.

	Flush points			Random points				
Variable	*0*	**SE**	**Range**	*0*	**SE**	**Range**	*z*	***P*-value**[a]
0–1 m percent canopy[b,c]	76.4	3.7	38–100	84.5	1.7	33–100	-2.11	0.0346
1–3 m percent canopy[b,c]	53.5	3.1	29–81	25.4	2.5	0–100	5.12	< 0.0001
3–6 m percent canopy[b]	52.4	4.7	5–86	22.3	3.1	0–100	4.70	< 0.0001
6–9 m percent canopy[b]	26.7	5.1	0–81	11.8	2.2	0–81	3.70	0.0002
Percent herbaceous cover[b]	68.5	4.4	24–100	80.6	2.0	10–100	-2.54	0.0112
Average herbaceous height (cm)	41.6	3.0	18.2–76.0	43.2	1.7	7.8–90.0	-0.68	0.4935
Percent litter cover	82.0	3.1	26–100	81.5	1.9	24–100	-0.24	0.8133
Stems per hectare[b]	4,249	745	678–19,888	1,556	193	0–8,588	4.95	< 0.0001
Water retention difference (cm/cm)	0.13	0.01	0.001–0.27	0.14	0.01	0.001–0.30	-1.03	0.3027
Soil pH[b]	4.80	0.10	3.74–5.44	5.24	0.11	3.48–7.75	-1.64	0.1004
Soil organic matter percent[b]	15.5	1.6	7.9–43.2	12.0	0.5	5.8–32.2	2.52	0.0118
Age of reclamation (yr)[b,c]	24.9	2.0	10–45	20.1	1.0	1–45	2.01	0.0440
Earthworm biomass (g/m^2)[b,c]	1.62	0.38	0–6.78	2.12	0.44	0–25.44	1.80	0.0718
Soil compaction (1 = least, 5 = most)[b,c]	2.8	0.2	1–4	3.4	0.1	1–5	-2.69	0.0072

[a] Wilcoxon rank-sum test, normal approximation; significant difference at $P \leq 0.05$ between flush points and random points
[b] Entered in testing of logistic regression models
[c] Included in best logistic regression model

were higher at flush points. Soil pH and earthworm biomass also were retained for logistic regression analyses. We tested 12 logistic regression models; the best ($\chi^2 = 39.56$, $P < 0.0001$, $R^2 = 0.33$) was

point type (flush or random) = 0.333 + (0.066) (1–3 m percent canopy) - (1.079) (compaction) + (0.156) (earthworm biomass) - (0.022) (0–1 m percent canopy) + (0.021) (age).

This model correctly classified 93 of 113 (82%) observations. The model classified 19 points as flush points, 12 correctly. It incorrectly classified 13 flush points as random points.

When only points on sites 19 years or older were considered, vegetation characteristics were similar to analyses using all points on diurnal use sites, except that 0–1 m percent canopy coverage was not different by point type (Table 4). Water retention difference and pH did not differ, but organic matter and earthworm biomass were higher at flush points (Table 4).

At the site level, diurnal use areas had more stems per hectare, higher canopy cover at 1–3 m, lower soil pH, lower compaction, and higher organic matter (Table 5). For logistic regression analyses, we also retained distance to and percent of unmined habitat within 1 km, canopy cover at 3–6 m and 6–9 m, herbaceous height, and age class. No logistic regression models were significant.

Flush rate correlated positively with canopy cover at 1–3 m, 3–6 m, and 6–9 m, stems per hectare, herbaceous height, percent organic matter, and age class, and correlated negatively with pH (Table 6). In addition, size of the site, average water retention difference, average percent herbaceous cover, and average 0–1 m percent canopy were included in the logistic regression. Ten sets of variables were entered into stepwise multiple regression resulting in five reduced models. The best fit model ($R^2 = 0.44$, $P = 0.001$) was

flush rate = -7.742 + (0.434) (average percent organic matter) + (0.073) (average 1–3 m percent canopy) + (14.506) (average water retention difference).

Twelve of the 14 habitat variables differed ($P \leq 0.05$) between pre-1971 and post-1977 and between 1971–77 and post-1977 reclamation; seven variables differed between pre-1971 and 1971–1977 reclamation (Table 7).

Table 4. Characteristics of American woodcock flush points (*n* = 20) and random points (*n* = 100) in reclamation 19-years old on 17 West Virginia surface mines, 1995–1996.

	Flush points			Random points				
Variable	***0***	**SE**	**Range**	***0***	**SE**	**Range**	***z***	***P*- value**[a]
0–1 m percent canopy	73.7	4.2	38–100	78.5	1.8	10–100	-1.10	0.2700
1–3 m percent canopy	52.4	3.7	29–81	26.2	2.0	0–81	4.71	< 0.0001
3–6 m percent canopy	56.6	5.0	10–86	30.5	2.8	0–100	3.78	0.0002
6–9 m percent canopy	32.4	5.7	0–81	17.3	2.3	0–81	2.88	0.0040
Percent herbaceous cover	65.0	5.0	24–100	75.5	2.0	10–100	-2.01	0.0445
Average herbaceous height (cm)	39.4	3.0	18.2–66.6	40.5	1.5	3.5–74.1	-0.51	0.6097
Percent litter cover	79.3	3.6	26–100	81.6	1.8	0–100	-1.05	0.2940
Stems per hectare	4,283	933	678–19,888	1,718	184	0–8,588	4.02	< 0.0001
Water retention difference (cm/cm)	0.13	0.01	0.001–0.22	0.14	0.01	0.02–0.30	-1.10	0.2704
Soil pH	4.69	0.11	3.74–5.44	4.95	0.09	3.34–7.17	-0.80	0.4262
Soil organic matter percent	16.8	1.9	8.4–43.2	12.5	0.5	7.1–32.2	3.01	0.0026
Age of reclamation (yr)	28.5	1.6	19–45	26.1	0.7	19–50	1.49	0.1358
Earthworm biomass (g/m^2)	1.73	0.44	0–6.78	1.38	0.28	0–16.03	2.54	0.0111
Soil compaction (1 = least, 5 = most)	3.0	0.2	1–4	3.2	0.1	1–4	-1.14	0.2551

[a] Wilcoxon rank-sum test, normal approximation; significant difference at $P \leq 0.05$ between flush and random points

Table 5. Characteristics of reclaimed mine sites used (*n* = 11) and unused (*n* = 18) as diurnal habitat by American woodcock, in West Virginia, 1995–1996.

	Diurnal use sites			Unused sites				
Variable	*0*	**SE**	**Range**	*0*	**SE**	**Range**	*z*	*P*- value[a]
Average 0–1 m % canopy	81.7	3.1	59–92	81.2	2.3	64–96	0.20	0.8395
Average 1–3 m % canopy[b]	30.9	3.7	15–50	15.4	3.4	0–46	2.77	0.0056
Average 3–6 m % canopy[b]	29.2	5.0	3–57	17.6	4.3	0–58	1.69	0.0909
Average 6–9 m % canopy[b]	14.2	4.2	0–46	7.6	2.4	0–33	1.83	0.0679
Average % herbaceous cover	77.3	3.3	57–92	79.8	2.9	49–96	-0.81	0.4180
Average herbaceous height (cm)[b]	45.9	3.2	32.6–63.5	38.8	2.4	21.7–56.8	1.51	0.1321
Average % litter cover	80.5	1.9	70–90	82.2	1.4	74–94	-0.36	0.7183
Stems per hectare[b]	2,069	314	857–4,294	1,001	228	0–2,757	2.23	0.0261
Average water retention difference (cm/cm)	0.14	0.01	0.08–0.17	0.16	0.01	0.10–0.23	-0.58	0.5590
Average soil pH[b]	5.02	0.16	3.93–5.93	5.76	0.20	4.02–6.68	-2.31	0.0206
Average soil organic matter %[b]	12.9	0.9	9.1–17.2	10.9	0.6	7.9–18.4	1.98	0.0479
Average soil compaction (1 = least, 5 = most)[b]	3.2	0.1	2.7–3.8	3.6	0.1	2.5–4.3	-2.28	0.0225
Average earthworm biomass (g/m^2)	1.53	0.44	0–3.77	2.96	0.80	0.06–12.48	-0.90	0.3686
Size (ha)	56.1	15.5	9–148	50.4	9.2	9–142	-0.02	0.9821
Distance to unmined habitat (km)[b]	0.23	0.08	0.01–0.83	0.65	0.28	0.01–5.37	-1.64	0.1001
% Unmined habitat within 1 km[b]	4.5	1.3	0.1–14	2.4	0.7	0–8	1.53	0.1255
Distance to water (km)	0.36	0.11	0.05–1.12	0.36	0.07	0.02–0.98	-0.34	0.7356

[a] Wilcoxon rank-sum test, normal approximation; significant difference at $P \leq 0.05$ between diurnal-use and non-diurnal us sites

[b] Entered in testing of logistic regression models

Table 6. Site-level correlations between American woodcock flush rate (flushes/hr search time) and habitat variables on 29 reclaimed surface mines in West Virginia, 1995–1996.

Variable	*r*[a]	*P*
Average 0–1 m % canopy[b]	- 0.2962	0.1187
Average 1–3 m % canopy[b,c]	0.5530	0.0019
Average 3–6 m % canopy[b]	0.5038	0.0053
Average 6–9 m % canopy[b]	0.4823	0.0081
Average % herbaceous cover[b]	- 0.3168	0.0940
Average herbaceous height[b]	0.4277	0.0206
Average % litter cover	- 0.0800	0.6801
Stems per hectare[b]	0.4382	0.0174
Average water retention difference (cm/cm)[b, c]	- 0.2736	0.1510
Average soil pH[b]	- 0.4586	0.0123
Average soil % organic matter[b,c]	0.6044	0.0005
Average soil compaction (1 = least, 5 = most)	- 0.1942	0.3129
Average earthworm biomass	- 0.2117	0.2702
Size (ha)[b]	- 0.3514	0.0616
Distance to unmined habitat (km)	- 0.1101	0.5695
% Unmined habitat within 1 km	0.0569	0.7696
Distance to water (km)	0.0361	0.8523

[a] Pearson product-moment correlation with flush rate

[b] Entered in testing of multiple regression models

[c] Included in best multiple regression model

Table 7. Vegetation and soil characteristics at random points in 3 age classes from 29 surface mines in West Virginia, 1995–1996. Reclaimed prior to 1971 n = 34, reclaimed 1971–1977 n = 66, reclaimed since 1977 n = 146.

	Reclaimed prior to 1971			Reclaimed 1971–1977			Reclaimed after 1977		
Variable	*0*	**SE**	**Range**	*0*	**SE**	**Range**	*0*	**SE**	**Range**
0–1 m % canopy[b,c]	75.2	3.2	24–100	80.2	2.2	10–100	85.4	1.3	10–100
1–3 m % canopy[a,b,c]	38.7	3.4	0–81	19.8	2.1	0–57	11.0	1.6	0–100
3–6 m % canopy[a,b,c]	51.7	4.4	0–100	19.6	2.8	0–81	8.5	1.7	0–100
6–9 m % canopy[a,b,c]	32.1	4.1	0–81	9.6	2.3	0–81	1.9	0.6	0–38
% herbaceous cover[a,b,c]	71.1	3.0	24–100	77.7	2.6	10–100	84.0	1.5	10–100
Average herbaceous height (cm)[c]	40.7	2.7	15.9–69.8	40.3	1.8	3.5–74.1	35.6	1.4	8.1–90.0
% Litter cover	83.9	2.5	33–100	80.4	2.4	0–100	81.8	1.4	0–100
Stems per hectare[a,b,c]	2,951	380	0–8,588	1,082	150	0–6,102	543	91	0–7,006
Water retention difference (cm/cm)[b]	0.13	0.01	0.03–0.30	0.15	0.01	0.02–0.28	0.16	0.01	0.001–0.36
Soil pH[b,c]	4.66	0.11	3.34–6.16	5.10	0.12	3.48–7.17	6.09	0.09	3.50–7.98
Soil organic matter %[a,b,c]	14.1	1.0	8.0–32.2	11.7	0.5	7.1–28.6	10.6	0.3	5.1–23.8
Earthworm biomass (g/m^2)[b,c]	0.45	0.14	0–2.89	1.86	0.41	0–16.03	3.80	0.38	0–25.44
Soil compaction (1 = least, 5 = most)[b,c]	3.2	0.1	1–4	3.2	0.1	1–4	3.7	0.1	1–5

[a] Significantly different ($P \le 0.05$, Wilcoxon rank-sum test) between pre-1971 and 1971–1977 reclamation

[b] Significantly different ($P \le 0.05$, Wilcoxon rank-sum test) between pre-1971 and post-1977 reclamation

[c] Significantly different ($P \le 0.05$, Wilcoxon rank-sum test) between 1971–1977 and post-1977 reclamation

Discussion

Reclaimed surface mines were used by resident woodcock in West Virginia. Even after we omitted sites identified by biologists and hunters as possible habitat, about half the sites surveyed were used by woodcock for singing grounds, diurnal habitat, or both.

In our study, points identified as singing grounds on reclaimed mines were more open than random points, with lower stem densities and less litter cover. Most had scattered shrubs or small trees within or near the 0.04-ha plot that could provide cover. Wishart and Bider (1976) in Quebec and Gutzwiller and Wakeley (1982) in Pennsylvania reported similar results in unmined habitats. Liscinsky (1972) found that size, shape, and vegetative composition of woodcock singing grounds in Pennsylvania were variable. Thus, it was not surprising to find that singing grounds on reclaimed mines had variable habitat characteristics, and that we found no strong selection for specific habitat characteristics. Using data at the point-level, our models correctly classified only 8 of 22 singing grounds. This lack of clear differentiation between singing grounds and random points suggests that woodcock are not selecting for specific characteristics of openings, and that suitable openings for singing grounds are plentiful on those sites used by singing males. Typical examples of singing grounds on our study areas were partially overgrown haul roads and wet or rocky areas without dense herbaceous cover. These areas emerge incidentally to reclamation operations and probably do not have to be intentionally created.

At the site-level, our logistic regression model differentiated sites used for singing grounds and unused sites. Use of a site by singing male woodcock increased as soil organic matter, earthworm biomass, and size of a site increased. However, density of singing males could not be predicted. Singing male density (1.29/100 ha) on reclaimed mines in our study was less than that reported on unmined habitat in West Virginia (Goudy et al. 1977: 20 males/100 ha; Ellingwood et al. 1993: 12–15 males/100 ha). Descriptions of study areas sampled by Goudy et al. (1977) and Ellingwood et al. (1993) suggest that more diurnal habitat was present near singing grounds in their studies than in ours, potentially resulting in higher use by singing males. Singing grounds are used less if high quality nesting and brood cover are not available nearby (D. McAuley, USGS Patuxent Wildlife Research Center, personal communication)

Diurnal habitats selected by woodcock had high densities of woody cover, similar to previous habitat research (Morgenweck 1977, Hudgins et al. 1985). However, woodcock also selected areas of lower soil pH and less earthworm biomass, the opposite of what we expected. When we restricted our analyses to points 19 years old or older, vegetative structure and organic matter levels still differed between flush and random points, but moisture retention and pH no longer differed. Further, earthworm biomass was higher at flush points. Thus, on older reclamation, woodcock selected areas with better soil conditions from among those available.

At the site level, prediction of diurnal use with logistic regression was not successful. In general, woodcock diurnal use was concentrated on older sites that provided a complex vegetation structure with higher stem densities. Sites reclaimed after 1977 generally provided better soil conditions and greater earthworm biomass but inadequate cover, and thus received little diurnal use. We developed a multiple regression model to predict diurnal use, but it explained less than half of the variation (model $R^2 = 0.44$) .

Midstory canopy cover in our study averaged 53% and fell within the range considered most suitable for woodcock (McCoy 1987); however, stem densities were lower than in other studies of diurnal (Morgenweck 1977; Rabe 1977; Hudgins et al. 1985) and nesting habitat (McAuley et al. 1996). Low stem densities on older sites (reclaimed before 1977) reflect poor soil conditions and a harsh microclimate for woody plant germination (Hedin 1987), while low stem densities on newer sites (reclaimed after 1977) reflect a combination of low planting densities, high compaction from regrading, and competition from dense grass and forb plantings (Lyle 1987). Particularly during periods of leaf-off (e.g., initiation of nesting), the low stem densities of reclaimed sites likely provide less than optimal cover for woodcock.

Further, soil conditions and earthworm availability in existing reclamation are of concern. Earthworm biomass levels below 8 g/m^2 are poor for woodcock (Parris 1986). On reclaimed mines, no flush sites were above this level ($0 = 1.62$ g/m^2). Because we collected earthworm samples several months after woodcock use was recorded, we cannot directly compare our results to previous studies and gauge the magnitude of this problem. In general, however, our data support earlier findings that mine soils, especially older ones, contain few earthworms (Vimmerstedt 1983). This suggests that earthworm abundance is a major concern for quality of woodcock habitat on reclaimed sites.

Our flush rates (1.04 woodcock/h) during summer on reclaimed mines are similar to those in studies in Quebec (0.5–1.7 flushes/h from June to September; Wishart and Bider 1976) and in Maine and New Brunswick (1 flush/h; Nicholson et al. 1977), but lower than in Michigan (1–7 flushes/h in June and August; Rabe 1977). We believe that the similar flush rates do not necessarily reflect high habitat quality on reclaimed mines, but instead indicate that inadequate amounts of high-quality diurnal habitat are available in West Virginia. Conversely, reclaimed mines provide a large number of sites for singing grounds, and we believe the low densities of singing males result from a shortage of high-quality diurnal or nesting cover nearby.

Habitat features of reclaimed sites relate closely to site age and consequently, reclamation techniques. Older sites provided better vegetation structure for diurnal habitat but lacked good-quality soil. Recently reclaimed sites had abundant areas for singing grounds and better soil conditions, but often lacked adequate diurnal habitat. Sites with interspersed old and new reclamation (mixed age class) had high levels of both singing male and diurnal use. These areas provided openings for singing grounds near early successional woody cover and provided the best balance of good cover with better soil.

Our models reflect sites as they were in the mid-1990s; few sites had both good cover and good soil. Consequently, woodcock used sites that provided adequate cover despite the poor soil conditions. Thus, our models tend to predict higher woodcock use in association with poor soil conditions. We expect that as more of the recently reclaimed sites (with better soil conditions) become reforested, woodcock use will shift to them. If so, our models will become less effective and should be updated. Because many sites with older reclamation presently are available to woodcock, our models will provide a useful assessment of their suitability for use by woodcock.

Woodcock use of reclaimed sites was not influenced by the presence or amount of unmined diurnal habitat located nearby. Although there was a slight tendency for use to increase as more unmined habitat was available nearby, on-site features had the most predictive power. Thus, if reclaimed sites are to be managed for woodcock, providing appropriate habitat on the site itself will be most important.

As size of sites increased, use as singing grounds increased while diurnal use decreased. Smaller sites generally had more woody cover and were older, probably because earlier mining operations were smaller, resulting in habitat more conducive to diurnal use and less suitable for singing grounds. Most older sites had some openings, but the height of surrounding trees may have reduced their attractiveness as singing grounds. Thus, the relations between site size and woodcock use probably reflect habitat conditions more than a response to size and providing appropriate habitat conditions should enhance the value of sites of any size for woodcock.

Our study did not address the survival and productivity of woodcock using reclaimed mines. Van Horne (1983) and Pulliam (1988) suggest that use of a site by a species does not necessarily mean the site is of high quality because some habitats may be population sinks in which mortality exceeds reproduction. Wray et al. (1982) found that four species of grassland sparrows reproduced below replacement levels on a surface mine. Sepik et al. (1993) pointed out that many woodcock habitat studies have not considered this question and so may have looked only at the best available habitat rather than optimal habitat. Our results raise some concerns about the quality of habitat in existing reclamation, but we do not know if reclaimed mines are habitat sinks for woodcock or suboptimal but acceptable habitat. If mines are suboptimal but acceptable, the large areas of reclaimed surface mines in West Virginia may have created large enough quantities of habitat to benefit woodcock. Promoting reclamation techniques that provide habitat for woodcock would be one way to augment woodcock habitat in the state. However, if mine sites are sinks for woodcock, reclamation will not benefit woodcock populations and management for woodcock should not be a goal.

Management Implications and High Priority Research Needs

Plantings of woody species have been deemphasized in recent reclamation, whereas planting of grasses and forbes has increased. We believe use of woody species should be encouraged to develop a diversity of habitats on reclaimed mine sites. Hawthorn (*Crataegus* sp.) and black alder have been successfully used in reclamation plantings and will provide early successional conditions (Skousen 1988). A reclamation manual for the Appalachian region (Ohlsson et al. 1982) is available and should be consulted.

On older mine sites where mature forest is established, management techniques described by Sepik et al. (1981) can be applied to return areas to early successional stages. Bigtooth aspen (*Populus grandidentata*) is a valuable timber species that could be perpetuated on many older sites in West Virginia.

Mixed ages of reclamation received high levels of woodcock singing and diurnal use in our study. Partial remining of older reclamation sites may provide benefits such as abatement of acid mine drainage sources (Skousen and Politan 1995) while producing an interspersion of old and new reclamation. Such interspersion will benefit woodcock, as well as other edge species.

Finally, continued research on the comparative population dynamics of woodcock on reclaimed mines and unmined areas, and on the effects of succession on the habitat features of sites of different ages, should be pursued. Woodcock use of reclaimed mines suggests that such research would be a worthwhile part of woodcock habitat management efforts in West Virginia and in other eastern states with significant surface mining activity.

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References

Anderson, R. J., and D. E. Samuel. 1980. Evaluation of reclaimed surface mines as wild turkey brood range. Proceedings of the National Wild Turkey Symposium 4:186–202.

Baker, G. H., and K. E. Lee. 1993. Earthworms. Pages 359–371 *in* M. R. Carter, editor. Soil sampling and methods of analysis. Lewis Publishers, Boca Raton, Florida.

Blume, L. J., B. A. Schumacher, P. W. Schaffer, K. A. Cappo, M. L. Papp, R. D. Van Remortel, D. S. Coffey, M. G. Johnson, and D. J. Chaloud. 1990. Handbook of methods for acid deposition studies: Laboratory analyses for soil chemistry. U.S. Environmental Protection Agency Report 600/4-90/023. Washington, D.C.

Brenner, F. J., D. S. Baker, and N. E. Poling. 1997. Comparison of factors determining woodcock (*Scolopax minor*) use of scrub–shrub wetland on mined and unmined land in western Pennsylvania. Journal of the Pennsylvania Academy of Science 70:113–117.

Bruggink, J. G. 1996. American woodcock harvest and breeding population status, 1996. U.S. Fish and Wildlife Service, Laurel, Maryland. 14 pp.

Duke, G. E. 1966. Reliability of censuses of singing male woodcocks. Journal of Wildlife Management 30:697–707.

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.

Ellingwood, M. R., B. P. Shissler, and D. E. Samuel. 1993. Evidence of leks in the mating strategy of the American woodcock. Pages 109–115 *in* J. R. Longcore and G. F. Sepik, editors. Proceedings of the eighth American woodcock symposium. U.S. Fish and Wildlife Service Biological Report 16. Washington, D.C.

Feierabend, J. S. 1983. Mourning doves and reclaimed surface mines: Management and hunting potential. M. S. Thesis, West Virginia University, Morgantown. 126 pp.

Fenwood, J. D., and L. O. Webb. 1981. An aerial photo inventory of woodcock habitat in West Virginia. Wildlife Society Bulletin 9:306–307.

Goudy, W. H., W. K. Igo, and D. R. Beightol. 1977. Impact of an urban-industrial environment on woodcock in West Virginia. Pages 119–124 *in* D. M. Keppie and R. B. Owen, Jr., editors. Proceedings of the sixth woodcock symposium, Fredericton, New Brunswick.

Gutzwiller, K. J., and J. S. Wakeley. 1982. Differential use of woodcock singing grounds in relation to habitat characteristics. Pages 51–54 *in* T. J. Dwyer and G. L. Storm, technical coordinators. Woodcock ecology and management. U. S. Fish and Wildlife Service Wildlife Research Report 14. Washington, D.C.

Hedin, R. S. 1987. The consequences of strip mine reclamation: Vegetation and economics of reclaimed and unreclaimed sites in west-central Pennsylvania. Ph. D. Dissertation, Rutgers University, New Brunswick, New Jersey. 314 pp.

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.

Kimmel, R. O., and D. E. Samuel. 1978. Ruffed grouse use of a twenty year old surface mine. Pages 345–351 *in* D. E. Samuel, J. R. Stauffer, C. H. Hocutt, and W. T. Mason, Jr., editors. Proceedings of symposium on surface mining and fish/wildlife needs in the eastern United States. U.S. Fish and Wildlife Service Office of Biological Services Publication 78/81.

Liscinsky, S. A. 1972. The Pennsylvania woodcock management study. Pennsylvania Game Commission Research Bulletin 171. 95 pp.

Lyle, E. S., Jr. 1987. Surface mine reclamation manual. Elsevier Science Publishing Company, New York. 268 pp.

McAuley, D. G., J. R. Longcore, G. F. Sepik, and G. W. Pendleton. 1996. Habitat characteristics of American woodcock nest sites on a managed area in Maine. Journal of Wildlife Management 60:138–148.

McCoy, R. W. 1987. PAM HEP habitat suitability index model for American woodcock. U.S. Fish and Wildlife Service, State College, Pennsylvania, USA.

Morgenweck, R. O. 1977. Diurnal high-use areas of hatching-year female American woodcock. Pages 155–160 *in* D. M. Keppie and R. B. Owen, Jr., editors. Proceedings of the sixth woodcock symposium, Fredericton, New Brunswick.

Nicholson, C. P., S. Homer, R. B. Owen, Jr., and T. G. Dilsworth. 1977. Woodcock utilization of timberlands in the Northeast. Pages 101–108 *in* D. M. Keppie and R. B. Owen, Jr., editors. Proceedings of the sixth woodcock symposium, Fredericton, New Brunswick.

Noon, B. R. 1981. Techniques for sampling avian habitats. Pages 42–52 *in* D. E. Capen, editor. The use of multivariate statistics in studies of wildlife habitat. U.S. Forest Service General Technical Report RM-87.

Ohlsson, K. E., A. E. Robb, Jr., C. E. Guindon, Jr., D. E. Samuel, and R. L. Smith. 1982. Best current practices for fish and wildlife on surface-mined land in the Northern Appalachian coal region. U.S. Fish and Wildlife Service Office of Biological Services Publication 78/84. 305 pp.

Parris, R. W. 1986. Forest vegetation, earthworm, and woodcock relationships. Ph. D. Dissertation, State University of New York at Syracuse, Syracuse.

Pulliam, H. R. 1988. Sources, sinks, and population regulation. American Naturalist 132:652–661.

Rabe, D. L. 1977. Structural analysis of woodcock habitat in northern Michigan. Pages 125–134 *in* D. M. Keppie and R. B. Owen, Jr., editors. Proceedings of the sixth woodcock symposium, Fredericton, New Brunswick.

SAS Institute. 1989. JMP user's guide. SAS Institute, Cary, North Carolina.

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* J. R. Longcore and G. F. Sepik, editors. Proceedings of the eighth American woodcock symposium. U.S. Fish and Wildlife Service Biological Report 16. Washington, D.C.

Sepik, G. F., R. B. Owen, Jr., and M. W. Coulter. 1981. A landowner's guide to woodcock management in the Northeast. University of Maine Agricultural Experiment Station Miscellaneous Report 253. 23 pp.

Skousen, J. 1988. Woody plants for revegetation. Green Lands 19(1):34–37.

Skousen, J., and K. Politan. 1995. Remining in West Virginia. Pages 111–114 *in* J. G. Skousen and P. F. Ziemkiewicz, editors. Acid mine drainage control and treatment. West Virginia University and the National Mine Land Reclamation Center, Morgantown.

Sobek, A. A., W. A. Schuller, J. R. Freeman, and R. M. Smith. 1978. Field and laboratory methods applicable to overburdens and minesoils. U.S. Environmental Protection Agency Report 600/2-78-054. 204 pp.

Soil Survey Staff. 1984. Procedures for collecting soil samples and methods of analysis for soil survey. U.S. Department of Agriculture Soil Conservation Service Report 1.

Strasbaugh, P. D., and E. L. Core. 1970. Flora of West Virginia. Volume 1. Second edition. West Virginia University Bulletin, Morgantown. 273 pp.

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.

U.S. Fish and Wildlife Service. 1990. American woodcock management plan. U.S. Department of the Interior, Washington, D.C. 11 pp.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. Journal of Wildlife Management 47:893–901.

Vimmerstedt, J. P. 1983. Earthworm ecology in reclaimed opencast coal mining sites in Ohio. Pages 229–240 *in* J. E. Satchell, editor. Earthworm ecology from Darwin to vermiculture. Chapman and Hall, London.

Wishart, R. A., and J. R. Bider. 1976. Habitat preferences of woodcock in southwestern Quebec. Journal of Wildlife Management 40:523–531.

Wray, T., II, K. A. Strait, and R. C. Whitmore. 1982. Reproductive success of grassland sparrows on a reclaimed surface mine in West Virginia. Auk 99:157–164.

Food Habits and Preferences of American Woodcock in East Texas Pine Plantations

by

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Abstract. The feeding habits of 121 American woodcock (*Scolopax minor*) collected in pine plantations in East Texas were examined. Fifty of these birds were used to analyze food preferences. Woodcock ate invertebrates from 13 orders representing 5 classes. On a dry weight basis, earthworms comprised the majority (78.0%) of the identified animal matter in the diet. Other groups that contributed >1.0% to the diet were adult beetles, larval beetles, geophilid centipedes, Orthoptera insects (grasshoppers, etc.), and spiders. Geophilid centipedes were the only taxon in the most-preferred group and lithobid centipedes were the only invertebrates in the least-preferred group. Eight other taxa comprised three centrally-ranked groups. Because of their high availability ranking, earthworms were in a relatively low-ranked preference group, but because they are the staple of the woodcock's diet, their importance cannot be overemphasized. The results demonstrate that in the southern United States, forest management strategies beneficial to earthworms also may be beneficial to woodcock.

Keywords: American woodcock, feeding habits, *Scolopax minor*, woodcock foods, woodcock food preferences.

Although the American woodcock (*Scolopax minor*) consumes other invertebrates, earthworms (Class Oligochaeta, Order Opisthopora, Family Lumbricidae) are the primary item in its diet (Pettingill 1936; Glasgow 1958; Sheldon 1971; Miller and Causey 1985; Stribling and Doerr 1985). Sheldon (1971) and Miller and Causey (1985) described woodcock as opportunistic feeders. Miller and Causey's (1985) study in Alabama showed that woodcock did not prefer earthworms, rather they were exploiting a high availability food source. In South Carolina, however, Stribling and Doerr (1985) reported that birds selected feeding sites with high earthworm biomass and protein as opposed to adjacent randomly selected sites.

Eastern Texas is on the western extreme of the woodcock's range (Keppie and Whiting 1994). Leopold (1933) noted the value of studying a species on the periphery of its range to determine limiting factors. However, no published studies consider food habits or preferences of woodcock in eastern Texas and no study of food habits has been conducted in pine plantations in southern states. Therefore, our objectives were to analyze food habits and preferences of woodcock collected in young pine plantations in eastern Texas.

Methods

We collected woodcock over pointing dogs during February and early March, 1978, and December–February, 1986–87. During 1978, birds were collected throughout the day. Visual examination indicated that digestive tracts of birds collected during early morning and late afternoon contained more food than did those collected during the remainder of the day. Therefore, during 1986–87, we collected woodcock during early morning (daylight to 1 h after sunrise) and late afternoon (30 min before sunset to dark) in an attempt to maximize digestive tract contents.

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Study Areas

In 1978, all woodcock were collected in 5-year-old pine plantations described in detail by Whiting (1978). All plantations were in Nacogdoches County. In 1986–87, most (80%) birds were collected in a 7-year-old pine plantation in the same county. The remainder came from a 5-year-old pine plantation in Houston County (Gregory 1987). All Nacogdoches County plantations exceeded 100 ha; the Houston County plantation was approximately 20 ha.

All plantations were regenerated similarly. Naturally-regenerated, second-growth timber was harvested, residual vegetation was sheared and raked into windrows along with logging debris. One-year-old pine seedlings were planted the first winter after site preparation. Vegetation in the plantations ranged from 0.3 to 3.3 m high. Conifer species included loblolly pine (*Pinus taeda*), shortleaf pine (*P. echinata*), and eastern red cedar (*Juniperus virginiana*). Broadleaf species included sweetgum (*Liquidambar styraciflua*), black tupelo (*Nyssa sylvatica*), sassafras (*Sassafras albidum*), southern red oak (*Quercus falcata*), blackjack oak (*Q. marilandica*), smooth sumac (*Rhus glabra*), shining sumac (*R. copallina*), mockernut hickory (*Carya tomentosa*), shagbark hickory (*C. ovata*), bitternut hickory (*C. cordiformis*), flowering dogwood (*Cornus florida*), southern wax myrtle (*Myrica cerifera*), hawthorn (*Crataegus* spp.), and American beautyberry (*Callicarpa americana*). Greenbrier (*Smilax* spp.), trumpet-creeper (*Campsis radicans*), Carolina jessamine (*Gelsemium sempervirens*), and pepper-vine (*Ampelopsis arborea*) were also present. Blackberry and dewberry (*Rubus* spp.) were dominant ground cover in many areas.

Soils where birds were collected in 1978 were dominated by Tenaha loamy fine sand, Cuthbert fine sandy loam, Etoile loam, and Woodtell very fine sandy loam (Whiting 1978). The majority of the birds collected in 1986–87 were found on Cuthbert, Kirvin, and Ruston fine sandy loams. These are upland, moderately-to-well-drained soils that are suited for woodland usage (Dolezel 1980).

Field Procedures

During both sampling periods, immediately after a bird was killed, it was sexed, age was determined (adult or subadult) using wing characteristics (Martin 1964), and weighed. We then dissected the bird and the upper digestive tract (mouth, esophagus, proventriculus, ventriculus) was removed, injected with 10% formalin, and placed in a labeled, self-sealing plastic bag.

During 1986–87, we collected soil and litter samples to determine abundance of invertebrates available to the woodcock that we killed. Our procedures were similar to those of Miller and Causey (1985). The point of the first encounter with the bird was used as the center of a circular plot with a radius of 3.57 m. We divided the plot into four quadrants and collected five soil and litter subsamples (i.e., replications), one at plot center and one from a random point in each quadrant. For each subsample, all litter within a 24-cm diameter circle was first gathered by hand and placed in a self-sealing plastic bag. Then, where the litter had been removed, a short section of 10-cm diameter PVC pipe was driven approximately 10 cm into the soil. A large knife was wedged into the soil in the pipe and all were lifted out of the ground. The soil was then placed in a labeled, self-sealing plastic bag. Finally, an additional litter subsample was collected at random from an undisturbed site in the plot. Soil and litter samples were collected the same day as the bird.

Laboratory Procedures

During 1978, each digestive tract collected was stored in a labeled jar containing 80% ethanol. In 1986–87, digestive tracts were frozen. During both periods, digestive tract contents were processed within two months after collection.

Miller and Causey (1985) reported ventricular contents were insignificant in their study. Although they noted a higher diversity of food items than in the esophagus and proventriculus, it was difficult to identify many particles. Also, partially digested earthworms were less frequent than other food items in the ventriculus; this was attributed to easy digestibility. Therefore, instead of using the contents of the entire digestive tract, they used the esophageal and proventricular contents and attained satisfactory results without the bias of high amounts of unidentifiable material.

We evaluated this bias using the first six birds collected in 1986–87. We found that birds not killed instantly were prone to regurgitate, thus it was difficult to distinguish proventricular and esophageal contents from that of the ventriculus. Most birds collected had esophageal and proventricular contents that contained vomitus. Also, in 1978, we had examined food items in the entire upper digestive tract. To be comparable, we included all contents from the upper digestive tract in the 1986–87 analyses. Because of this, our analysis may have underestimated the relative importance of soft-bodied prey such as earthworms.

To sort food items, a tract was first opened its entire length and the contents removed for gross analysis. Items that could be identified were separated by taxon and placed in vials of 10% formalin. Small, fragmented items were identified with a dissecting microscope, sorted, and placed in appropriate vials. Unidentifiable items were classified as plant or animal matter and placed in separate vials. We used keys from Jaques (1947), Borror and White (1970), Borror et al. (1976), and Pennak (1978).

Processing of soil and litter samples began immediately upon return from the field. Soil subsamples for each collection site (i.e., bird) were combined in a wooden tray. Large peds were broken and the soil was slowly raked across the tray while searching for invertebrates. Collected invertebrates were separated by taxon and stored in vials of 10% formalin solution. Searches were conducted at one-day intervals until a complete search revealed no invertebrates. Usually two searches were sufficient to collect all invertebrates.

We handled litter samples similarly. A small amount of litter was placed on a sorting tray and thoroughly searched for invertebrates, which were collected and placed in vials of 10% formalin. After searching, the litter was raked to the side and another subsample introduced to the tray. After the entire sample for a bird had been searched, the procedure was repeated until an entire search revealed no invertebrates.

Miller and Causey (1985) reported that the use of dry weights of food items produced results similar to those obtained by using volumes. Britt (1971) had similar results when comparing percentages by weight and volume. We used dry weights because they were easier to obtain, accurate, and the results would be comparable to those of Miller and Causey (1985).

To obtain dry weights of food items, we numbered and then dried empty crucibles in a muffle furnace at 550 C° for 30 min. After drying, crucibles were dessicated for 24 h and weighed to the nearest 0.0001 g. Each food item was placed in a crucible and dried at 105 C° for 30 min, then the crucible and the food item were desiccated for 24 h and weighed. Dry weight of the food item was determined by subtracting the weight of the empty crucible from that of the crucible with the dried item in it. After each procedure, the crucibles were washed, fired at 550 C°, desiccated, and reweighed before reuse. We obtained dry weights of potential food items available in the litter and soil in a similar manner.

Statistical Analysis

We compared weights of total digestive tracts, total animal matter in the digestive tracts, and earthworms in the digestive tracts between collection periods using unpaired *t*-tests. We chose Johnson's (1980) method of analyzing resource preference because it offers a number of advantages over other multiple comparison methods (Alldredge and Ratti 1986). His method allowed us to rank food items used by woodcock and those available in the soil and litter sample. The use of ranks reduces the effect of sampling error associated with sorting and identifying digestive tract contents and sampling food availability (Johnson 1980). Also, usage and availability ranks can be compared statistically. Finally, Miller and Causey (1985) used this technique, thus our results should be comparable to theirs.

For each bird collected in 1986–87, we determined the percentage of the total weight of each food item in the digestive tract. The percentage of each potential food item in the soil and litter samples also was determined. We ranked use and availability percentages separately for each bird; in each category, the largest percentage was ranked one. Potential food items that were available but not used were given an average rank. We calculated the average rank by summing the ranks of items not used and dividing by the number of items not used (Johnson 1980).

The measure of a bird's preference for a food item was the difference between the usage and availability ranks. We summed preferences for each food for all birds and then averaged them to obtain an overall preference score for that food item. This procedure was repeated until all food items consumed were scored.

We analyzed average preference scores with Waller–Duncan k-ratio t-tests. This test uses a type-1 to type-2 error–seriousness or error–weight ratio of k. We used a k-ratio of 100:1, which is analogous to an alpha level of 0.05 (Waller and Duncan 1969).

Results

We examined digestive tracts of 121 woodcock, 60 from 1978 and 61 from 1986–87. However, 4 birds from 1978 and 11 from 1986–87 had empty upper digestive tracts and were excluded from the analysis.

Food Habits

We found differences in digestive tract contents of birds collected in 1978 and in 1986–87. Average weights of total digestive tract contents were 0.9360 g/bird (SE = 0.1349) in 1978 and 0.5971 g/bird (SE = 0.1220) in 1986–87 ($t = 1.8466$, 104 df, $P = 0.068$). Total animal matter in the digestive tracts was not different and averaged 0.5479 g/bird (SE = 0.1071) in 1978 and 0.5180 g/bird (SE = 0.1101) in 1986–87 ($t = 0.1928$, 104 df, $P = 0.848$).

Average weights of earthworms consumed (0.3411 g/bird [SE = 0.0972] in 1978 and 0.3782 g/bird [SE = 0.0979] in 1986–87) were not different between collection periods ($t = 0.1392$, 104 df, $P = 0.890$). However, earthworms made up a higher proportion of total identified animal matter in 1986–87 (91.0%) than in 1978 (68.3%; Table 1).

We identified invertebrates from 13 orders in 5 classes in woodcock digestive tracts (Table 1). Earthworms comprised most (78.0%) of the identifiable animal matter. Other relatively important food items included adult and larval beetles (Coleoptera; 10.8%) and geophilid centipedes (5.7%). Grasshoppers, crickets, and cockroaches (Orthoptera) made up 2.6% of the identifiable animal matter, but were recorded in only 12 woodcock (6 during each collection period; Table 1).

Spiders (Araneida) made up 1.1% of the identifiable food items, but were eaten by only five woodcock (Table 1); one adult female ate 95% of the spiders recovered during the 1978 collection period. Other minor components of the diet included butterfly larvae (Lepidoptera), found in three birds in 1986–87, and true bugs (Hemiptera) and earwigs (Dermaptera), found in one and two birds, respectively, in 1978. One subadult female collected in 1986–87 ate a ground skink (*Scincella lateralis*), which was not included in the analyses.

Non-animal matter accounted for 41.5% of the total dry weight of the digestive tract of woodcock collected in 1978 and only 13.2% for birds collected in 1986–87. Much of the difference can be attributed to the greater amounts of grit in the birds during 1978. During each collection period, vegetation comprised a very small proportion of the digestive tract contents (Table 1).

Table 1. Total dry weights of food items in the digestive tracts of American woodcock collected in eastern Texas during the winters of 1978 and 1986–1987. For each food item, percentages of identified animal matter and total contents are also shown.

	1978 (*n* = 56)				1986–1987 (*n* = 50)				Combined (*n* = 106)			
			Percent of				Percent of				Percent of	
Taxa	Dry weight (g)	Number of birds	Identified animal matter	Total contents	Dry weight (g)	Number of birds	Identified animal matter	Total contents	Dry weight (g)	Number of birds	Identified animal matter	Total contents
Animal matter (order)												
Opisthopora	19.1038	34	68.3	36.4	18.9122	42	91.0	63.3	38.0160	76	78.0	46.2
Coleoptera adult	3.2560	29	11.6	6.2	0.1262	10	0.6	0.4	3.3822	39	6.9	4.1
Coleoptera larvae	1.4853	10	5.3	2.8	0.3995	22	1.9	1.3	1.8848	32	3.9	2.3
Geophilomorpha	1.7450	35	6.2	3.3	1.0330	41	5.0	3.5	2.7780	76	5.7	3.4
Orthoptera	1.2148	6	4.3	2.3	0.0547	6	0.3	0.2	1.2695	12	2.6	1.5
Araneida	0.5409	2	1.9	1.0	0.0101	3	tr.[a]	tr.	0.5510	5	1.1	0.7
Scolopendromorpha	0.2992	7	1.1	0.6	0.0782	16	0.4	0.3	0.3774	23	0.8	0.5
Diptera	0.2176	8	0.8	0.4	0.0351	8	0.2	0.1	0.2527	16	0.5	0.3
Lepidoptera larvae	—	—	—	—	0.1041	3	0.5	0.4	0.1041	3	0.2	0.1
Chordeumida	0.0257	3	0.1	tr.	0.0325	1	0.1	0.1	0.0582	4	0.1	0.1
Lithobiomorpha	0.0330	2	0.1	tr.	0.0054	1	tr.	tr.	0.0384	3	0.1	tr.
Dermaptera	0.0257	2	0.1	tr.	—	—	—	—	0.0257	1	0.1	tr.
Hemiptera	0.0146	1	tr.	tr.					0.0146	1	tr.	tr.
Subtotal	27.9616	—	99.9	53.3	20.7910	—	100.0	69.6	48.7526	—	100.0	59.2
Unidentified	2.7360	28	—	5.2	5.1110	40	—	17.1	7.8470	71	—	9.5
Non-animal matter												
Grit	21.5195	52	—	41.0	3.8582	26	—	12.9	25.3777	78	—	30.8
Vegetation	0.2233	8	—	0.4	0.0939	10	—	0.3	0.3172	18	—	0.4
Subtotal	21.7428	—	—	41.4	3.9521	—	—	13.2	25.6949	—	—	31.2
Total	52.4404	56	—	99.9	29.8541	50	—	99.9	82.2945	106	—	99.9

[a] Values <0.1% are noted as trace.

Food Preferences

Only birds collected during the 1986–87 period were used in analysis of food preferences. Taxa representing seven classes of invertebrates were present in the soil and litter samples (Table 2). We identified seven taxa to order and 16 to family. Woodcock ate 16 of these 23 potential food items. Food items available to and eaten by woodcock included earthworms, centipedes, insects, and millipedes (Chordeumida). Invertebrates that occurred in soil and litter samples that were not eaten by woodcock included termites (Isoptera), pseudoscorpions (Chelonethida), ants (Hymenoptera), pillbugs (Isopoda), snails (Stylommatophora), and springtails (Collembola).

We analyzed preferences of food items consumed using two arrays. The first array established preferences for 10 food items by orders; the second, in which some orders were subdivided into families, contained 14 food items.

Results from the first test ranked the food items into five groups (Table 3). Geophilid centipedes were the only taxon in group one and were preferred to all other taxa. Five taxa, including scolopendrid centipedes, comprised the second group. Five taxa were in the third group, which included earthworms. The fourth-ranked group included two taxa and the fifth group included only lithobid centipedes (Table 3).

In the second analysis, we subdivided three orders (Diptera, Coleoptera, and Orthoptera) into families. Again, geophilid centipedes were preferred to all other groups (Table 4). In the second group, horse fly (Tabanidae) larvae ranked highest as did darkling beetle (Tenebrionidae) larvae in the third group. Earthworm preference fell to the fourth-ranked group in this test. The fifth group was comprised of six taxa. The last two groups were made up of the same taxa as in the first test (Table 4).

Discussion

Food Habits

Most studies reported that woodcock rely heavily on earthworms as a prey base (Keppie and Whiting 1994). Generally, studies from the northern parts of the range have shown that 68–90% of the animal matter in the diet is earthworms (Aldous 1939; Vander Haegen et al. 1993). Most studies from the southern United States have reported that earthworms comprise 63–73% of the diet (Britt 1971; Pace and Wood 1979; Miller and Causey 1985); the 68.3% (Table 1) that we recorded in 1978 is in that range. However, earthworms comprised 91.0% of the diet of woodcock that we collected in 1986–87 (Table 1). This percentage is somewhat lower than the 99% reported by Stribling and Doerr (1985), who collected woodcock at night in agricultural fields in North Carolina. They attributed the high proportion of earthworms to birds selecting cut-over soybean fields rather than disked corn fields and winter wheat fields. Soybean fields provided thermal advantages to woodcock and earthworms in such fields had higher protein content than did those in corn and winter wheat fields (Stribling and Doerr 1985).

We know of no reason why woodcock might have eaten higher proportions of earthworms in the plantations we used in 1986–87 than in those we used in 1978. All plantations were established in the same manner and were topographically and edaphically similar; vegetation composition and structure likewise appeared similar. However, the time of day that woodcock were collected and climatic conditions may have affected proportions of earthworms in the digestive tracts. Although collecting woodcock during early morning and late afternoon did not increase average weights of food items or earthworms in the digestive tracts, there was an increase in the percentage of earthworms in the identifiable animal matter. For birds collected later in the day in 1978, earthworms consumed during dawn feeding periods would have been partially or wholly digested. In 1986–87, we did not collect woodcock from an hour after sunrise until 30 min before sunset.

Table 2. Total dry weight and percentage dry weight composition of each invertebrate available in soil and litter samples taken at flush sites where 50 American woodcock were collected during winter 1986–1987 in eastern Texas. Number of samples in which each taxon occurred is also shown.

				Dry weight		
Class	**Order**	**Family**	**Common name**	**Grams**	**Percent**	**Number samples**
Arachnida			Spiders, etc.			
	Araneida[a]		Spiders	0.1780	1.1	33
	Chellthida		Pseudoscorpions	0.0032	tr.[b]	1
Chilopoda			Centipedes			
	Geophilomorpha[a]		—	0.4754	2.8	31
	Lithobiomorpha[a]		—	4.5150	26.9	35
	Scolopendromorpha[a]		—	0.0784	0.5	15
Crustaceae			Crustaceans			
	Isopoda		Pill bugs	0.0176	0.1	4
Diplopoda			Millipedes			
	Chordeumida[a]		—	0.8778	5.2	29
Gastropoda			Snails			
	Stylommatophora		—	0.3078	1.8	8
Insecta			Insects			
	Coleoptera		Beetles			
		Elateridae[a]	Click beetles	0.0695	0.4	10
		Tenebrionidae[a]	Darkling beetles	0.0751	0.4	9
		Others[a]	—	0.7380	4.4	33
	Collembola		Springtails	0.0120	0.1	10
	Diptera		Flies			
		Tabanidae[a]	Horse flies	0.0132	0.1	2
		Others[a]	—	0.1906	1.1	11
	Hemiptera[a]		True bugs	0.3131	1.9	25
	Hymenoptera		Ants			
		Formicidae	Ants	0.0397	0.2	18
		Others	—	0.0066	tr.	2
	Isoptera		Termites			
		Rhinotermitidae	Subterranean termites	0.0750	0.4	7
	Lepidoptera[a]		Butterflies	0.0990	0.6	8
	Orthoptera		Grasshoppers, etc.			
		Acrididae[a]	Shorthorned grasshopper	0.8962	5.3	3
		Blattidae[a]	Cockroaches	0.0948	0.6	9
		Gryllidae[a]	Crickets	0.2137	1.3	6
Oligochaeta			Earthworms			
	Opisthopora		Earthworms			
		Lumbricidae[a]	—	7.4797	44.6	46
Total				16.7694	99.8	50

[a] Consumed by woodcock.

[b] Values <0.1% are noted as trace.

Table 3. Mean differences between usage and availability and preference rankings of 10 food items consumed by 50 American woodcock collected in eastern Texas pine plantations during winter 1986–1987.

Invertebrates	Difference	
Geophilomorpha (O)[a]	2.285714	A[b]
Scolopendromorpha (O)	1.020408	B
Diptera-larvae (O)	0.816327	BC
Lepidoptera-larvae (O)	0.663265	BC
Coleoptera (O)	0.510204	BC
Orthoptera (O)	0.112245	BC
Lumbricidae (F)	0.142857	C
Araneida (O)	-1.000000	D
Diplopoda (C)	-1.520408	D
Lithobiomorpha (O)	-3.030612	E

[a] O = order, F = family, C = class.

[b] Means with the same capital letters are not different ($P>0.05$). Differences were determined using Waller–Duncan *k*-ratio *t*-tests.

Table 4. Mean differences between usage and availability and preference rankings of 14 food items consumed by 50 American woodcock collected in eastern Texas pine plantations during winter 1986–1987.

Invertebrates	Difference	
Geophilomorpha (O)[a]	3.326531	A[b]
Tabanidae-larvae (F)	1.602041	B
Tenebrionidae-larvae (F)	1.469388	BC
Scolopendromorpha (O)	1.142857	BC
Lepidoptera-larvae (O)	0.887755	BCD
Gryllidae (F)	0.765306	BCDE
Diptera larvae (O)	0.683673	BCDE
Blattidae (F)	0.316327	CDE
Lumbricidae (F)	-0.234694	DE
Coleoptera-misc. (O)	-0.397959	E
Araneida (O)	-2.500000	F
Diplopoda (C)	-3.071429	F
Lithobiomorpha (O)	-4.806122	G

[a] O = order, F = family, C = class.

[b] Means with the same capital letters are not different ($P>0.05$). Differences were determined using Waller–Duncan *k*-ratio *t*-tests.

The winter of 1977–78 was much colder (60 days vs. 41 days below freezing) than that of 1986–87 (Gregory 1987). In 1978, earthworms may have been less available or woodcock may have been selecting other food items. Animals may use food resources based on need. Selective feeding processes are thought to be an attempt to maximize nutritional intake whereas generalist feeding processes may be used to maximize energy reserves (Nudds 1980).

Consumption of centipedes by woodcock has been reported in several studies (Pettingill 1939; Sperry 1940; Britt 1971; Miller and Causey 1985; Vander Haegen et al. 1993). Miller and Causey (1985) reported substantial use of centipedes (16%) in their study. They hypothesized that in the southern United States, woodcock may modify their reliance on earthworms by eating greater proportions of centipedes. In our study and that of Miller and Causey (1985), geophilid centipedes comprised the bulk of the centipedes eaten. Woodcock may have eaten relatively high proportions of geophilid centipedes because that order is somewhat sluggish (Pratt 1935) and burrows in the soil in a fashion similar to earthworms (Brusca and Brusca 1990).

Most studies have shown that woodcock consume insects (Britt 1971; Pace and Wood 1979), including beetles (Dyer and Hamilton 1974; Miller and Causey 1985). Beetles were 10.8% of the diet in our study; that value is similar to those reported by Britt (1971) and Miller and Causey (1985). In our study, eight families in the order Insecta were identified in woodcock digestive tracts. No other order included more than two families (Gregory 1987).

Adult beetles and other exoskeletal animals comprised a much larger proportion of the identifiable animal matter in the diet of woodcock collected in 1978 (26.2%) than in 1986–87 (6.6%; Table 1). Birds from 1978 contained more grit than did 1986–87 birds. Perhaps woodcock require more grit to digest beetles than earthworms; conversely, the grit may have been the remains of digested earthworms.

The low proportion of fly larvae reported in this study (Table 1) is similar to that of Britt (1971), but different from the results of some other studies (Mendall and Aldous 1943; Miller and Causey 1985). Conversely, low use of the order Lepidoptera in this study contradicts Britt (1971), who reported high proportions of army worms (Family Noctuidae) in his study in Louisiana. That is the only study that showed the extensive use of Lepidoptera in the diet during winter.

The consumption of spiders and a skink by woodcock we collected is noteworthy. Although several studies have reported that woodcock consume spiders (Pettingill 1939; Sperry 1940; Mendall and Aldous 1943; Krohn 1970; Vander Haegen et al. 1993), none took place in the southern portion of the species' range. Likewise no recent studies have reported the use of vertebrates by woodcock. Pettingill (1939) reported several vertebrae of a minute salamander in the stomach of a woodcock from Nova Scotia. Also, Sperry (1940) reported he "had heard" of frogs and salamanders being eaten by woodcock but his analysis of food habits did not identify any vertebrates.

Ants were entirely lacking and millipedes only a minor component in the diet of woodcock we collected. These results are similar to those of Miller and Causey (1985), who reported that each taxon comprised a trace of the dry weight in the diet of their birds. In contrast, Dyer and Hamilton (1974) reported that ants accounted for the majority of the diet of birds collected during nocturnal feeding periods in Louisiana. They also reported that during a 24-h period, woodcock consumed more than three millipedes per hour and that millipedes were eaten with approximately the same intensity as were earthworms. Sperry (1940) reported that millipedes and centipedes were consumed in 7 of the 10 months of his study.

The vegetation we recorded was primarily seeds and in one instance, two green leaves from a small annual plant; vegetative matter comprised only 0.4% of the digestive tract contents (Table 1). Various amounts of vegetation have been reported by other authors. For birds collected in northern locales, Sperry (1940) reported 10% vegetation. For studies on the wintering ground, Miller and Causey (1985) reported that seeds composed 4% and vegetable matter 1% of the total stomach volume. Britt (1971) reported 15.6% plant debris and stated "...further study is needed to clarify the importance of plant material in the diet of the woodcock."

Food Preferences

Our results confirm those of Miller and Causey (1985) that centipedes are a preferred food item in the southern part of the woodcock's range. Preference tests ranked scolopendrid centipedes high in both studies. However, geophilid centipedes were the most-preferred food item in our study whereas that taxon was in the third-ranked group, which included lithobid centipedes, in the study by Miller and Causey (1985). In our study sites, the available biomass of lithobid centipedes was second only to earthworms (Table 2). However, that taxon was eaten by only one bird and was ranked lowest in our preference analyses (Tables 3 and 4). Millipedes likewise were well represented in the soil and litter samples but were eaten by only one woodcock. As a result, millipedes ranked second lowest in the preference tests in our study (Tables 3 and 4). Millipedes were not included in Miller and Causey's (1985) preference groups.

In our study and that of Miller and Causey (1985), earthworms were in centrally-ranked preference groups. However, the significance of earthworms in the woodcock's diet should not be underestimated. Although other groups of invertebrates may have higher preference ratings, woodcock use earthworms for at least 60% of their diet. Johnson (1980) recognized four levels of selection. In the first and second levels of selection, a species selects a geographic province and a home range, respectively. Woodcock may base the third level of selection, for a feeding site, on the amount of earthworms present at that site. At the time a bird enters a feeding site, the site is subjected to a fourth-level of selection, acquisition of food items. At this time, woodcock may encounter more-preferred food items. However, while earthworms may not be the most preferred food item, their high availability and the body morphology and food searching technique of the woodcock make them the most important.

In contrast to the results of Miller and Causey (1985), Scarab beetle larvae and Diplurans (Diplura) were not available and thus were not eaten by birds collected in our study; both items were in the top-ranked group in the Alabama study. Conversely, no Lepidoptera larvae were reported by Miller and Causey (1985); that taxon ranked in the middle of the second group in our study. In our study, ants occurred in 36% of the soil and litter samples but were never found in woodcock digestive tracts, thus were not in the preference tests. Ants were in the fourth-ranked group in the Alabama study (Miller and Causey 1985).

Although darkling beetles (Tenebrionidae) were not listed in Miller and Causey's (1985) study, they may have been included in miscellaneous Coleoptera larvae in the lowest-ranked group. In our study, darkling beetle larvae comprised 0.5% of the woodcock's diet, 0.4% of the dry weight of available food items, and ranked third overall in the second group (Table 4). Pettingill (1939) reported that six woodcock killed in Nova Scotia had eaten darkling beetles. That is the only study to specifically mention Tenebrionidae in relation to woodcock food habits.

It is not surprising that there were differences between our study and that of Miller and Causey (1985). Our study took place during one winter and 80% of the woodcock were collected in the same young pine plantation; the remainder were in a very similar plantation. The Alabama study was over two years and the birds were collected over the Piedmont and Upper Coastal Plain physiographic provinces. Had our preference analyses included the winter of 1977–78 or had we collected woodcock throughout eastern Texas in 1986–87, our results may have been different.

Conclusions

Differences in diet composition of woodcock are quite common. Two studies reported the woodcock as an opportunist in its food habits (Sheldon 1971; Miller and Causey 1985). Although the species exhibits opportunistic tendencies, its morphology, feeding behavior, the habitats selected, and food habits highlight the importance of earthworms as the staple of the diet. However, the results of this and other studies indicate that the importance of some food items, especially centipedes and millipedes, needs clarification. Another need is to investigate the accessibility, availability, and nutritional value of food items eaten by woodcock.

In eastern Texas, woodcock used young pine plantations (Kroll and Whiting 1977; Boggus and Whiting 1982; Whiting and Boggus 1982) for diurnal and nocturnal cover. Our results demonstrate that the southern pine regeneration technique of clearcutting, intensive site preparation, and replanting creates foraging habitat suitable to woodcock. However, many other silvicultural techniques are used to manage and regenerate forest lands in the southern United States. As a result, information is needed to determine which methods are most practical to the landowner and beneficial to the woodcock.

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References

Aldous, C. M. 1939. Studies of woodcock management in Maine, 1938. Transactions of the North American Wildlife Conference 4:437–441.

Alldredge, J. R., and J. T. Ratti. 1986. Comparison of some statistical techniques for analysis of resource selection. Journal of Wildlife Management 50:157–165.

Boggus, T. G., and R. M. Whiting, Jr. 1982. Effects of habitat variables on foraging of American woodcock wintering in East Texas. Pages 148–153 *in* T. J. Dwyer and G. L. Storm, technical coordinators. Woodcock ecology and management. U.S. Fish and Wildlife Service Wildlife Research Report 14. Washington, D.C.

Borror, D. J., D. M. DeLong, and C. A. Triplehorn. 1976. An introduction to the study of insects. Fourth edition. Holt, Rinehart, and Winston, New York. 852 pp.

Borror, D. J., and R. E. White. 1970. A field guide to the insects of America north of Mexico. Houghton Mifflin Company, Boston, Massachusetts. 404 pp.

Britt, T. L. 1971. Studies of woodcock on the Louisiana wintering ground. M.S. Thesis, Louisiana State University, Baton Rouge. 105 pp.

Brusca, R. C., and G. J. Brusca. 1990. Invertebrates. Sinauer Associates, Sunderland, Massachusetts. 922 pp.

Dolezel, R. 1980. Soil survey of Nacogdoches County, Texas. U.S. Forest Service, Southern Forest Experimental Station and U.S. Soil Conservation Service, Washington, D.C. 146 pp.

Dyer, J. M., and R. B. Hamilton. 1974. An analysis of feeding habits of the American woodcock (*Philohela minor*) in southern Louisiana. Pages 285–296 *in* Proceedings of the Fifth American Woodcock Workshop. Athens, Georgia.

Glasgow, L. L. 1958. Contributions to the knowledge of the ecology of the American woodcock, *Philohela minor* (Gmelin), on the wintering range in Louisiana. Ph.D. Dissertation, Texas A&M University, College Station. 153 pp.

Gregory, J. F. 1987. Food habits and preferences of American woodcock wintering in young pine plantations of East Texas. M.S. Thesis, Stephen

F. Austin State University, Nacogdoches, Texas. 70 pp.

Jaques, H. E. 1947. The insects. Second edition. William C. Brown Company, Dubuque, Iowa. 205 pp.

Johnson, D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61:65–71.

Keppie, D. M., and R. M. Whiting, Jr. 1994. American woodcock (*Scolopax minor*). *In* A. Poole and F. Gill, editors. The Birds of North America, Number 100. Academy of Natural Science of Philadelphia. 28 pp.

Krohn, W. B. 1970. Woodcock feeding habits as related to summer field usage in central Maine. Journal of Wildlife Management 34:769–775.

Kroll, J. C., and R. M. Whiting, Jr. 1977. Discriminant function analysis of woodcock winter habitat in East Texas. Pages 63–72 *in* D. M. Keppie and R. B. Owen, Jr., editors. Proceedings of the sixth woodcock symposium. Fredericton, New Brunswick.

Leopold, A. 1933. Game management. Charles Scribner's Sons, New York. 481 pp.

Martin, F. W. 1964. Woodcock age and sex determination from wings. Journal of Wildlife Management 28:287–293.

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. 201 pp.

Miller, D. L., and M. K. Causey. 1985. Food preferences of American woodcock wintering in Alabama. Journal of Wildlife Management 49:492–496.

Nudds, T. D. 1980. Forage "preference": Theoretical considerations of diet selection by deer. Journal of Wildlife Management 44:735–740.

Pace, R. M., III, and G. W. Wood. 1979. Observations of woodcock wintering in coastal South Carolina. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 33:72–80.

Pennak, R. W. 1978. Freshwater invertebrates of the United States. Second edition. John Wiley and Sons, New York. 803 pp.

Pettingill, O. S., Jr. 1936. The American woodcock, *Philohela minor* (Gmelin). Memoirs of the Boston Society of Natural History 9:169–391.

Pettingill, O. S., Jr. 1939. Additional information on the food of the American woodcock. Wilson Bulletin 51:78–82.

Pratt, H. S. 1935. A manual of common invertebrate animals, exclusive of insects. P. Blakiston's Son & Company, Philadelphia, Pennsylvania. 854 pp.

Sheldon, W. G. 1971. The book of the American woodcock. University of Massachusetts Press, Amherst. 227 pp.

Sperry, C. C. 1940. Food habits of a group of shore birds: Woodcock, snipe, knot, and dowitcher. U.S. Bureau of Biological Survey, Wildlife Research Bulletin 1. 37 pp.

Stribling, H. L., and P. D. Doerr. 1985. Nocturnal use of fields by American woodcock. Journal of Wildlife Management 49:485–491.

Vander Haegen, W. M., W. B. Krohn, and R. B. Owen, Jr. 1993. Effect of weather on earthworm abundance and foods of the American woodcock in spring. Pages 26–31 *in* J. R. Longcore and G. F. Sepik, editors. Proceedings of the eighth American woodcock symposium. U.S. Fish and Wildlife Service Biological Report 16. Washington, D.C.

Waller, R. A., and D. B. Duncan. 1969. A Bayes rule for the symmetric multiple comparison problem. American Statistics Association Journal 64:1484–1503.

Whiting, R. M., Jr. 1978. Avian diversity in various age pine forests in East Texas. Ph.D. Dissertation, Texas A&M University, College Station. 160 pp.

Whiting, R. M., Jr., and T. G. Boggus. 1982. Breeding biology of American woodcock in East Texas. Pages 132–138 *in* T. J. Dwyer and G. L. Storm, technical coordinators. Woodcock ecology and management. U.S. Fish and Wildlife Service Wildlife Research Report 14. Washington, D.C.

Activities and Preliminary Results of Research on Woodcock (*Scolopax rusticola*) in Europe

by

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Abstract. The European woodcock (*Scolopax rusticola*) is a popular game bird throughout its range. To avoid overharvest, the Woodcock and Snipe Research Group was established within the International Waterfowl Research Bureau (IWRB) in 1974. In various European countries the IWRB initiates and coordinates studies that include banding programs to determine migration patterns and rates of harvest, wing sampling to assess migration phenology and breeding success, hunter harvest statistics, and removal experiments to assess the effect of traditional spring hunting on roding birds.

Keywords: Banding, European woodcock, hunting, IWRB, roding, *Scolopax rusticola*.

The European woodcock is widely distributed in the forest belt of Eurasia where it is a popular game bird. To avoid overharvest more research was required. Wetlands International (WI; formerly the International Waterfowl and Wetlands Research Bureau [IWRB]) formed the Woodcock and Snipe Research Group in 1974 to study the effects of harvest on and the biology of woodcock (*Scolopax* spp.) and snipes (*Gallinago* spp.). Since 1995, when WI became a global organization and cooperated closely with the World Conservation Union (IUCN), the group's name was changed to the Woodcock and Snipe Specialist Group (WSSG) of the IUCN-Species Survival Commission.

Since 1974, several research and management activities have been coordinated in European countries. Unfortunately, because of the political barrier ("iron curtain") throughout Europe, research activities were limited to western European countries. Only recently has cooperation extended into the former Soviet Union, which is the primary breeding range of European woodcock (*Scolopax rusticola*).

To facilitate cooperation, research results and progress reports are published annually in the WSSG-Newsletter. Four workshops have been held and scientific papers published in proceedings.

Estimates of the European Fall Population

Because woodcock are difficult to observe, there is a general opinion among bird watchers and other naturalists that this species is very rare or even "endangered" (Tucker and Heath 1994). This opinion is, however, contradicted by the large number of woodcock harvested annually. Therefore, to determine the size of the European woodcock population more accurately we collected harvest data and recovery rates of banded birds.

The range of the American woodcock (*Scolopax minor*) is encompassed by only two countries, the United States and Canada, with similar systems of wildlife management and data collection. In contrast, the range of the European woodcock extends over many countries with different political systems and hunting regulations. Hence, there are considerable differences in the quality of harvest data. However, data on woodcock harvest are generally more accurately recorded than for other game species, such as single duck species. About 3.7 million woodcock are harvested annually in 27 European countries including the western provinces of the former Soviet Union (Hepburn 1983; Kalchreuter 1983; Marcström 1994).

Before the WSSG was established, woodcock were banded only locally and occasionally. Between 1900 and 1980 not more than 10,000 woodcock were banded in 12 countries (Kalchreuter 1974, 1975; Shorten 1974). This has changed recently. The French Office National de la Chasse (ONC) organized banding programs not only in France, but also in the primary breeding range of the species (Russia, Scandinavia). More than 2000 woodcock are now banded annually (Gossmann and Bastat-Lequerré 1996).

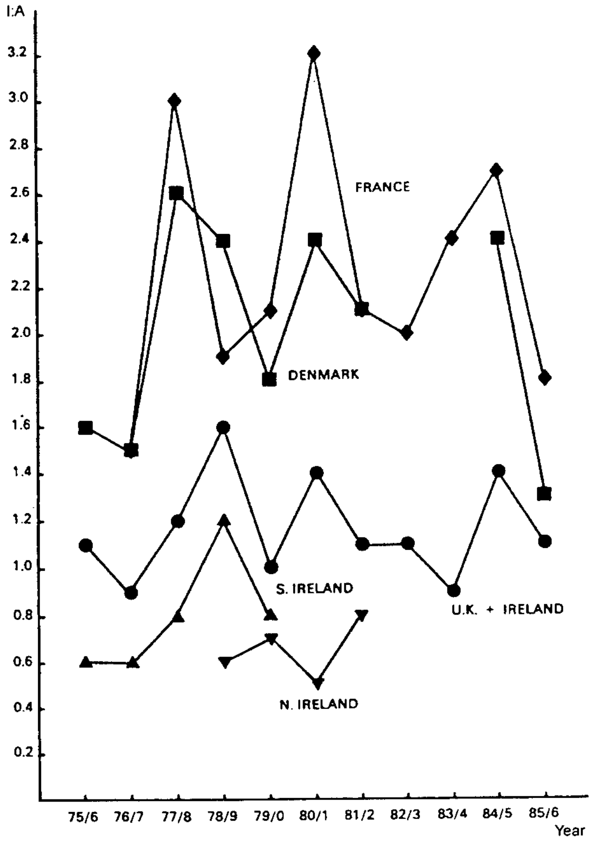
In the past, banding in Europe was conducted primarily to determine migration patterns. Therefore, only recovery data were analyzed. Banding data of birds not recovered have not been computerized by all national banding stations, therefore, modern methods to calculate survival rates using the numbers banded each year (see Brownie et al. 1985) have not been applied. Nevertheless, Shorten (1974) analyzed the number of woodcock banded over long periods (up to 70 years) and determined the portion of the banded cohort harvested, providing an estimate of the harvest rate of the population. There were large regional differences in recovery rates, primarily caused by regional differences in the popularity of woodcock hunting. For example, about 10% of the woodcock banded in the British Isles and more than 25% (based on a small sample) banded in France were recovered (Shorten 1974; Kalchreuter 1983). Assuming a total annual bag of about 3.7 million woodcock, and annual harvest rates between 10 and 25%, the fall flight in Europe may be 15–37 million woodcock (Hepburn 1983; Kalchreuter 1994a).

Reproduction

Since the late 1970s the British Association for Shooting and Conservation has coordinated the collection of woodcock wings from hunters in France, Denmark, Britain, and Ireland (Harradine 1988, 1994). The objectives of this long-term study were to determine migration phenology and reproductive success. In contrast to *S. minor*, *S. rusticola* cannot be sexed using the size of the wings. However, juveniles (< 1 year old) can be distinguished from adults. Thus, recruitment is measured by the ratio of juveniles to adult, not by juveniles to adult female. This is a less accurate index, because the sex ratio of the adult breeding population fluctuates annually in both species (Krohn et al. 1974; Couture and Bourgeouis 1977; Kalchreuter 1983). Because males usually suffer greater mortality in spring, the adult sex ratio in fall may be skewed in favor of females in most years. Although less accurate, the measurement of juveniles to adult ratio does provide a relative index to recruitment.

Reproductive rates (age ratios) differ considerably among populations of European woodcock (Figure 1). Woodcock migrating long distances (e.g., from Russia through Denmark to France) exhibited higher juvenile to adult ratios than those of the British Isles, which consist mostly of nonmigratory birds, especially in mild winters (Kalchreuter 1983). Also there are considerable annual variations, especially in populations that travel long distances. During a 25-year study in Denmark (Clausager 1993, 1995) the average age ratio was 2.1:1 juveniles to adult, but fluctuated between 0.9:1 (1992–93) and 2.7:1 (1994–95) juveniles to adult. The lowest value was similar to some other species (e.g., Wigeon [*Anas penelope*]) breeding in north-eastern Europe and monitored in the same way in Denmark. Extreme drought conditions in the summer of 1992, especially in Russia, may have caused this low reproductive success.

In populations that migrate long distances the reproductive rates of *S. rusticola* seem to be considerably higher than of *S. minor* (1.04:1 juveniles to adult, Straw et. al. 1994; 1.79:1 juveniles to adult female, Tautin 1977). If the adult sex ratio is assumed to be 50:50, then two juveniles per adult would equal four juveniles per adult female. Considering chick mortality and losses during fall migration, the number of young hatched must be even higher. This assumption is supported by the



Note : Danish data from I. Clausager
French data from C. Fadat.

Figure 1. Immature to adult ratios in woodcock harvested from 1974 to 1986 in several northwest European countries (Harradine 1988).

age ratios of Russian woodcock caught for banding before fall migration (4.4:1, 2.1:1, 4.1:1 juveniles to adult in 1991, 1992 and 1993, respectively, Kuzyakin 1996). However, the mean clutch size of *S. rusticola* is four eggs (3.8, Alexander 1946; 3.9, Shorten 1974), about the same as *S. minor* (Straw et al. 1994).

There may be some age-related bias in capture techniques as described by Dwyer et al. (1988) for *S. minor*. However, the banding teams of the ONC captured birds at night with hand nets using spotlights and did not use mist nets. Moreover, the variations in age ratios over the three years of the study were similar to birds harvested during the fall hunting seasons in western countries (few woodcock are harvested in Russia before migration). Also, there may be some age-related bias in harvesting. However, in Europe woodcock are hunted during fall by the same methods used in North America.

Consequently, it is difficult to explain an age ratio twice as high for European woodcock. These age ratios suggest that, in contrast to *S. minor*, which fledges only one brood per year, at least some populations of *S. rusticola* may raise two broods. Although there is no direct evidence (e.g., by telemetry) of two broods, there are two observations from Sweden made by Jensen (Pay 1937) who described one woodcock incubating three eggs and another incubating five eggs. The first was surrounded by four 1-week-old chicks, the second by three 3-week-old chicks. Similar observations were made by von Zedlitz (Glutz et al. 1977). Alexander (1946) reported six instances of woodcock laying a second clutch in the same nest. These instances were most likely examples of second broods, although there was no proof that the same female was involved in each instance.

There is also evidence for second broods from the population dynamics point of view. Mortality rates have not been calculated using modern methodology. Clausager (1974) and Kalchreuter (1975, 1983) used life table analyses, which probably overestimated mortality rates, and determined that woodcock that migrate over long distances (e.g., from Russia to France) suffer high losses. Direct recovery rates of woodcock banded in winter in France and harvested, on average, 28 days later were greater than 10% (Gossmann and Bastat-Lequerré 1996). Reporting rates and crippling losses were unknown. Thus, harvest rates of *S. rusticola* may be considerably higher than of *S. minor* (2.5–4.7%, Straw et al. 1994) and it is unlikely that these losses could be sustained without second broods from a large portion of the female cohort (Clausager 1974; Kalchreuter 1975). The much longer nesting season of *S. rusticola* (15 weeks; *S. minor* 5–6 weeks) suggests that there is time for females to raise 2 broods.

Spring Hunting

The largest portion (probably > 95%) of the European woodcock harvest occurs during fall and winter. In some countries, especially within the primary breeding range of the woodcock, there is a tradition of harvesting roding males in spring or summer. However, hunting immediately before and during the breeding season is opposed by many naturalists (summary in Kalchreuter 1983, 1994b).

Since the 1980s the WSSG has conducted telemetry studies and removal experiments in several countries to measure the effect of this method of hunting on the populations. They found that harvesting roding woodcock is highly selective for males, especially during the incubating and chick-rearing period, when females rarely join the evening flights. Woodcock exhibit polygamous breeding behaviour, do not form pair bonds, and males do not take part in incubation nor in rearing the chicks (Hirons 1983). Irrespective of hunting, the sex ratios within the breeding population are subject to considerable annual fluctuations (Hirons 1983). Several removal experiments in various countries (summary in Kalchreuter 1994b) revealed that the number of males in the population was larger than the number of males that were roding. Irrespective of habitat quality, a certain portion of the male population did not display. After displaying birds were removed, nondisplaying birds joined the evening flights and quickly (within 1–2 days) exhibited the same behaviour as their predecessors (Figure 2). Similar behaviour by *S. minor* has been documented (Whitcomb and Bourgeois 1974).

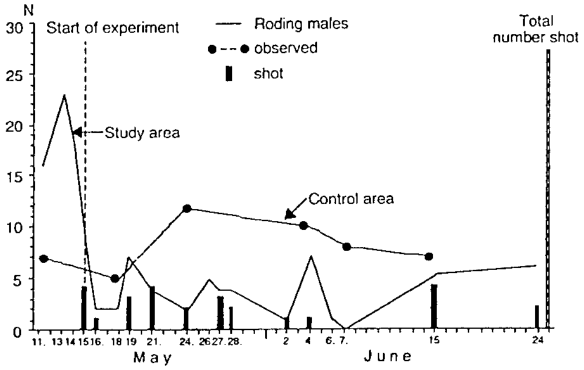


Figure 2. Number of male European woodcock roding over 2 study areas (175 x 50 m) in Sweden. On one area (Study area) roding males were shot, on the control area, none were shot. (after Marcström 1980).

Dominance may be age related, but results are contradictory. Marcström (1988) removed males during an 8-week period in Sweden and did not find any selection for adult males. The ratio of juveniles to adults of removed birds was nearly constant throughout this period. Conversely, Hirons (1983) found only adults roding in his study area in the United Kingdom. Similar results were reported for *S. minor* (Whitcomb and Bourgeois 1974; Keppie and Redmond 1985). Investigations of the size of gonads of juvenile woodcock in spring by Stronach (1983) and Marcström (1988) revealed all were large enough to produce spermatozoa. There was no evidence that juvenile males were less capable of breeding than adults.

These studies suggest spring hunting has little effect on the population. Removal experiments did not appreciably reduce the number of roding males and there was no evidence that a reduction of the male cohort negatively affected the reproductive output of the population. On the contrary, Hirons (1983) recorded the highest number of broods of *S. rusticola* in years when the number of males was lowest (and vice versa). Couture and Bourgeois (1977) found similar results for *S. minor*. These results are similar to other polygamous species (mammals as well as birds; summary in Kalchreuter 1994b) and were the basis for maintaining or reestablishing spring seasons on roding males. Spring hunting is a sustainable way of harvesting woodcock populations in Northern and Eastern European countries.

Research Needs

In many respects woodcock research in Europe is still in its infancy. There are still many geographical gaps in the collection of harvest data, wing sampling, and banding that, hopefully, will be closed in the near future. The most urgent need is a comprehensive analysis of the rapidly increasing banding and recovery data using modern methodology. Telemetric studies during the reproductive season in Russia are planned to study breeding biology. In contrast to *S. minor*, management of breeding habitats does not seem to be of primary importance for *S. rusticola*, because most of the European population originates from the natural forests of Northern and Eastern Europe, mainly in the former Soviet Union.

References

Alexander, W. B. 1946. The woodcock in the British Isles. Ibis 88:1–24, 159–179, 271–286, 427–444.

Brownie, C., D. R. Anderson, K. P. Burnham, and D. S. Robson. 1985. Statistical inference from band recovery data - A handbook. U.S. Fish, and Wildlife Service Research Publication 156. 305 pp.

Clausager, I. 1974. Migration of Scandinavian Woodcock (*Scolopax rusticola*) with special reference to Denmark. Danish Review of Game Biology 8(8):1–38.

Clausager, I. 1993. Vingeindsamling fra jagtsaesonen 1992/93 i Danmark. Faglig rapport fra DMU, Nr. 85. Danmarks Miljøundersøgelser.

Clausager, I. 1995. Vingeindsamling fra jagtsaesonen 1994/95 i Danmark. Faglig rapport fra DMU, Nr. 137. Danmarks Miljøundersøgelser.

Couture, R., and J. C. Bourgeois. 1977. Annual American Woodcock density variations during the breeding season in the Trois-Rivieres area. Pages 93–99 *in* D. M. Keppie and R. B. Owen, Jr., editors. Proceedings of the sixth woodcock symposium. Fredericton, New Brunswick.

Dwyer, T. J., G. F. Sepik, E. L. Derleth, and D. G. McAuley. 1988. Demographic characteristics of a Maine woodcock population and effects of habitat management. U.S. Fish and Wildlife Service, Fish and Wildlife Research Report 4.

Glutz v. Blotzheim, U. N. 1977. Handbuch der Vögel Mitteleuropas. Volume 7. Akademische Verlagsgesellschaft, Wiesbaden.

Gossmann, F., and C. Bastat-Lequerre´. 1996. La Becasse des bois (*Scolopax rusticola*) - rapport baguage saison 1995/96. Newsletter of the Woodcock and Snipe Specialist Group of Wetlands International 22:8–17.

Harradine, J. 1988. The woodcock production survey in the United Kingdom and Ireland. Pages 87–91 *in* P. Havet and G. Hirons, technical coordinators. Proceedings of the Third European Woocock and Snipe Workshop 1986. IWRB, Slimbridge.

Harradine, J. 1994. Woodcock wing survey 1993/94 in Britain and Ireland. Newsletter of the Woodcock and Snipe Research Group of IWRB 20:3–6.

Hepburn, I. R. 1983. Hunting bags and population of woodcock in Europe. Pages 138–145 *in* H. Kalchreuter, technical coordinator. Proceedings of the Second European Woodcock and Snipe Workshop 1982. IWRB, Slimbridge.

Hirons, G. 1983. A five-year study of the breeding behaviour and biology of the woodcock in England - a first report. Pages 51–67 *in* H. Kalchreuter, technical coordinator. Proceedings of the Second European Woodcock and Snipe Workshop 1982. IWRB, Slimbridge.

Kalchreuter, H. 1974. Über den Zug der Waldschnepfe nach europäischen Ringfunden. Vogelwarte 27:153–166.

Kalchreuter, H. 1975. Zur Populationsdynamik der Waldschnepfe nach europäischen Ringfunden. Zeitschrift für Jagdwissenschaft 21:1–14.

Kalchreuter, H. 1983. The Woodcock. Verlag Dieter Hoffmann. Mainz. 119 pp.

Kalchreuter, H. 1994a. On the wise use of woodcock and snipe populations. Pages 108–114 *in* H. Kalchreuter, technical coordinator. Proceedings of the Fourth European Woodcock and Snipe Workshop. IWRB Publication 31.

Kalchreuter, H. 1994b. Auswirkungen der Jagd auf Tierpopulationen - kompensatorische Mechanismen. Habilitation Thesis, Agricultural University of Poznan, Poland.

Keppie, D. M and G. W. Redmond. 1985. Body weight and the possession of territory for male American woodcock. Condor 87:287–290.

Krohn, W. B., F. W. Martin, and K. P. Burnham. 1974. Band recovery distribution and survival estimates of Maine Woodcock. Proceedings of the fifth American woodcock workshop. Athens, Georgia.

Kuzyakin, V. A. 1996. Woodcock (*Scolopax rusticola*) ringing in Russia - report 1991–93. Newsletter of the Woodcock and Snipe Specialist Group of Wetlands International 22:18–21.

Marcström, V. 1980. Removal of roding woodcock. Newsletter of the IWRB Woodcock and Snipe Research Group 6:63–68.

Marcström, V. 1988. A study on display activities of woodcock in Sweden. Pages 83–85 *in* P. Havet and G. Hirons, technical coordinators. Proceedings of the Third European Woodcock and Snipe Workshop 1986. IWRB, Slimbridge.

Marcström, V. 1994. Roding activity and woodcock hunting in Sweden. Pages 55–60 *in* H. Kalchreuter, technical coordinator. Proceedings of the Fourth European Woodcock and Snipe Workshop. IWRB Publication 31.

Pay, L. M. 1937. Die Waldschnepfe. F. C. Mayer-Verlag, München.

Shorten, M. 1974. The European Woodcock. A search of literature since 1940. Game Conservancy, Hampshire.

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.

Stronach, B. 1983. A report concerning the reproductive organs of woodcock in the month of February. Pages 43–50 *in* H. Kalchreuter, technical coordinator. Proceedings of the Second European Woodcock and Snipe Workshop. IWRB, Slimbridge.

Tautin, J. 1977. The current status of woodcock and woodcock surveys in the United States. Pages 17–23 *in* D. M. Keppie and R. B. Owen, Jr., editors. Proceedings of the sixth woodcock symposium. Fredericton, New Brunswick.

Tucker, G. M., and M. F. Heath. 1994. Birds in Europe: Their conservation status. Birdlife International, Conservation Series 3. Cambridge, UK.

Whitcomb, D. A., and A. Bourgeois. 1974. Studies of singing male surveys on High Island, Michigan. Proceedings of the fifth American woodcock workshop. Athens, Georgia.

Determining Multiscale Habitat and Landscape Associations for American Woodcock in Pennsylvania

by

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Abstract. To more completely understand the processes affecting wildlife populations, these processes must be viewed from appropriate spatial scales. American woodcock (*Scolopax minor*) populations have been studied at fine spatial scales, but little is known about broad-scale habitat relations. Areas of known woodcock habitat (present routes) were compared with random areas (random routes) and the proportional cover of seven land cover types and values for six landscape heterogeneity indices were determined. All habitat variables were calculated at 16 different spatial scales. For land cover variables, differences between present and random routes were most pronounced at finer spatial scales. In contrast, differences in landscape heterogeneity indices were most pronounced at broader spatial scales. The results indicate possible multiscale habitat selection by woodcock and provide an approach for assessing the spatial scales at which habitat relations are most evident. These results provide the basis for the construction of habitat models to assess woodcock habitat availability over large geographic areas.

Keywords: American woodcock, land cover, landscape heterogeneity, *Scolopax minor*, spatial scale.

Wildlife populations are affected by processes occurring at multiple spatial scales (Turner et al. 1989; Wiens 1989; Kotliar and Wiens 1990; Pearson 1993; McGarigal and Marks 1995). The relative abundance and spatial arrangement of habitats and resources also affect the behavior of organisms (Turner et al. 1995). Therefore, to understand complex ecological interactions, appropriate habitat variables and spatial scales must be considered (Wiens 1989).

There are several reasons for the explicit consideration of spatial scale in ecological investigations. First, the selection of spatial scales in ecological investigations is often arbitrary or based on convenience, resulting in analyses inappropriate to the processes being studied (Addicott et al. 1987). Second, conclusions reached at one spatial scale may be inappropriately extrapolated to other spatial scales (Turner et al. 1989; Wiens 1989). Third, examination of a system at only one spatial scale may be inadequate because processes may occur at different scales (Addicott et al. 1987). Fourth, relative influence of landscape elements has been shown to change at different spatial scales for several species (Milne et al. 1989; Pearson 1993). Last, fine-scale investigations may reveal greater detail about a system; however, broad-scale investigations are more likely to reveal generalizations. Therefore, analyses conducted at multiple spatial scales may provide more complete information about ecological systems.

Because of the continued decline of American woodcock populations (Straw et al. 1994; Bruggink 1996) there is a need to develop efficient and effective techniques to inventory and monitor availability of woodcock habitat over large geographic areas (U.S. Fish and Wildlife Service 1990; Williamson 1993; Straw et al. 1994). American woodcock populations have been studied at fine spatial scales (Mendall and Aldous 1943; Wishart and Bider 1976; Gutzwiller et al. 1983; Hudgins et al. 1985; Straw et al. 1986; McGinley 1996). However, local populations may be influenced by characteristics of surrounding landscapes, as well as local environmental characteristics (Pearson 1993; Turner et al. 1995). A more complete understanding of broad-scale habitat relations will aid in the future creation of habitat models (e.g., Milne ct al. 1989; Pereira and Itami 1991; Clarke et al. 1993; Mladenoff et al. 1995) that can then be used for broad-scale monitoring of availability of woodcock habitat.

Our objective was to investigate habitat differences between areas used by American woodcock (present routes) and random areas (random routes) to determine woodcock-habitat relations at different spatial scales. We compared the relative influence of different landscape elements at multiple spatial scales of habitat used by woodcock. This exploratory analysis provided the appropriate landscape elements and spatial scales for future use in broad-scale habitat modeling.

Methods

One-hundred sixty singing-ground survey (SGS) routes were selected nonrandomly throughout Pennsylvania to identify habitats used by American woodcock. Routes were selected by Pennsylvania Game Commission (PGC) personnel in areas where suitable woodcock habitat was known or expected to occur. Routes were delineated on field maps and later digitized into the ARC/INFO geographic information system (GIS; Environmental Systems Research Institute, Inc., Redlands, California, 92373). Each SGS route consisted of five survey stops with each stop spaced no closer than 0.8 km. Some stops were spaced farther apart to survey habitats with a higher potential of supporting woodcock.

Modified SGSs (Tautin et al. 1983) were conducted on each route during 1986–1990. Each route was surveyed at least once, and as many as five times in 5 years, but not more than once per year. Surveys were conducted 5–25 April in southern Pennsylvania and 10–30 April in northern Pennsylvania. If the sky was <75% overcast surveys began 25 min after local sunset; if the sky was ≥ 75% overcast surveys began 15 min after local sunset. Surveys were not conducted during rain, strong wind, or when the temperature was <4.4°C. An observer listened for singing woodcock or courtship flights for 3 min at each survey stop. All surveys were completed within 30 min.

We used only those SGS routes on which woodcock were detected (n = 133, present routes). To increase the specificity of our analyses, we used only those stops where woodcock were detected on each present route. Thus a present route was composed of one–five survey stops that were sampled as a single unit and where woodcock were detected. The final present route data set contained 19 routes with 1 stop, 24 routes with 2 stops, 29 routes with 3 stops, 34 routes with 4 stops, and 27 routes with 5 stops.

For comparative purposes, we used ARC/INFO to generate a database of hypothetical SGS routes randomly distributed along the existing road network (n = 266, random routes). Singing-ground surveys were not conducted on random routes. Random routes were designed to represent habitats that were randomly available for use by woodcock and that could potentially be surveyed using SGS methodology. Random routes were allocated proportionately to present routes by county in a stratified sampling design (Thompson 1992). All stops on random routes were 0.8 km apart. To prevent differences in the spatial structure between present and random routes, the numbers of stops that were retained for analysis on random routes were selected proportionately to the numbers of stops retained on present routes. Stops analyzed on random routes were selected randomly from the five available stops on each route. Our random route data set contained 38 routes with 1 stop, 48 routes with 2 stops, 58 routes with 3 stops, 68 routes with 4 stops, and 54 routes with 5 stops.

The spatial extent of our analyses consisted of a series of 16 buffers around present and random routes. This allowed us to investigate the effects of changing spatial scales on observed broad-scale habitat relations. The first buffer (scale 1) was the area within a radius of 350 m of each survey stop. Scale 1 corresponded to the approximate maximum distance at which a singing male woodcock can be detected on a SGS route (Duke 1966). Fifteen additional buffers were delineated every 150 m with the largest buffer being 2,600 m from each stop (scale 16; Figure 1). We selected a 150-m increment because we believed this would allow us to detect changes in habitat relations given the resolution of our digital land cover database. This methodology resulted in a nested hierarchy of buffers such that smaller buffered areas were completely contained within larger buffered areas (Urban et al. 1987).

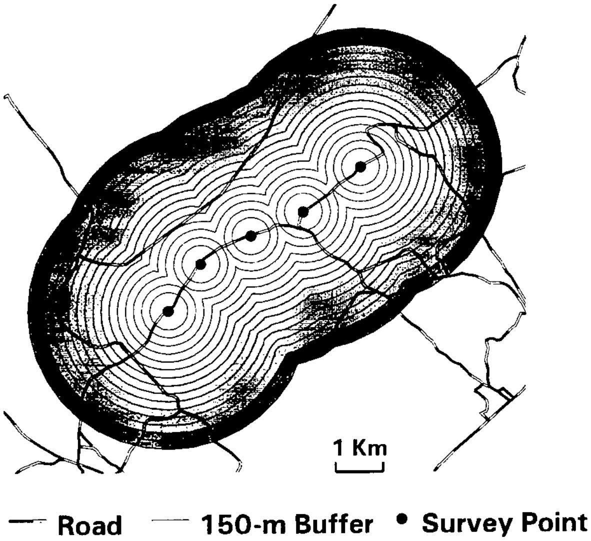

Figure 1. Schematic representation of the 16 spatial extents used in the determination of multiscale habitat relations for American woodcock in Pennsylvania. The smallest buffer was created at a distance of 350 m from each survey point. Additional buffers were constructed at 150-m increments with the largest buffer at 2,600 m. Routes may have consisted of fewer stops; this figure represent one possible configuration.

Land cover characteristics and landscape heterogeneity indices were based on information from the Multi-resolution Land Characteristic (MRLC) database for the Environmental Protection Agency Region III (Vogellman et al. 1996). The MRLC data was derived primarily from Thematic Mapper imagery with 37- x 37-m resolution. We reduced the MRLC data to seven primary land cover categories. Agricultural lands were defined as MRLC categories Hay/pasture/grass, Row crops, and Probable row crops. Developed lands were defined as MRLC categories Low intensity developed and High intensity developed. Wetlands were defined as MRLC categories Woody wetlands and Emergent wetlands. The MRLC categories Coniferous forest, Deciduous forest, Mixed forest and Water were unaltered. Due to extreme rarity, we eliminated all MRLC Barren and Transitional categories from the analyses.

The FRAGSTATS Spatial Pattern Analysis program was used to calculate values for landscape heterogeneity indices at each spatial scale (McGarigal and Marks 1995). Because coarse-scale habitat heterogeneity has not been considered in studies of woodcock habitat, we investigated six variables from five major metric types (McGarigal and Marks 1995). These or similar metrics were used in other studies of landscape structure and broad-scale wildlife habitat (Lyon et al. 1987; Turner 1989; Mladenoff et al. 1995). The contagion index measured the degree to which landscape elements were aggregated or clumped. Higher values of the double-log fractal dimension index indicated higher patch shape complexity. The interspersion and juxtaposition index measured the extent that patch types were well interspersed. The mean degree of isolation and fragmentation of patches was measured by the mean proximity index. Higher values of the Shannon diversity index indicated increasing patch richness and patch type equitability. The total length of edges between patch types was measured by the total edge index (McGarigal and Marks 1995). We standardized total edge by total landscape area to adjust for differences in sizes of landscapes associated with SGS routes of different lengths and numbers of stops.

We calculated means and standard errors (SAS PROC MEANS, SAS Institute Inc. 1989) for present and random routes at each spatial scale for all land cover and landscape heterogeneity variables. To make general broad-scale comparisons between present and random routes, we explored differences among route types for all variables across all spatial scales (Figures 2 and 3). We used two-sample randomization tests to test for significant differences

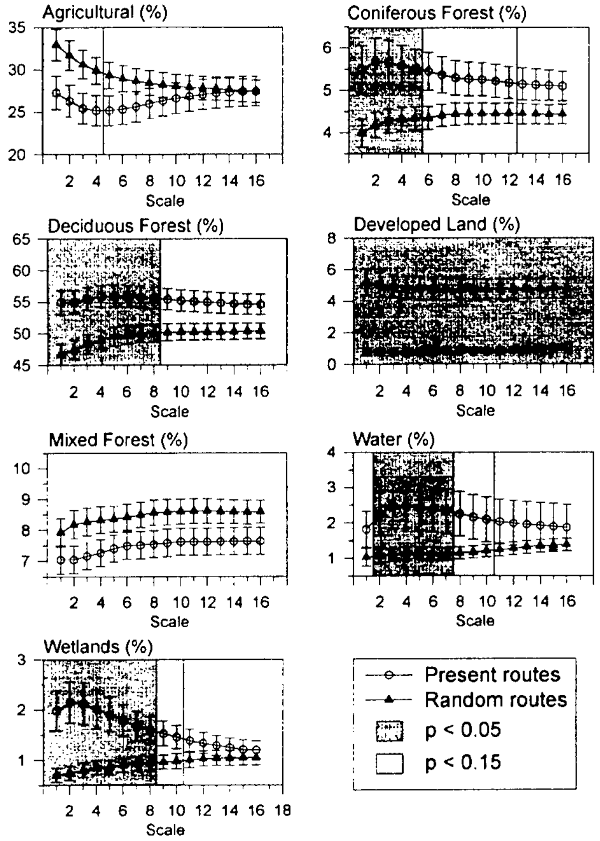

Figure 2. Mean ± SE for 7 land cover variables measured across 16 spatial scales for present (n = 133) and random (n = 266) singing-ground survey routes in Pennsylvania, 1986–1990. Significance levels ($P \leq 0.5$, $P \leq 0.15$) based on two-sample randomization tests are indicated.

in habitat variables between present and random routes at each spatial scale (Manly 1991). We constructed bootstrap estimates of means for present and random routes using the Resampling Stats software package (Resampling Stats Inc. 1991). Samples of size $n = 133$ and 266 were randomly selected from the pooled present and random route data and means were calculated. Deviations between the bootstrapped means were calculated for each of 5,000 iterations. The empirical distribution of bootstrapped deviations was compared with the observed deviation among present and random routes using the percentile method (Efron 1982; Mooney and Duval 1993). In order to detect gradients of significance across spatial scales, we considered two significance thresholds: $P \leq 0.05$ and $P \leq 0.15$. Use of liberal significance levels (e.g., $P = 0.15$) for exploratory univariate analyses has been suggested to prevent oversight of potentially important variables that may not exhibit univariate significance at more traditional levels (e.g., $P = 0.05$; Hosmer and Lemeshow 1989; Afifi and Clark 1996). Furthermore, collections of weakly associated variables may be important predictors when taken as a group (Hosmer and Lemeshow 1989).

Results

At fine spatial scales, present routes exhibited significantly larger values for the percent cover of coniferous forest, water, and wetlands and significantly smaller values for the percent cover of agricultural land (Figure 2). The percent cover of deciduous forest and developed land was significantly different between routes types across all spatial scales. No significant differences were detected for the percent cover of mixed forest.

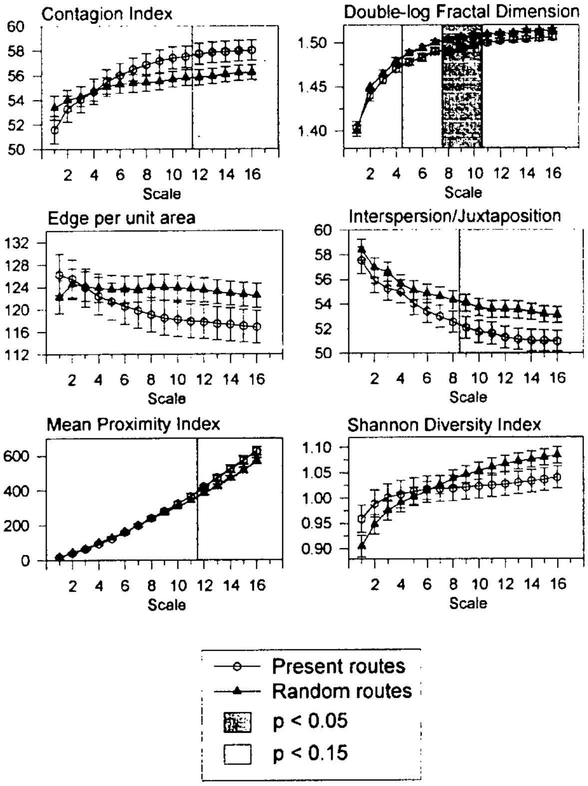

Figure 3. Mean ± SE for 6 landscape heterogeneity indices measured across 16 spatial scales for present (n = 133) and random (n = 266) singing-ground survey routes in Pennsylvania, 1986–1990. Significance levels ($P \leq 0.5$, $P \leq 0.15$) based on two-sample randomization tests are indicated.

Differences between means for present and random routes were greatest at spatial scale 1 for agricultural land, deciduous forest, developed land; at spatial scale 2 for coniferous forest and wetlands; and at spatial scale 3 for water. Differences between route types for land cover variables generally decreased with increasing spatial scale.

At broad spatial scales, present routes exhibited significantly larger values for the contagion index and the mean proximity index and smaller values for the double-log fractal dimension and the interspersion/juxtaposition index (Figure 3). No significant differences were detected for the Shannon diversity index or edge per unit area. Differences between means for present and random routes were greatest at spatial scale 8 for the double-log fractal dimension and at spatial scale 16 for the contagion index, interspersion/juxtaposition index, and mean proximity index. Differences between route types for landscape heterogeneity indices generally increased with increasing spatial scale.

Discussion

For land cover variables, differences between route types were most pronounced at finer spatial scales. These habitat relations are consistent with previously demonstrated fine-scale woodcock habitat relations: positive associations with mesic forests, wetlands, and water and negative associations with agricultural and urbanized lands (Wishart and Bider 1976; Gutzwiller et al. 1980; Kinsley et al. 1980; Gutzwiller et al. 1983; Hudgins et al. 1985; Straw et al. 1986). However; differences between present and random routes generally decreased for nearly all land cover variables as spatial scale increased. In the context of habitat modeling, the observed differences between route types for land cover variables suggested that more accurate models of woodcock habitat quality may be constructed by considering land cover variables measured at fine spatial scales.

No previous research has explicitly considered associations between woodcock habitat use and landscape heterogeneity at multiple, broad spatial scales. For landscape heterogeneity indices, differences between route types were most pronounced at broader spatial scales but generally exhibited only marginal significance. Thus, habitat selection by American woodcock at broad spatial scales may be more strongly associated with landscape heterogeneity than with land cover types. In contrast with land cover data, landscape heterogeneity indices measured at broad spatial scales may help to produce more accurate models of woodcock habitat suitability.

Our results also provided insight into the landscape structure associated with habitats used by woodcock; however, these conclusions are meaningful only when considered at the particular scale from which they were measured (McGarigal and Marks 1995). At fine spatial scales woodcock have often been associated with fragmented landscapes composed of a variety of interspersed habitat components (Liscinsky 1972; Sepik et al. 1981). With the relatively coarse grain and large extent of our analyses, present routes had higher values for the contagion and mean proximity indices and lower values for the double-log fractal dimension and interspersion/juxtaposition indices than random routes at broad spatial scales. This result indicated that present routes occurred in broad-scale landscapes that were less fragmented and less heterogeneous than random routes. Woodcock were associated with landscapes composed of relatively homogeneous habitats, although fine-scale habitat selection may yet focus on more heterogeneous habitats within these more homogenous broad-scale landscapes.

Our results also demonstrated the potential usefulness of broad-scale land cover databases for identifying woodcock breeding habitat. Few other researchers have explored the use of remotely sensed data and GIS for identifying woodcock habitat (see Perras et al. 1988; Couture et al. 1993; Storm et al. 1995). Using GIS in conjunction with broad-scale land cover databases, such as the MRLC database, allows relatively quick and easy assessment of wildlife habitat suitability— and inventory of the habitat—over very large geographic areas. Furthermore, broad-scale land cover databases are often widely available, thereby making widespread applicability of habitat models created from these databases convenient and effective.

Our analyses indicated possible multiscale habitat selection by American woodcock and provided an approach for exploring the spatial scales at which habitat relations were most pronounced. With this increased understanding of woodcock-habitat relations at previously unexplored spatial scales, we have a basis for the development of more accurate predictive models of woodcock habitat quality. Once developed, such models will be valuable tools for the assessment of woodcock habitat suitability over very large geographic areas. Additionally, broad-scale identification of areas of increased woodcock habitat suitability should prove valuable to public and private land owners interested in the management of regional woodcock populations.

Acknowledgments

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References

Addicott, J. F., J. M. Aho, M. F. Antolin, D. K. Pakilla, J. S. Richardson, and D. A. Soluk. 1987. Ecological neighborhoods: Scaling environmental patterns. Oikos 49:340–346.

Afifi, A. A., and V. Clark. 1996. Computer-aided multivariate analysis. Third edition. Chapman & Hall, London.

Bruggink, J. G. 1996. American woodcock harvest and breeding population status, 1996. U.S. Fish and Wildlife Service, Laural, Maryland. 14 pp.

Clarke, J. D., J. E. Dunn, and K. G. Smith. 1993. A multivariate model of female back bear habitat use for a geographic information system. Journal of Wildlife Management 57:519–526.

Couture, R., M. Babin, and S. Perras. 1993. Survey of woodcock habitat with Landsat: Possibilities and limitations of remote sensing. Page 50–56 *in* J. R. Longcore and G. F. Sepik, editors. Proceedings of the eighth American woodcock symposium. U.S. Fish and Wildlife Service Biological Report 16. Washington, D.C.

Duke, G. E. 1966. Reliability of censuses of singing male woodcocks. Journal of Wildlife Management 30:697–707.

Efron, B. 1982. The jackknife, the bootstrap and other resampling plans. Society for Industrial and Applied Mathematics. Philadelphia, Pennsylvania.

Gutzwiller, K. J., C. H. Strauss, K. R. Kinsley, J. S. Wakeley, and G. L. Storm. 1980. Relationships between land use and woodcock habitat in Pennsylvania, with guidelines for rangewide research. Pages 86–96 *in* T. J. Dwyer and G. L. Storm, technical coordinators. Woodcock ecology and management. U.S. Fish and Wildlife Service Wildlife Research Report 14. Washington, D.C.

Gutzwiller, K. J., K. R. Kinsley, 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 47:535–540.

Hosmer, D. W., Jr., and S. Lemeshow. 1989. Applied logistic regression. John Wiley & Sons, New York.

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.

Kinsley, K. R., S. A. Liscinsky, and G. L. Storm. 1980. Changes in habitat structure on woodcock singing grounds in central Pennsylvania. Pages 40–50 *in* T. J. Dwyer and G. L. Storm, technical coordinators. Woodcock ecology and management. U.S. Fish and Wildlife Service Wildlife Research Report 14. Washington, D.C.

Kotliar, N. B., and J. A. Wiens. 1990. Multiple scales of patchiness and patch structure: A hierarchical framework for the study of heterogeneity. Oikos 59:253–260.

Liscinsky, S. A. 1972. The Pennsylvania woodcock management study. Research Bulletin 171, Pennsylvania Game Commission, Harrisburg, Pennsylvania.

Lyon, J. G., J. T. Heinen, R. A. Mean, and N. E. G. Roller. 1987. Spatial data for modeling wildlife habitat. Journal of Survey Engineering 113:88–100.

Manly, B. F. J. 1991. Randomization and Monte Carlo methods in biology. Chapman & Hall, New York.

McGarigal, K., and B. J. Marks. 1995. FRAGSTATS: Spatial pattern analysis program for quantifying landscape structure. U.S. Forest Service General Technical Report PNW-GTR-351.

McGinley, K. E. 1996. Habitat selection in spring by male American woodcock in Maine. M. S. Thesis, University of Massachusetts, Amherst.

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.

Milne, B. T., K. M Johnston, and R. T. T. Forman. 1989. Scale-dependent proximity of wildlife habitat in a spatially-neutral Bayesian model. Landscape Ecology 2:101–110.

Mladenoff, D. J., T. A. Sickley, R. G. Haight, and A. P. Wydeven. 1995. A regional landscape analysis and prediction of favorable gray wolf habitat in the northern Great Lakes region. Conservation Biology 9:279–294.

Mooney, C. Z., and R. D. Duval. 1993. Bootstrapping: A nonparametric approach to statistical inference. Sage Publications, Inc., Newbury Park, California.

Pearson, S. M. 1993. The spatial extent and relative influence of landscape-level factors on wintering bird populations. Landscape Ecology 8:3–18.

Pereira, J. M. C., and R. M. Itami. 1991. GIS-based habitat modeling using logistic multiple regression: A study of the Mt. Graham red squirrel. Photogrammetric Engineering and Remote Sensing 57:1475–1486.

Perras, S., F. Bonn, Q. H. J. Gwyn, M. Babin, and R. Couture. 1988. Inventory of the habitat of the American woodcock (*Scolopax minor*) by remote sensing. Photo Interpretation, 1998-1, fascicule 3:19–24.

Resampling Stats Inc. 1991. Resampling Stats user's guide. Arlington, Virginia.

SAS Institute Inc. 1989. SAS/STAT user's guide: volume 2, GLM - VARCOMP, version 6, fourth ed. Cary, North Carolina.

Sepik, G. F., R. B. Owen, Jr., and M. W. Coulter. 1981. A landowner's guide to woodcock management in the northeast. Miscellaneous Report 253, Maine Agricultural Experiment Station, Orono.

Storm, G. L., M. J. Lovallo, D. S. Klute, W. M. Tzilkowski, and T. Delong. 1995. Predicting American woodcock presence in Pennsylvania from local and landscape-scale habitat variables. Northeast Wildlife 52:39–48.

Straw, J. A., Jr., J. S. Wakeley, and J. E. Hudgins. 1986. A model for management of diurnal habitat for American woodcock in Pennsylvania. Journal of Wildlife Management 50:378–383.

Straw, J. A., Jr., 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.

Tautin, J. P. H. Geissler, R. E. Munro, and R. S. Pospahala. 1983. Monitoring the population status of American woodcock. Transactions of the North American Wildlife and Natural Resources Conference 48:376–388.

Thompson, S. K. 1992. Sampling. John Wiley and Sons, Inc., New York.

Turner, M. G. 1989. Landscape ecology: The effect of pattern on process. Annual Review of Ecology and Systematics 20:171–197.

Turner, M. G., V. H. Dale, and R. H. Gardner. 1989. Predicting across scales: Theory development and testing. Landscape Ecology 3:235–252.

Turner, M. G., R. H. Gardner, and R. V. O'Neill. 1995. Ecological dynamics at broad scales. Bioscience Supplement S-29-S-35.

Urban, D. L., R. V. O'Neill, and H. H. Shugart, Jr. 1987. Landscape ecology: A hierarchical perspective can help scientists understand spatial patterns. Bioscience 37:119–127.

U.S. Fish and Wildlife Service. 1990. American woodcock management plan. U.S. Fish and Wildlife Service, Washington, D. C.

Vogellman, J. E., S. M. Howard, and T. Sohl. 1996. Regional land cover characterization using multiple sources of intermediate-scale data. Proceedings of the 1996 International Geoscience and Remote Sensing Symposium 1:246–247.

Wiens, J. A. 1989. Spatial scaling in ecology. Functional Ecology 3:385–397.

Williamson, L. L. 1993. The American woodcock management plan: Can it work? Pages 105–108 *in* J. R. Longcore and G. F. Sepik, editors. Proceedings of the eighth American woodcock symposium. U.S. Fish and Wildlife Service Biological Report 16. Washington, D.C.

Wishart, R. A., and J. R. Bider. 1976. Habitat preferences of woodcock in southwestern Quebec. Journal of Wildlife Management 40:523–531.

Habitat Management for Wintering American Woodcock in the Southeastern United States

by

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Abstract. Although much information has been gathered on American woodcock (*Scolopax minor*) wintering east of the Lower Mississippi Alluvial Valley, that information has not been compiled into a single source assembled for land managers. The objectives of this paper are to pose a few important questions that should be addressed before implementing a land management plan and to briefly review some of the management options available to managers that are interested in helping woodcock. The primary focus is on timber management because a sound timber management plan, it is believed, will be advantageous to wintering woodcock.

Keywords: Land management, *Scolopax minor*, timber management.

Roberts (1993) concluded that although much research had been conducted on wintering American woodcock (*Scolopax minor*), there was no compilation of information from that research into guidelines useful for managers. At present, there is no readily available land management guide for the Southeast. I intend to introduce some of the questions that need to be answered before implementing management practices for woodcock wintering in woodlands east of the Lower Mississippi Alluvial Valley, and to discuss some land management options available to land managers.

Process

The first decision that every land manager must make is whether sufficient time and money are available to accommodate management for wintering woodcock. Every manager is aware that modern multiresource management strategies have resulted in many demands on public lands. If a decision to manage for wintering woodcock is made, the decision will probably be at a cost to the management of something else.

The initial decision-making process should include an inventory of the property to be managed and an evaluation of how it fits into the landscape. For example, upland hardwoods are not used much by wintering woodcock (Krementz and Pendleton 1994). Thus, if the property to be managed is entirely made up of upland hardwoods, it might be prudent to reconsider altering present land management guidelines to accommodate woodcock. The juxtaposition of the property in relation to the landscape also needs to be considered. If all surrounding properties have been clear-cut recently and the property to be managed is composed of older extensively forested stands, it would not make much sense to clear-cut your property.

Because woodcock are polygynous (Dwyer et al. 1988), the influence of males on population levels is less important than that of females (Aldrich 1973). Thus it is important, through a review of the literature (Cade 1985; Roberts 1993; Keppie and Whiting 1994; Straw et al. 1994), to determine if there are any sex-specific differences in habitat use, survival rates, or movements. For example, Berdeen and Krementz (1998) found that females flew

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significantly less distance (230 m + 32.1) to nocturnal fields than did males (525 m + 53.1). Priority should be given to such differences when managing for the needs of female woodcock.

Habitat Management

Food is a difficult item to manage for woodcock because the primary food of woodcock is earthworms (Oligochaeta; Roberts 1993; Keppie and Whiting 1994). Further, the importance of earthworm abundance in explaining woodcock distributions is not clear (Keppie and Whiting 1994). Thus, even given the capacity to manage for earthworms, woodcock may not respond to alteration of local earthworm densities or distributions. Water requirements are not a critical management concern (Keppie and Whiting 1994). Because woodcock frequent a wide variety of cover types (Roberts 1993) general guidelines on management practices that can be used across broad categories of habitats are most appropriate. Cover types in the Southeast are often intertwined to such an extent that managing for a single habitat type is almost impossible.

Management of habitat for wintering woodcock should include nocturnal and diurnal habitat. Because woodcock sometimes move from diurnal habitat to a completely different habitat type at night (Krementz et al. 1995; Berdeen and Krementz 1998), it is important to design a management plan that provides both types of habitat in close proximity.

Nocturnal Habitat

Woodcock usually move from wooded diurnal cover to a field at night about every other day (Berdeen and Krementz 1998). Woodcock move to fields to feed, avoid predation, or perform courtship activities (Roberts 1993). Woodcock demonstrate distinct preferences for particular types of fields at night. Berdeen and Krementz (1998) documented that woodcock that frequented palustrine forested wetlands during the day preferred either young clear-cuts or old fields over either pastures or hayfields at night. They also found that 80% of the variation in woodcock visits to clear-cuts and old fields was explained by the presence of vegetation, primarily shrubs, between 1 and 2 m in height, and the presence of bare ground. Woodcock apparently need overhead cover to reduce the risk of predation, and the presence of bare ground allows woodcock easy access to soil while foraging. Access to bare soil is important because sod forming grasses, which are common throughout the Southeast, are difficult to move through and to probe in (Cade 1985). Further, Berdeen and Krementz (1998) found that given a choice, woodcock preferred fields >5 ha over smaller fields. Most important, Berdeen and Krementz (1998) found that females, on average, moved <250 m between their diurnal locations and nocturnal fields. This differed somewhat from the Lower Coastal Plain where daily movements were about 700 m (Krementz et al. 1995), which suggested geographic differences. Daily crepuscular movements >1.1 km have never been reported (Krementz et al. 1995). Thus, a land management plan should include timber cuts (>5 ha) close (<1 km) to heavily used diurnal habitats, usually in palustrine forested wetlands. However, some timber cuts should be located away from floodplains (>1 km) to allow alternative sites during bottomland flooding. Also, because vegetation in these fields grows quickly, they become less attractive to woodcock for nocturnal use within 5–8 years, depending on the site. For this reason, it is important to rotate cuts around diurnal habitat to provide a variety of different-aged stands.

The use of intensive management practices such as mowing, burning, and herbicide application can be used to set back succession to maintain the attractiveness of some nocturnal fields. J. Welch (University of Georgia, personal communication) compared the relative attractiveness to woodcock of old fields treated by mowing, burning, and mowing and burning combined. He found that fields treated by burning alone were the most attractive. Burning is also relatively inexpensive compared to mowing or using herbicides.

The use of pastures or hayfields by woodcock varies from high in the Mississippi Alluvial Valley (Glasgow 1958) to low in the Georgia Piedmont (Berdeen and Krementz 1998). If pastures are an integral part of a land management plan, those pastures should be moderately grazed (Glasgow 1958), and sod forming grasses should be discouraged. Berdeen and Krementz (1998) observed that most woodcock use of pastures and hayfields was along field edges. Creation of a 10-m-wide fallow field border will encourage woodcock to frequent these edges. However, this practice may put woodcock at higher risk of predation because many raptors hunt from field edges.

The relation between preferred nocturnal habitats (e.g., clear-cuts) and survival is not known. Managers should be aware that it is possible that by attracting woodcock to a field and increasing local abundance, they also may attract predators of woodcock and thereby reduce overwinter survival.

Diurnal Habitat

Krementz and Pendleton (1994) found that, during the day, woodcock preferred shrub, bottomland hardwoods, and pine–hardwoods and used pine plantations according to availability. Shrub land can be created by clear-cutting without replanting. These stands are most attractive for about 5–15 years. As these stands mature, they typically regenerate into either bottomland hardwoods or pine–hardwood stands depending on the history and location of the stand. These preferred habitat types require little management after cutting. Pine plantations are often intensively managed. This reduces their attractiveness to woodcock because ground and midstory vegetation are reduced or removed.

Regardless of the diurnal habitat type, some management may be needed. For example, water management is sometimes needed because flooding is the major cause of large scale and usually permanent within-winter woodcock movements (Krementz and Pendleton 1994). This observation differs from the commonly held belief that woodcock move during the winter in response to unusually cold temperatures (Roberts 1993). Woodcock often frequent sites that are prone to flooding. To accommodate woodcock during periods of flooding, treated stands should be located near (~1 km) diurnal sites that flood.

Roads placed in clear-cuts can act as dams and eliminate use of the site by woodcock because water accumulates quickly and drains slowly (personal observation). Management of water in managed stands requires that roads are located so that they do not restrict the movement of water across the site.

It also is necessary to locate a few cuts in wetter sites in case of drought. Soils used by wintering woodcock are often high in clay content (Roberts 1993), and such soils become concrete-like during drought and inhibit probing by woodcock for earthworms (Krementz and Pendleton 1994). Thus, during drought, having diurnal sites available within the floodplain or around seeps can be critical.

Timber Management

Woodcock use all age classes of managed timber except mid-aged pine plantation stands (15–30 years, Krementz and Pendleton 1994). However, some timber management practices produce cover that tends to be more attractive to woodcock than others.

Following clear-cutting, timberlands are often replanted to pine. Roberts (1993) and Krementz and Pendleton (1994) found that the most preferred diurnal habitat type is shrub land. Shrub lands are clear-cut sites not replanted to pine and where the succeeding vegetation has grown to about 2 m. These stands will eventually develop into either mixed pine–hardwood or hardwood stands. Although the economics of such stands must be reviewed, they are optimal for woodcock.

Seedbed preparation usually is conducted before a site is replanted with pine. Because less intensive methods result in sites that are patchy, these methods result in sites that are preferred by woodcock (Berdeen and Krementz 1998). It is this horizontal and vertical patchiness that allows woodcock to escape predators, forage, rest, and conduct courtship activities.

Spacing of seedstock is an important consideration because overstocking accelerates elimination of ground and understory vegetation. Wide spacing, e.g., 2.5 X 2.5 m, will prolong the attractiveness of the site through a longer period of understory duration (P. B. Hamel, U.S. Forest Service, personal communication). After a stand has reached the closed canopy stage, it should be thinned as soon as possible to allow light to get to the forest floor to stimulate plant growth. Woodcock will readily use a sparsely-canopied pine stand if there is sufficient shrub cover (Johnson and Causey 1982).

Fire is an integral part of any pine timber management plan, and it is a useful tool for managing woodcock habitat. Woodcock habitat will respond positively to fire (Johnson and Causey 1982). Cool season burns tend to promote shrubs and trees (woody vegetation) while warm season burns tend to promote grasses and forbs (Brender 1973). Cool season burns are advised because woodcock use shrubs and trees more than grasses and forbs in the understory of canopied stands (Cade 1985). The objective of the cool season burn should be to eliminate ground cover but leave some vegetation in the 1–2 m zone. Woodcock use sites where travel on the ground is easy, but with sufficient overhead cover to escape predation (Berdeen and Krementz 1998).

Stand age is an important factor because woodcock tend to use managed stands early and late in the rotation. In a typical managed pine stand, woodcock avoid stands between 15 and 30 years old (Krementz et al. 1995). Two options are available to the manager interested in promoting woodcock. Shorter rotations (20 years) can be used for pulpwood production. Doing so would only preclude woodcock for about 5 years of the rotation and timber product income would be generated quickly. The other option would be to manage for sawtimber but thin the stand at an early stage (e.g., 15 years) to promote understory development earlier in the life of the stand.

Stand size is a sensitive issue with the public. Some public lands agencies limit clear-cut sizes to <25 ha, in part, for public relations. Woodcock are area sensitive, and prefer stands >5 ha up to about 40 ha (Berdeen and Krementz 1998). Smaller cuts greatly increase the interior to edge ratio and this may give avian predators a better chance to observe woodcock. Predation also may make seedtree cuts problematic unless the seedtrees are removed shortly after they have had a chance to drop their seeds. Maintenance and promotion of snags in clear-cuts through injecting and girdling also may enhance predation.

Management of native and domestic herbivores is often necessary. The objective is to avoid the extremes, light or heavy grazing (Glasgow 1958). Managing domestic livestock should be a matter of rotating animals among stands. Native herbivore management will have to be accomplished through harvesting. Feral swine should be managed because their habit of rooting, especially in bottomlands, is quite destructive in areas most used by woodcock.

Concluding Remarks

Woodcock populations are declining (Bruggink 1996); land managers in the Southeast can help to slow or reverse these declines. By slightly altering land management plans, woodland habitat can be enhanced. The primary thing to keep in mind about managing for wintering woodcock is that they are attracted to moist sites with lots of vegetation between 1–2 m tall and little vegetation on the ground. Keep a variety of different habitat types available to get woodcock through unusual times (e.g. drought, floods) and woodcock will take care of the rest.

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N.B. Between the time of submission and publication of this article, a bulletin dealing with land management for wintering woodcock entitled, "Woodcock in the Southeast: Natural History and Management for Landowners" by David G. Krementz and Jeffrey J. Jackson was published. This relevant bulletin can be accessed through the internet at http://www.ces.uga.edu/pubcd/b1183.htm#."

References

Aldrich, J. W. 1973. Disparate sex ratios in waterfowl. Pages 482–489 *in* D. S. Farner, editor. Breeding biology of birds. National Academy of Sciences. Washington, D.C.

Berdeen, J. B., and D. G. Krementz. 1998. The use of fields at night by wintering American woodcock. Journal of Wildlife Management 62:939–947.

Brender, E. V. 1973. Silviculture of loblolly pine in the Georgia Piedmont. Georgia Forestry Research Council. Report 33. Macon. 74 pp.

Bruggink, J. G. 1996. American woodcock harvest and breeding population status, 1996. U.S. Fish and Wildlife Service, Laurel, Maryland. 14 pp.

Cade, B. S. 1985. Habitat suitability index models: American woodcock (wintering). U.S. Fish and Wildlife Service Biological Report 82. 23 pp.

Dwyer, T. J., G. F. Sepik, E. L. Derleth, and D. G. McAuley. 1988. Demographic characteristics of a Maine woodcock population and effects of habitat management. U.S. Fish and Wildlife Service, Fish and Wildlife Research Report 4. 29 pp.

Glasgow, L. L. 1958. Contributions to the knowledge of the ecology of the American woodcock, *Philohela minor* (Gmelin), on the wintering range in Louisiana. PhD dissertation, Texas A&M University, College Station. 158 pp.

Johnson, R. C., and M. K. Causey. 1982. Use of longleaf pine stands by woodcock in southern Alabama following prescribed burning. Pages 120–125 *in* T. J. Dwyer and G. L. Storm, technical coordinators. Woodcock ecology and management. U.S. Fish and Wildlife Service Wildlife Research Report 14. Washington, D.C.

Keppie, D. M., and R. M. Whiting, Jr. 1994. American woodcock (*Scolopax minor*). Pages 1–28 *in* A. Poole and F. Gill, editors. The Birds of North American 100. Philadelphia: The Academy of Natural Sciences: The American Ornithologists' Union. Washington, D.C.

Krementz, D. G., and G. W. Pendleton. 1994. Diurnal habitat use of American woodcock wintering along the Atlantic coast. Canadian Journal of Zoology 72:1945–1950.

Krementz, D. G., J. S. Seginak, and G. W. Pendleton. 1995. Habitat use at night by wintering American woodcock in coastal Georgia and Virginia. Wilson Bulletin 107:686–697.

Roberts, T. H. 1993. The ecology and management of wintering woodcocks. Pages 86–96 *in* J. R. Longcore and G. F. Sepik, editors. Proceedings of the eighth American woodcock symposium. Fish and Wildlife Service Biological Report 16. Washington, D.C.

Straw, J. A., Jr., D. G. Krementz, M. W. Olinde, and G. F. Sepik. 1994. American woodcock. Pages 97–116 *in* T. C. Tacha and C. E. Braun, editors. Migratory shore and upland game bird management in North America. International Association Fish and Wildlife Agencies, Washington, D.C.

Sources of Variation in Survival and Recovery Rates of American Woodcock

by

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Abstract. All bandings and recoveries of American woodcock (*Scolopax minor*) since the last similar investigation of survival and recovery rates were examined for this study. The previous parameter estimates from the Eastern Region were augmented with 4 years of bandings. Banding effort in the Central Region was sufficient to conduct analyses for the 5 years after the previous analyses. Females generally had higher survival rates than males but recovery rates were not different. Adults had higher survival rates and lower recovery rates than young. Recovery rates, but not survival rates, were variable over time. Survival rates of woodcock from the Eastern Region were lower and recovery rates were higher compared to the Central Region. The calculated rate of population increase (λ) for the Eastern Region (0.89) indicates that survival rates will need to be increased before the current population decline can be reversed. Poor data sets hampered our ability to draw strong conclusions.

Keywords: American woodcock, harvest rates, production rates, recovery rates, *Scolopax minor*, survival rates.

Since Dwyer and Nichols (1982) analyzed variation in survival and recovery rates of American woodcock *(Scolopax minor*), woodcock populations have declined in both the Eastern and Central regions (Bruggink 1996). The long-term declines in woodcock populations have caused the U.S. Fish and Wildlife Service (USFWS) to alter present harvest regulations. Updated survival and recovery rates for woodcock would be useful to the USFWS for making such decisions and understanding woodcock population dynamics.

Our objectives were to update estimates of woodcock survival and recovery rates, compare our estimates to those of Dwyer and Nichols (1982), and examine sources of variation in these rates. We also estimated production rates and developed population projection models for each region. Finally, we examined the relation between direct recovery rates (an index of harvest rates) and changes in harvest regulations.

Methods

We obtained woodcock banding and recovery files from the U.S. Geological Survey Patuxent Wildlife Research Center Bird Banding Laboratory, Laurel, Maryland. We created banding files for the Eastern and Central regions as defined by Coon et

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al. (1977), and included a slightly larger area than was used by Dwyer and Nichols (1982). Our areas included all bandings from entire states (except for Indiana, see below) and no bandings from any provinces. Banding files included birds banded from 1 April through 31 August, which was longer than the banding period used by Dwyer and Nichols (1982, 1 May–31 July). This long banding period (April–August) was not optimal but the small number of woodcock banded forced us to be liberal with the banding period. Recoveries were from normal, wild birds reported shot or found dead during subsequent hunting seasons (1 September–15 February). We estimated survival and recovery rates using the models of Brownie et al. (1985). We eliminated all bandings and recoveries from Indiana because virtually all of them were from a single public hunting area where the woodcock population was subjected to both unusually high harvest rates and band solicitation (R. P. Stonebraker, Indiana Department of Natural Resources, personal communication).

Woodcock were grouped into 3 age classes: adults (birds $\geq$ 1 year old), young (birds < 1 year old that were capable of sustained flight), and locals (birds $\leq$ 3 weeks old and incapable of sustained flight). Almost all local birds were banded in Michigan. We used three sex categories: male, female, and unknown. Only locals were categorized as sex unknown. Bandings and recoveries of local birds were not included in the survival analyses.

We tested for variation in survival and recovery rates based on sex, age, time, and management region. We tested the hypotheses that neither survival or recovery rates varied by sex, age, or time, and that there was no difference in survival or recovery rates between regions. We tested hypotheses using program CONTRAST, which employs modified chi-square (χ^2) analyses (Sauer and Williams 1989).

After examining variation in survival and recovery rates, we followed the methods of Dwyer and Nichols (1982) to determine an estimate of production rate for each region and a region-specific population growth rate. We estimated production rate by dividing the long-term average age ratio for each region (Bruggink 1996) by the region-specific female differential vulnerability to harvest ($\hat{f}_y/\hat{f}_a$). We defined female differential vulnerability as the quotient of the recovery rates of young divided by the recovery rate of adults. We believe that all assumptions made by Dwyer and Nichols (1982) regarding fidelity to harvest units (regions) remained true; a necessary requirement for production rate estimates to be valid. We then used a population projection matrix (Martin et al. 1979), which assumed constant survival and production rates over time, and a 50:50 sex ratio of young birds to estimate the population growth rate.

Finally, we tested the hypothesis that direct recovery rates were not different before and after the change in harvest regulations in 1985 in the Eastern Region—the 65 day season was shortened to 45 days and the 5 bird daily bag limit was reduced to 3 birds. For controls, we compared the direct recovery rates before and after 1985 in the Central Region where no change in regulations occurred. A comparison of the direct recovery rates was made using a Wilcoxon rank sum test to address whether overall direct recovery rates differed before and after regulation changes within region. We ran the same test on local woodcock from the Central Region because this data set contained larger numbers of bandings and recoveries than the comparable Eastern Region data set. To eliminate the possibility of a geographic effect on these comparisons, we compared direct recovery rates between regions before and after regulation changes in the Eastern Region and for the 20-year period 1975–94. Direct recovery rates should reflect harvest rates in a more direct fashion than indirect recovery rates (Anderson and Burnham 1976). Indirect recovery rates are from birds banded during the preseason and recovered in any hunting season after the initial hunting season.

Results

Parameter Estimates

Because few woodcock were banded in the Eastern Region after 1979, we estimated survival and recovery rates from 1967 to 1979 for males and from 1967 to 1978 for females (Table 1). These data sets only differed from the data used by Dwyer and Nichols (1982) by 4 years for males and 3 years for females. Fit of the male data to model H_{02} was reasonable ($\chi^2 = 24.13$, 29 df, $P = 0.72$) and statistics from the likelihood ratio test indicated that model H_{02} was the most appropriate model ($\chi^2 = 85.65$, 24 df, $P < 0.001$). Model H_{02} assumes that recovery rates are year specific and survival rates are constant (Brownie et al. 1985). Data for females were more problematic as the goodness-of-fit test statistic for model H_{02} was poor ($\chi^2 = 55.33$, 38 df, $P = 0.03$). Examination of the standard normal deviates under the H_{02} model indicated that both adults and young had two and four deviates, respectively, that caused the large chi-square value. In all instances, the deviates indicated that there were several birds recovered more than 3 years after banding; in one case, a young bird survived seven hunting seasons. However, because the likelihood ratio test between models H_{01} and H_{02} indicated that H_{02} was a more appropriate model ($\chi^2 = 48.41$, 22 df, $P < 0.001$), we selected model H_{02} for females in the Eastern Region despite the poor fit.

Banding effort in the Central Region after 1969–77, the time period examined by Dwyer and Nichols (1982), was adequate to estimate survival and recovery rates from 1978–82 for both males and females (Table 2). Fit of the data for males to model H_{02} was good ($\chi^2 = 3.17$, 3 df, $P = 0.37$), but the

Table 1. Estimates of survival and recovery rates of woodcock banded preseason in the Eastern Region using model H_{02} of Brownie et al. (1985).

		Adults				Young			
		Recovery rate		Survival rate		Recovery rate		Survival rate	
Sex	Year	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Male	1967	0.059	0.015			0.092	0.018		
	1968	0.067	0.014			0.073	0.014		
	1969	0.073	0.012			0.095	0.015		
	1970	0.034	0.008			0.057	0.011		
	1971	0.032	0.006			0.063	0.009		
	1972	0.040	0.007			0.038	0.007		
	1973	0.048	0.007			0.041	0.007		
	1974	0.047	0.008			0.022	0.008		
	1975	0.039	0.009			0.032	0.012		
	1976	0.037	0.010			0.011	0.008		
	1977	0.038	0.011			0.019	0.009		
	1978	0.042	0.012			0.016	0.009		
	1979	0.023	0.010			0.029	0.017		
Mean[a]		0.044	0.003	0.343	0.025	0.045	0.003	0.234	0.031
Female	1967	0.055	0.018			0.051	0.015		
	1968	0.066	0.014			0.103	0.023		
	1969	0.054	0.010			0.076	0.016		
	1970	0.029	0.007			0.055	0.012		
	1971	0.029	0.006			0.038	0.008		
	1972	0.037	0.006			0.037	0.008		
	1973	0.037	0.006			0.054	0.010		
	1974	0.042	0.008			0.045	0.012		
	1975	0.027	0.007			0.020	0.012		
	1976	0.026	0.008			0.043	0.021		
	1977	0.018	0.007			0.019	0.011		
	1978	0.032	0.010			0.024	0.012		
Mean[b]		0.038	0.004	0.522	0.028	0.047	0.004	0.394	0.052

[a] Data set included 3,519 bandings and 233 recoveries of adults and 5,043 bandings and 319 recoveries of young.

[b] Data set included 2,454 bandings and 181 recoveries of adults and 3,491 bandings and 255 recoveries of young.

likelihood ratio test statistic between models H_{02} and H_{01} was not significant ($\chi^2 = 3.44$, 9 df, $P = 0.94$) indicating that model H_{01} was appropriate. Model H_{01} assumes that both recovery and survival rates are constant over time (Brownie et al. 1985). We did not obtain convergence of parameter estimates for females under model H_{02}. We used model H_1 parameter estimates for females, and this model assumes that both recovery and survival rates are year specific (Brownie et al. 1985).

Although our data sets for the Eastern Region overlapped with the previously analyzed data of Dwyer and Nichols (1982), and the estimates for females from the Central Region were not well estimated, we proceeded with our investigations because these are the only data available and because no updates of these parameters have been estimated for 15 years. The reader should note that parameter estimates are not available for either region after 1982.

Sex-specific Variation

Recovery rates varied ($P = 0.03$) between sexes for adults in the Eastern Region with males having higher recovery rates than females (Table 3). No other comparison of recovery rate for either region or age was different ($P > 0.16$). However, the differences between point estimates for all other comparisons were in the same direction, i.e., females had higher recovery rate estimates than males (Table 2). To investigate the possibility of a sex effect that was not being detected by the multiple test runs using CONTRAST, we constructed a test that combined the recovery rates of adult females and young from the Eastern Region and Central Region and compared them against the appropriate recovery rates for males. The difference between the combined female and male recovery rates was small (0.002) resulting in no difference between female and male recovery rates ($\chi^2 = 0.22$, 1 df, $P = 0.64$). Thus, the pattern that females always had slightly higher recovery rates was not supported.

Survival rates were higher for both adult and young females ($P < 0.01$) in the Eastern Region (Table 3). Neither adult nor young survival rates differed between sexes in the Central Region ($P > 0.6$, Table 3).

Age-specific Variation

Simultaneous comparisons of survival and recovery rates by age indicated that the only difference was between young and adult males in the Eastern Region ($P < 0.01$, Table 4). There was no age-specificity in either survival or recovery rates in the Central Region (Table 4). Poor precision in parameter estimation in the Central Region may preclude strong conclusions there.

Further examination of age-specific survival and recovery rates in the Eastern Region using separate

Table 2. Estimates of survival and recovery rates of woodcock banded preseason (1978–1982) in the Central Region using model H_{01} for males and model H_1 (Brownie et al. 1985) for females.

		Adults				Young			
		Recovery rate		Survival rate		Recovery rate		Survival rate	
Sex	Year	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Male									
Mean[a]	1978-1982	0.016	0.005	0.548	0.098	0.020	0.004	0.386	0.139
Female	1978	0.013	0.013	0.520	0.337	0.028	0.010	0.235	0.138
	1979	0.006	0.006	0.599	0.347	0.021	0.011	0.201	0.118
	1980	0.065	0.027	0.833	0.550	0.042	0.016	0.494	0.325
	1981	0.030	0.015	0.362	0.323				
	1982	0.037	0.026						
Mean[b]		0.030	0.009	0.578	0.121	0.030	0.007	0.310	0.124

[a] Data set included 470 bandings and 15 recoveries of adults and 1,245 bandings and 40 recoveries of young.

[b] Data set included 323 bandings and 22 recoveries of adults and 690 bandings and 34 recoveries of young.

Table 3. Results of testing hypotheses regarding sex-specific variation in woodcock recovery and survival rates by age class.

Management unit	Age	Years	Recovery rates[a]				Survival rates[b]			
			$\hat{f}_f - \hat{f}_m$	df	χ^2	P	$\hat{S}_f - \hat{S}_m$	df	χ^2	P
Eastern	Adult	1967–1978	-0.009	1	4.522	0.03	0.178	1	22.571	< 0.001
	Young	1967–1978	0.001	1	0.019	0.89	0.160	1	7.00	0.01
Central	Adult	1978–1982	0.014	1	1.95	0.16	0.030	1	0.019	0.89
	Young	1978–1982	0.010	1	1.57	0.21	-0.076	1	0.164	0.69

[a] Results of a χ^2 test (Hines and Sauer 1989) of the null hypothesis that recovery rates for males (m) and females (f) were similar. The estimated difference between the mean annual recovery rates of males (m) and females (f) is denoted by $\hat{f}_f - \hat{f}_m$

[b] Results of a χ^2 test (Hines and Sauer 1989) of the null hypothesis that survival rates for males (m) and females (f) were similar. The estimated difference between the mean annual survival rates of males (m) and females (f) is denoted by $\hat{S}_f - \hat{S}_m$

tests demonstrated that adult females had lower recovery rates ($P = 0.05$) and higher survival rates ($P = 0.03$) than young females (Table 4). Adult males in the Eastern Region had higher survival rates ($P = 0.01$) than young males. This same pattern of generally higher recovery rates and lower survival rates of young compared to adults also occurred in the Central Region, but parameter estimates were imprecise.

Temporal Variation

Recovery rates exhibited strong temporal variation for both males and females in the Eastern Region ($P < 0.001$, Table 5), but not for males in the Central Region ($P = 0.94$) where recovery rates were modeled as constant. Because of poor fit of data to the models for recovery rates of Central Region females, we could not conduct the likelihood ratio test. Instead we used direct recovery rates and estimated standard errors using the binomial (White and Garrott 1990). We found no evidence for heterogeneity of direct recovery rates between 1978 and 1982 for females from the Central Region ($P = 0.24$, Table 5).

Survival rates for males in both the Eastern and Central regions were modeled as constant over time ($P > 0.3$, Table 5). Temporal variation in survival rates of females could not be tested.

Geographic Variation

The Eastern and Central region data did not overlap in time (Table 1). Thus, any comparisons conducted between parameter estimates is confounded between time and location. However, because the separation in years between the data sets was small (they were adjacent) and questions regarding differences in survival and recovery rates between the locations are important, we tested for geographic differences in parameter estimates. We caution that interpretation of these results is tenuous.

Recovery rates of adult males and young females were significantly greater ($P < 0.05$) in the Eastern Region compared to the Central Region (Table 6). In the other age-sex comparisons, point estimates of recovery rates were not different ($P > 0.05$).

Survival rates of adult males in the Eastern Region were lower ($P = 0.04$) than in the Central Region (Table 6). Survival rates for no other age-sex comparison differed between regions (Table 6).

Population Model

We calculated differential vulnerabilities ($\hat{f}_y/\hat{f}_a$) and found the Eastern Region estimate (1.27) was greater than the Central Region estimate (1.00). Using the long-term harvest age ratio of 1.7 immatures per adult female for both regions (Bruggink 1996; Table 2), the Eastern Region production rate (1.34) was lower than the Central Region production rate (1.70).

Table 4. Results of testing hypotheses regarding age-specific variation in woodcock recovery and survival rates by sex classes.

			Survival and recovery rates[a]			Recovery rates[b]				Survival rates[c]			
Management unit	Sex	Years	df	χ^2	*P*	$\hat{f}_a - \hat{f}_y$	df	χ^2	*P*	$\hat{S}_a - \hat{S}_y$	df	χ^2	*P*
Eastern	Male	1967–1979	25	45.63	0.01	-0.002	1	0.002	1.00	0.109	1	7.444	0.01
	Female	1967–1978	23	31.08	0.12	-0.009	1	3.780	0.05	0.127	1	4.715	0.03
Central	Male	1978–1982	10	6.02	0.81	-0.004	1	0.390	0.53	0.162	1	0.909	0.34
	Female	1978–1982	10	12.54	0.25	-0.003	1	0.043	0.83	0.340	1	1.544	0.21

[a] Results of a likelihood ratio test of model H_0 vs. H_1 (Brownie et al. 1985:88-89) testing the hypothesis that survival and recovery rates were similar for adults (a) and young (y).

[b] Results of a χ^2 test (Hines and Sauer 1989) testing the null hypothesis that recovery rates of adults (a) and young (y) were similar. The estimated difference between the mean annual recovery rates of adults (a) and young (y) is denoted by $\hat{f}_a - \hat{f}_y$

[c] Results of a χ^2 test (Hines and Sauer 1989) of the null hypothesis that survival rates of adults (a) and young (y) were similar. The estimated difference between the mean annual survival rates of adults (a) and young (y) is denoted by $\hat{S}_a - \hat{S}_y$

Table 5. Results of testing hypotheses regarding temporal variation in woodcock recovery and survival rates.

			Recovery rates[a] (young and adult)			Survival rates[b] (young and adult)		
Management unit	Sex	Years	df	χ^2	*P*	df	χ^2	*P*
Eastern	Male	1967–1979	24	85.65	< 0.001	22	24.22	0.34
	Female	1967–1978	22	48.41	< 0.001			
Central	Male	1978–1982	9	3.44	0.94	7	5.03	0.66
	Female	1978–1982	4	5.45	0.24[c]			

[a] Results of likelihood ratio tests of model H_{01} vs. H_{02} (Brownie et al. 1985:87) testing the hypothesis that recovery rates of young and adults were constant from year to year.

[b] Results of likelihood ratio tests of model H_{02} vs. H_1 (Brownie et al. 1985:87) testing the hypothesis that recovery rates varied temporally but that survival rates were constant versus the hypothesis that both survival and recovery rates varied temporally.

[c] Results of CONTRAST (Sauer and Williams 1989) test testing the hypothesis that recovery rates were homogeneous over time versus the hypothesis that recovery rates were heterogeneous over time.

Table 6. Results of testing hypotheses regarding differences in woodcock recovery and survival rates between the Eastern and Central Regions.

	Recovery rates[a]				Survival rates[b]			
Age-sex class	$\hat{f}_f - \hat{f}_m$	df	χ^2	*P*	$\hat{S}_f - \hat{S}_m$	df	χ^2	*P*
Adult male	0.030	1	28.195	0.001	-0.205	1	4.1180	.04
Young male	0.001	1	0.083	0.77	-0.151	1	1.1230	.29
Adult female	0.008	1	0.709	0.40	-0.057	1	0.0790	.78
Young female	0.017	1	4.182	0.04	0.084	1	0.3890	.53

[a] Results of a χ^2 test (Hines and Sauer 1989) of the null hypothesis that recovery rates of Central and Eastern woodcock were similar. The estimated difference between mean annual recovery rates for the two areas is denoted by $\hat{f}_f - \hat{f}_m$

[b] Results of a χ^2 test (Hines and Sauer 1989) of the null hypothesis that survival rates of Central and Eastern woodcock were similar. The estimated difference between mean annual survival rates for the two areas is denoted by $\hat{S}_f - \hat{S}_m$

Using the mean annual survival rates by age-sex class (Tables 1 and 2), a sex ratio of 50%, and the above production rate estimates, we calculated the rate of population increase to be 0.89 for the Eastern Region and 1.23 for the Central Region. The ratio of these rates (1.4) is nearly identical to the ratio (1.3) calculated by Dwyer and Nichols (1982).

Direct Recovery Rates

Direct recoveries selected for known-age birds in both regions pre- and post-dated the year of regulation (1985) change by 10 years (1975–94), whereas we used all local birds banded between 1968 and 1995. For both the Eastern and Central Region data sets for known-age birds, there were few direct recoveries (0–6 per year) after the change in harvest regulations. There were more direct recoveries (6–28 per year) of local birds after the regulation change. Direct recovery rates before the change in harvest regulations in the Eastern Region were significantly higher ($P = 0.01$) than after that time (Table 7). In the Central Region, where no comparable change in regulations occurred, there was no change in direct recovery rates for either the known-age ($P = 0.40$) or local birds ($P = 0.10$) before and after 1985. Although there was no difference in recovery rates between flyways ($P = 0.09$), the Central Region tended to have higher recovery rates. Recovery rates between regions were not different before ($P = 0.73$) or after ($P = 0.15$) regulations changed in the Eastern Region.

Discussion

Dwyer and Nichols (1982) noted three important patterns in their comparisons of survival and recovery rates of woodcock: female woodcock had higher survival rates than males, there were no age-specific differences in recovery rates, and young males had very low survival rates. Our reanalysis suggested that there was less evidence of females having higher survival rates than males, there was little evidence of age-specificity in recovery rates, and survival rates of young were generally low. Of most importance, the continuing lack of an adequate banding effort and the problem of low recovery rates (possibly the result of high crippling losses [Pursglove 1975], low harvest rates, or low reporting rates), has resulted in poor data sets available to estimate survival and recovery rates. Although point estimates are generally robust (Nichols et al. 1982), wide variance estimates resulted in low power to test for differences, which hampered our ability to draw strong inferences. This was evident in both the sex- and age-specific tests where distinct patterns were evident from the point estimates, but test statistics were inconclusive.

Poor banding and recovery data sets have always been a problem in the investigations of woodcock population dynamics (Dwyer and Nichols 1982). In lieu of new banding data, we believe that the general patterns provided by the point estimates lead to the following interpretations: females have higher survival rates than males; and adults have higher survival rates and lower recovery rates than young. That female survival rates are higher than male survival rates is important. Because woodcock are

Table 7. Results of testing hypotheses regarding differences in woodcock direct recovery rates in the Eastern and Central Regions before and after changes in harvest regulations.[a]

		Wilcoxon 2-Sample Test				
Comparison	**Years**	**Mean Score**	**Standard Deviation**	**S**	**Z**	***P***
Eastern Region Liberal Regulations (All Ages)	1975–84	13.80	13.178	138.0	2.466	0.01
vs.						
Eastern Region Restrictive Regulations (All Ages)	1985–94	7.20	13.178			
Central Region (Known Ages) pre-1985	1975–84	11.65	13.204	116.5	0.833	0.40
vs.						
Central Region (Known Ages) post-1984	1985–94	9.35	13.204			
Central Region (All Ages) pre-1985	1968–84	16.59	21.241	124.0	-1.648	0.10
vs.						
Central Region (All Ages) post-1984	1985–95	11.27	21.241			
Known Ages Eastern Region	1975–94	17.38	36.929	347.5	-1.679	0.09
vs.						
Known Ages Central Region	1975–94	23.63	36.929			
Known Ages Eastern Region pre-1985	1975–84	10.0	13.214	100.0	-0.340	0.73
vs.						
Known Ages Central Region pre-1985	1975–84	11.0	13.214			
Known Ages Eastern Region post-1984	1985–94	8.55	13.159	85.5	-1.444	0.15
vs.						
Known Ages Central Region post-1984	1985–94	12.45	13.159			

[a] Harvest regulations became more restrictive in the Eastern Region during the 1985–86 hunting season. No changes occurred in Central Region.

polygynous (Dwyer et al. 1988, McAuley et al. 1993) males are of less value in determining population trends (Aldrich 1973) and females need to be conserved. The higher recovery rates of females when compared to males might suggest that males are dying at times of the year other than the hunting season. Spring is the most likely time because males perform conspicuous courtship activities that expose them to high rates of predation (Longcore et al. 1996). Age-specificity in survival and recovery rates is typical of most game birds (Dwyer and Nichols 1982), but our point estimates differ from the findings of Dwyer and Nichols (1982) who found that young and adults had similar recovery rates. Our generally low survival rate estimates for young support Dwyer and Nichols' (1982) similar estimates. The timing of mortality and causes of low survival rates in young are important areas of future research. Low annual survival rates of young in combination with the continuing decline in harvest age ratios (Bruggink 1996), a measure of recruitment, is a serious problem for woodcock and should be a central focus of future research and management efforts.

The difference in direct recovery rates in the Eastern Region before and after the change in regulations compared to the Central Region indicates that reductions in season length and bag limits for woodcock will result in a reduction in harvest rate and possibly an increase in survival. Thus, if harvest rate is viewed as too high or low, altering harvest regulations can be used as an effective management tool.

Our efforts illustrate the inadequacy of woodcock banding programs following the late 1970s for the Eastern Region and the early 1980s for the Central Region; sample sizes are insufficient for analysis of survival and recovery rates after this time. Thus, our most recent region-wide estimates of survival are more than 15 years old. Information on annual survival is needed to understand woodcock population dynamics. These data may also be useful for population modeling and examining the role of hunting mortality in woodcock population dynamics. Unfortunately, the age of our estimates limits their usefulness.

Owen et al. (1977) noted the high cost and difficulty of banding adequate numbers of woodcock; this problem is exacerbated by low recovery rates (Sheaffer and Malecki 1995) and declining populations (Bruggink 1996). Thus, despite the importance of banding and recovery data, we believe that initiating an adequate woodcock banding program at this time would be very difficult, and perhaps not the best use of limited resources. We suspect that those responsible for woodcock management will have to make decisions without the benefit of current region-wide information on survival for the foreseeable future.

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References

Aldrich, J. W. 1973. Disparate sex ratios in waterfowl. Pages 482–489 *in* D. S. Farner, editor. Breeding biology of birds. National Academy of Sciences. Washington, D.C.

Anderson, D. R., and K. P. Burnham. 1976. Population ecology of the mallard. VI. The effect of exploitation on survival. U.S. Fish and Wildlife Service Resource Publication 128. 66 pp.

Brownie, C., D. R. Anderson, K. P. Burnham, and D. S. Robson. 1985. Statistical inference from band recovery data - a handbook. Second edition. U.S. Fish and Wildlife Service Resource Publication 156. 305 pp.

Bruggink, J. G. 1996. American woodcock harvest and breeding population status, 1996. U.S. Fish and Wildlife Service. Laurel, Maryland. 14 pp.

Coon, R. A., T. J. Dwyer, and J. W. Artmann. 1977. Identification of potential harvest units in the United States for the American woodcock. Pages 147–153 *in* D. M. Keppie and R. B. Owen, Jr., editors. Proceedings of the sixth woodcock symposium. Fredericton, N. B.

Dwyer, T. J., and J. D. Nichols. 1982. Regional population inferences for the American woodcock. Pages 12–21 *in* T. J. Dwyer and G. L. Storm, technical coordinators. Woodcock ecology and management. U.S. Fish and Wildlife Service Wildlife Research Report 14.

Dwyer, T. J., G. F. Sepik, E. L. Derleth, and D. G. McAuley. 1988. Demographic characteristics of a Maine woodcock population and effects of habitat management. U.S. Fish and Wildlife Service, Fish and Wildlife Research 4. 29 pp.

Longcore, J. R., D. G. McAuley, G. F. Sepik, and G. W. Pendleton. 1996. Survival of breeding male American woodcock in Maine. Canadian Journal of Zoology 74:2046–2054.

Martin, F. W., R. S. Pospahala, and J. D. Nichols. 1979. Assessment and population management of North American migratory birds. Pages 187–239 *in* J. Cairns, Jr., G. P. Patil, and W. E. Waters, editors. Environmental biomonitoring assessment, prediction, and management - Certain case studies and related quantitative issues. Statistical Ecology, Volume 11. International Cooperative Publication House, Fairland, Maryland.

McAuley, D. G., J. R. Longcore, and G. F. Sepik. 1993. Behavior of radio-marked breeding American woodcocks. Pages 116–125 *in* J. R. Longcore and G. F. Sepik. Proceedings of the eighth American woodcock symposium. U.S. Fish and Wildlife Service Biological Report 16. Washington, D.C.

Nichols, J. D., S. L. Stokes, J. E. Hines, and M. J. Conroy. 1982. Additional comments on the assumption of homogeneous survival rates in modern bird banding estimation models. Journal of Wildlife Management 46:953–962.

Owen, R. B., Jr., J. M. Anderson, J. W. Artmann, E. R. Clark, T. G. Dilworth, L. E. Gregg, F. W. Martin, J. D. Newsom, and S. R. Pursglove. 1977. American woodcock (*Philohela minor* = *Scolopax minor* of Edwards 1974). Pages 149–186 *in* G. C. Sanderson, editor. Management of migratory shore and upland game birds in North America. International Association of Fish and Wildlife Agencies, Washington, D.C.

Pursglove, S. R., Jr. 1975. Observations on wintering woodcock in northeast Georgia. Proceedings of the Annual Conference of the Southeast Association of Game and Fish Commissions 29:630–639.

Sauer, J. R., and B. K. Williams. 1989. Generalized procedures for testing hypotheses about survival. Journal of Wildlife Management 53:137–141.

Sheaffer, S. E., and R. A. Malecki. 1995. Waterfowl management: recovery rates, reporting rates, reality check! Wildlife Society Bulletin 23:437–440.

White, G. C., and R. A. Garrott. 1990. Analysis of wildlife radio-tracking data. Academic Press, Inc., San Diego, California. 383 pp.

Survival of Female American Woodcock Breeding in Maine

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Abstract. During 1986–1989, 89 female American woodcock (*Scolopax minor*) included in this study were radio-marked and survival estimated for the period 1 April–15 June. Eleven woodcock died: five (45%) were killed by mammals, two (18%) by unknown predators, and one (9%) by a raptor; two (18%) died from entanglement in the transmitter harness; and 1 (9%) collided with a vehicle. Survival varied among years from 0.700 (1986) to 0.900 (1989) with a 4-year mean (95% CI) of 0.826. Survival did not differ between age classes ($P = 0.900$), or among years ($P \geq 0.14$), except for higher ($P = 0.025$) survival (0.875) in 1987 than in 1988 (0.735). A composite survival estimate—based on telemetry studies for the breeding, post-breeding, and winter periods— was 0.363 for immatures and 0.474 for adults. Mean weights were not different between second year and after second year age classes ($P = 0.167$), but weight was related to woodcock capture date ($P = 0.001$). Survival for female woodcock was not related to mean snow depth or to mean, minimum temperature in winter or spring. Habitat use was different between females that died and those that lived, but sample size was small.

Keywords: American woodcock, breeding, habitat, predators, *Scolopax minor*, survival, weather.

The American woodcock (*Scolopax minor*) population continues to decline (Bortner 1990; Sauer and Bortner 1991; Kendall and Bruggink 1994; Bruggink 1997). During 1968–97 the mean number of courting males per Singing-ground Survey route declined 52% in the Eastern Region and 39% in the Central Region (Bruggink 1997). In recent years (1987–97) Singing-ground Survey trends have continued downward for the Eastern Region (-3.6% per year, $P < 0.01$) and the Central Region (-4.4% per year, $P < 0.01$; Bruggink 1997). Dwyer et al. (1983) documented an association between increases in urban and industrial development along survey routes and declines in numbers of woodcock counted during the late 1960s to the late 1970s in nine northeastern states. This same association has been reported in Canada (Dobell 1977).

Neither the number of males nor females in the population can be derived from counts of displaying

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males (Sheldon 1967; Godfrey 1974). It is important, however, to know the survival of the female, which accounts for more of the U.S. harvest (51% juveniles, 57% adults; Straw et al. 1994) than males. Most estimates of annual survival rates of American woodcock are for males and derived from analyses of band recoveries of birds banded before 1980 (Sheldon 1956; Martin et al. 1969; Krohn et al. 1974; Dwyer and Nichols 1982; Dwyer et al. 1988). Annual survival of female woodcock based on the Brownie H_{02} model, was estimated for adults (0.491) and immatures (0.358) by Dwyer and Nichols (1982) and later revised by Krementz and Bruggink (2000; Table 1). Derleth and Sepik (1990) estimated a period survival rate (PSR) for radio-marked female woodcock during summer and fall and Krementz et al. (1994) estimated a PSR for winter. A survival estimate for female woodcock during spring courtship and brood-rearing was unavailable. Inclement weather in spring is known to adversely affect male woodcock (Mendall and Aldous 1943; Alison 1976; Longcore et al. 1996). Our objectives were to determine a PSR for breeding females, to determine causes of death, and to evaluate relations between survival and body weight, weather, and use of habitat.

Study Area

We conducted this study on the 65-km^2 Baring Unit, Moosehorn National Wildlife Refuge, Washington County, Maine, near Calais (67° 15'W, 45° 5'N). Since 1973, 40–50 ha of woodlands have been harvested annually to maintain habitat for woodcock at the Baring Unit (Sepik et al. 1977). The area is mostly an uneven-aged, second-growth northern hardwood-conifer forest with mixed stands of quaking aspen (*Populus tremuloides*), bigtooth aspen (*P. grandidentata*), paper birch (*Betula papyrifera*), gray birch (*B. populifolia*), and red maple (*Acer rubrum*; Derleth and Sepik 1990). Mixed stands of white spruce (*Picea glauca*), red spruce (*P. rubens*), and balsam fir (*Abies balsamea*) dominate the coniferous types; these types often include some white pine (*Pinus strobus*), red pine (*P. resinosa*), and tamarack (*Larix laricina*). Margins of streams and some fields contain extensive stands of alder (*Alnus incana*). Habitat management for woodcock at Moosehorn National Wildlife Refuge was detailed by Sepik et al. (1977, 1981) and Sepik and Dwyer (1982).

Methods

Field Techniques

During 30 March–31 May, 1986–89 we used mist nests (Sheldon 1960) to capture female woodcock near display sites of males (McAuley et al. 1993b) and long-handled nets to capture females on nests or with broods, which were found by a pointing dog. We distributed our trapping efforts among forest types to obtain a sample of females from all habitat types. Captured birds were banded with U.S. Fish and Wildlife Service leg bands, sexed and aged (SY = second year [1-year old], ASY = after second year [≥ 2-year old]) by plumage

Table 1. Estimated annual survival rates for female American woodcock.

Years	Age	Mean annual survival ± SE	Source and model
1949–1969	Adult	0.56 ± 0.58	Martin et al. 1969, composite dynamic or relative recovery model
1967–1973	Adult	0.371 ± 0.05	Krohn et al. 1974, Seber-Robson-Young, Brownie models
	Immature	0.368 ± 0.08	
1967–1974	Adult	0.491 ± 0.07	Dwyer and Nichols 1982, Brownie H_1 Model
	Immature	0.358 ± 0.07	
1967–1978	Adult	0.522 ± 0.03	Krementz and Bruggink 2000, Brownie H_{02} Model
	Immature	0.394 ± 0.05	

characteristics (Martin 1964), and body weight was measured to the nearest gram with a spring scale. Radio transmitters (3–4 g, < 3% body weight) were attached on the bird's back with cattle tag cement (Hudgins et al. 1985) and a single loop of teflon-coated, steel wire, which encircled the breast (McAuley et al. 1993b).

We located signals of radio-marked birds daily with programmable, scanning receivers and vehicle-mounted, 7-element yagi antennas. To determine habitat use of females we walked toward the signal with a hand-held antenna and circled the signal within about 10 m. To plot locations we paced to landmarks that could be identified on black-and-white aerial photographs (RF = 1:7,900) overlaid with a grid. We categorized locations by forest type (Society of American Foresters 1975). Woodcock that were inactive during crepuscular periods and that were located in the same cover for two consecutive days were approached on foot to determine if they were alive. We searched for lost females with aircraft (Gilmer et al. 1981) by flying transects 8 km apart across the study area. Birds located by aircraft were approached on foot to determine status. When a carcass or a transmitter was found, the remains, recovery site, and transmitter were inspected to determine cause of death or if the radio had slipped off.

Statistical Analyses

Woodcock monitored for at least five days were used in the survival analyses. We used the Kaplan-Maier (1958) product-limit method with staggered entry of birds (Pollock et al. 1989) to calculate estimates of woodcock survival and 95% confidence intervals. The Kaplan-Maier procedure does not require a parametric, continuous survival distribution and allows right censoring of lost birds, birds that slip out of harnesses, and birds that die from causes related to the researcher's activities (Pollock et al. 1989). We assumed that independence of survival times existed among birds. We used Fisher's exact test to test for differences in proportions of deaths between females and males (Longcore et al. 1996) within years.

Mean monthly (December–March) depths (cm) of snow in the open, and minimum low temperature during winter were obtained from files at Moosehorn National Wildlife Refuge to evaluate their effects on survival. Mean depth of snow among years was evaluated with ANOVA and Tukey's test (SAS Institute Inc. 1989). Average, daily minimum temperatures (C) were compared among years and months by 2-way ANOVA. Year × month interactions were modeled with Mandel's method (Milliken and Johnson 1989) with the residual mean square used as the error term. With the same error term Tukey's multiple comparisons were used to separate means among years and among months. Because low temperatures in April can be critical to woodcock survival (Longcore et al. 1996), we compared minimum mean temperatures in April among years by 1-way ANOVA.

To evaluate associations between habitat use and survival we grouped forest types into four categories, alder-tamarack, hardwood, conifer, and mixed forest, and tested with Chi-square analyses the frequency of use of different habitats with woodcock fate (lived or died). An alpha value of 0.10 was used for tests of survival differences to reduce probability of Type II error (Nichols and Johnson 1989); an alpha value of 0.05 was used for other tests.

Period Survival and Annual Survival

Calculating an annual survival rate based on PSRs should be from PSRs obtained from the same cohort of birds as they progress through their annual cycle. Because of the difficulty in obtaining such data for migratory woodcock, no such data exist. Period survival rates are available from other studies for some periods of the year, but are lacking for the hunting and fall migration (H and FM) period (21 October–14 December), which actually begins in early October in the north and ends in late January in the south, and the spring migration (SM) period (16 February–31 March). We estimated the daily survival rate (DSR) for these combined periods by dividing the product of the breeding (B; this study), postbreeding (PB; Derleth and Sepik 1990), and winter (W) periods (Krementz et al. 1994) into an estimated annual survival rate of immature (0.394) or adult (0.522) female woodcock obtained from analysis of band recoveries (Krementz and Bruggink 2000). We obtained the PSRs by raising the DSR to the power of the individual period lengths (in days), that is, SM = DSR^{44}, H and FM = DSR^{55}.

Results

During 1986–89 (30 March–31 May) we radio-marked 89 (42 SY, 46 ASY, 1 AHY = after-hatching year) female, American woodcock (1986, $n = 11$; 1987, $n = 31$; 1988, $n = 27$; 1989, $n = 20$). Two females that died from harness entanglement and two that were caught late in the monitoring period were censored before analysis for survival, but data from these birds were used in other summaries. Data from the one unaged bird (classified as AHY) was included in all analyses.

Causes and Timing of Deaths

Deaths ($n = 11$) of female woodcock were attributed to mammals ($n = 5$, 45%), unidentified predators ($n = 2$, 18%), raptors ($n = 1$, 9%), and collision with a vehicle ($n = 1$, 9%; Table 2). Two (18%) females died from entanglement in the harness. Over all years, most birds died in May ($n = 7$); 2 died in April, and 2 in June. Excluding birds that died from entanglement, only 2 of 7 (28%) females (1 each in 1988 and 1989) died within 16 days of being radio-marked, which is within the period of most severe weather in spring.

Age, Body Weight, and Survival

Mean (± SE) weights (g) at capture were not different between age classes (GLM ANOVA, $F_{1,80} = 1.94$, $P = 0.167$); weights were different among years ($F_{3,80} = 6.80$, $P = 0.0004$), and related to capture date within years ($F_{1,80} = 16.2$, $P = 0.0001$; Table 3). Survival was not related to age; 5 of 42 (12%) SY and 6 of 46 (13%) ASY females died.

Period Survival

Mean PSR of female woodcock during 1986–89 was 0.826 and ranged from 0.700 in 1986 to 0.900 in 1989 (Table 4). Among years survival was different ($\chi^2_1 = 7.46$, $P = 0.025$) between 1987 (0.875) and 1988 (0.735; Table 4). For all years combined, survival estimates of SY (0.810) and ASY (0.815) woodcock were not different

Table 2. Causes of deaths of female American woodcock captured in spring at Moosehorn NWR, 1 April – 15 June, 1986–1989.

Year	**Fate of radio-marked woodcock**							
Age[a]	***n***	**Raptor kill**	**Mammal**[b] **kill**	**Unknown predator**	**Other**	**Lost signal**	**Slipped radio**	**Known alive**
1986 SY	3	1				1		1
ASY	8	1			1[c]	2	2	2
1987 SY	22			1	1[d]	12	1	7
ASY	9					5		4
1988 SY	10		1	1		2		6
ASY	17	1	1		1[c]	6	1	7
1989 SY	7					2	1	4
ASY	13[f]		1			4	1	7[f]
Total	89[f]	1	5	2	3	34	6	38[f]

[a] SY = second year, ASY = after second year, AHY = after-hatching year.

[b] Species of mammals mostly unknown, except two deaths thought to be caused by weasels (*Mustela* spp.)

[c] Female's transmitter antenna caught in chick's band, both birds died.

[d] Female caught bill under harness and died.

[c] Bird collided with a vehicle during a recess from its nest.

[f] These totals include one AHY female.

Table 3. Mean body weights of breeding female American woodcock captured in spring, Moosehorn National Wildlife Refuge, Calais, Maine, 1986–1989.

	Mean[a] ± SE (*g*)			
Year	***n***	**SY[b]**	***n***	**ASY**
1986	3	173.7 ± 4.3	8	204.9 ± 7.0
1987	22	202.4 ± 5.2	9	203.4 ± 7.1
1988	10	189.3 ± 3.5	15[c]	200.9 ± 5.3
1989	7	200.3 ± 8.2	12	209.2 ± 9.4
1986–1989	42	196.9 ± 3.3	44	204.4 ± 3.6

[a] Mean body weights were not different between SY and ASY age classes (GLM ANOVA, $F_{1,80} = 1.94$, $P = 0.167$), but weight was related to date of woodcock capture within years ($F_{1,80} = 16.1$, $P = 0.001$).

[b] SY = 1 year old, ASY = ≥ 2 years old.

[c] Weight data are missing for two of the 17 birds.

($\chi^2_1 = 0.018$, $P = 0.900$).

Weather Variables

The monthly mean depth of snow in December–March differed among 1986–89 ($F_{3,6} = 17.8$, $P = 0.002$); the 1989 average depth of snow was less ($HSD_6 = 6.76$, $P = 0.05$) than in the other years (Figure [*a*]). Neither daily average ($F_{3,9} = 0.77$, $P = 0.538$) nor daily minimum ($F_{3,9} = 1.26$, $P = 0.343$) temperatures (C) for December–March were different among years (Figure [*b*]), but were different among months ($F_{3,9} = 12.4$, $P = 0.001$; $F_{3,9} = 6.90$, $P = 0.01$). The average daily temperature in March was higher ($HSD_9 = 6.35$, $P = 0.05$) than in other months and the daily minimum temperature in March was higher (($HSD_9 = 7.89$, $P = 0.05$) than in January and February, but not December. No year × month interactions were detected. Mean minimum daily temperatures in April were not different ($F_{3,12} = 2.32$, $P = 0.126$) among years; the lowest temperature was in 1989 (-2.48) and the highest in 1986 (-0.18).

Habitat Use and Woodcock Survival

Fate (lived or died) of female woodcock was associated ($\chi^2_3 = 64.4$, $P = 0.001$) with use of habitat types. The predominant habitat type used by four birds that died was hardwood, three used conifer, one used alder-tamarack, and one bird used alder and conifer equally.

Table 4. Kaplan-Meier survival estimates for female American woodcock radio-marked (1 April–15 June) at Moosehorn National Wildlife Refuge, Calais, Maine, 1986–1989.

	n			
Year	**Marked[a]**	**Died**	**Mean survival[b] ± SE**	**95% C.I.**
1986	11	3[c]	0.7000 ± 0.029	0.3639–1.0000
1987	31	2	0.8750 ± 0.006	0.7184–1.0000
1988	27[d]	5	0.7350 ± 0.011	0.5293–0.9407
1989	20[d]	1	0.9000 ± 0.006	0.7453–1.0000
1986–1989	89	11	0.8256 ± 0.002	0.7319–0.9193

[a] Birds with unknown fate and two birds entangled in transmitter harnesses were censored from further survival analyses when they died.

[b] No differences in survival detected among years (all Ps ≥ 0.14), except for 1987 vs. 1989 ($\chi^2_1 = 7.457$, $P = 0.025$). No difference was detected in survival between SY and ASY age classes ($\chi^2_1 = 0.018$, $P = 0.90$).

[c] One bird entangled in harness and excluded from survival estimates.

[d] Two birds, one caught 15 June, 1988, and one caught 5 June, 1989, were excluded from survival estimates because they were marked too late in the monitoring period.

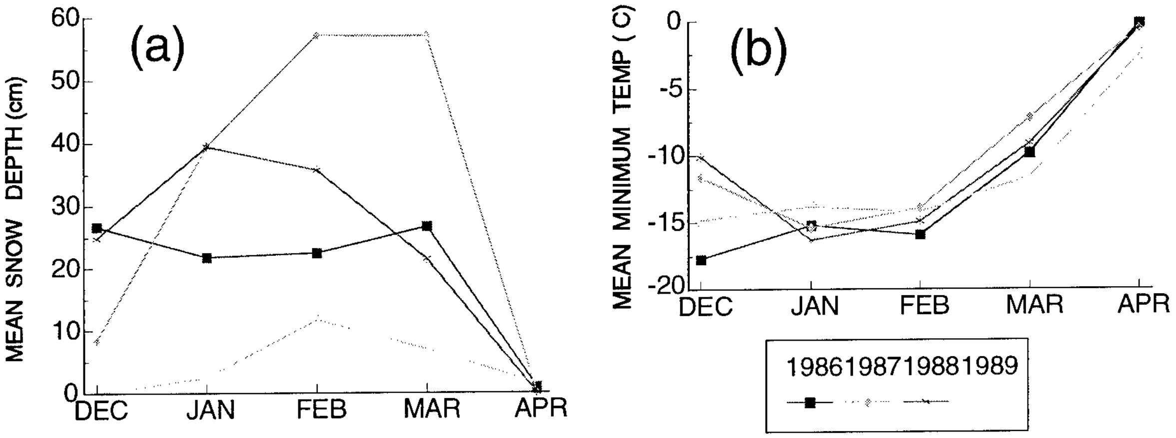

Figure. Mean depth (cm) of snow in the open (*a*) and mean minimum temperature (*b*) for December–April, 1986–1989 at Moosehorn National Wildlife Refuge, Calais, Maine. Values for December for each study year are from the preceding calendar year (e.g., December 1986 data used for 1987 study year).

Period Survival and Annual Survival

The PSR for the B period (1 April–15 June) for all years combined was calculated as 0.826 (Table 4). The rate for the H and FM period (21 October–14 December) was calculated as 1.045 and the rate for the SM period (16 February–31 March) was calculated as 1.036 (Table 5).

Discussion

Causes of Deaths

Eight of nine deaths (89%) were caused by predators; five by mammals, one by a raptor, and two by unidentified predators. One female that nested near a well-traveled road collided with a vehicle during a recess from the nest.

Table 5. Estimates of survival for female American woodcock during different periods of the annual cycle.

Period	Dates	Mean survival	Source
Immatures			
Spring migration[a] (SM)	16 Feb–31 Mar	1.036	Derived value
Breeding[b] (B)	1 Apr–15 Jun	0.810	This study, telemetry
Postbreeding[b] (PB)	15 Jun–20 Oct	0.693	Derleth and Sepik 1990, telemetry
Hunting and fall migration[a] (H and FM)	21 Oct–14 Dec	1.045	Derived value
Wintering[b] (W)	15 Dec–15 Feb	0.647	Krementz et al. 1994, telemetry
Annual estimate		0.394	Krementz and Bruggink 2000
Adults			
Spring migration[a]	16 Feb–31 Mar	1.036	Derived value
Breeding[b]	1 Apr–15 Jun	0.815	This study, telemetry
Postbreeding[b]	15 Jun–20 Oct	0.900	Derleth and Sepik 1990
Hunting and fall migration[a]	21 Oct–14 Dec	1.045	Derived value
Wintering[b]	15 Dec–15 Feb	0.647	Krementz et al. 1994
Annual estimate		0.522	Krementz and Bruggink 2000

[a] Derived PSRs were obtained for immatures, for example, by dividing the product of PSRs (B.PB.W = 0.363) into the annual estimate (0.394; Krementz and Bruggink 2000), which equaled 1.0848; then calculating (*99th* root of 1.0848) a daily survival rate (DSR) of 1.0008; then taking this DSR to the power of the period lengths, i.e., SM = 1.0008^{44}, H and FM = 1.0008^{55}. Note that the H and FM period actually begins in early October at northern latitudes; dates used are best fit for available telemetry data.

[b] PSR estimates were derived with the product-limit method (Kaplan-Meier 1958).

Mammals preying on females during nesting might be expected because of the female's nearly month-long association with its nest on the ground. Pettingill (1936) summarized the early literature that recorded deaths of woodcock (sexes not reported) caused by a variety of avian species, but he noted that "Definite evidence that wild animals take woodcock is noticeably slight." He reported one record of a pair of woodcock wings found at a red fox (*Vulpes vulpes*) den. Liscinsky (1972) reported that in Pennsylvania Cooper's hawks (*Accipiter cooperii*) killed two adult females and a sharp-shinned hawk (*Accipiter striatus*) killed an incubating female. Of 12 nests destroyed, 10 were by mammals (raccoon [*Procyon lotor*], skunk [*Mephitis* sp.], house cat [*Felis catus*]), and two by unknown predators. Mendall and Aldous (1943) identified the house cat as the leading mammalian predator of woodcock in Maine, but noted that the dog (*Canis familiaris*), red squirrel (*Tamiasciurus hudsonicus*), fox , and weasel (*Mustela* spp.) also killed woodcock. The sexes of woodcock killed were not reported but many deaths were associated with destroyed nests and presumably were females. Gregg (1984) reported that in Wisconsin only 3 of 24 non-hunting recoveries of immature woodcock were from predation; 1 each by a dog, a cat, and an unknown raptor. Hess (1910) documented that in Illinois a cat killed a female on a nest and Forbush (1916) in Massachusetts reported that cats killed woodcock; as many as 18 by 1 cat in a season. House cats lived at the refuge but we have no evidence that they killed marked woodcock.

The causes of death of males (Longcore et al. 1996) and females contrast sharply, although total deaths was similar between females (11 of 89, 12%) and males (33 of 173, 19%) for each year (Fisher's exact test, 2-tailed, $P \geq 0.085$). Raptors killed nearly half of the males (16 of 33, 48%), but only 1 of 11 (9%) females. Conversely, mammals killed 5 of 11 (45%) females, but only 5 of 33 (15%) males. The repetitious and prolonged courtship activity of males (McAuley et al. 1993a) with display flights and vocalizations that attract avian predators (Pettingill 1936), is in sharp contrast to the more sedentary activities of females, especially during nesting and brood-rearing (McAuley et al. 1993a). These differences in type, timing, and intensity of daily activities expose males and females to different predators.

Although the collision of a female with a vehicle was unique among deaths we recorded, woodcock colliding with objects, including moving vehicles, is not uncommon. White (1933) reported woodcock were killed on highways in New England and Mendall and Aldous (1943) reported nine woodcock deaths caused by them colliding with vehicles in Maine and the Maritime provinces. Gregg (1984) reported 11 woodcock deaths in Wisconsin, "...including birds struck by motor vehicles, found dead on highways, or killed by flying into objects." Bailey (1929) reported that in Illinois two breeding female woodcock were found after one had flown into a building and the other into a wire.

Woodcock Deaths Among Years

From one to two females in this study were killed in any one year, except for 1988 (five deaths), so no pattern of deaths could be identified. The greater number of deaths in 1988 may have been related to the extended period of breeding activities of renesting females; at least eight radio-marked females renested after nest ($n = 4$) or brood ($n = 4$) loss (McAuley et al. 1990). One of the eight renesting females was killed on the nest. We cannot discount that our presence in the vicinity of nests may have affected female behavior and altered susceptibility of females to predators. The fact that only one of eight renesting females was killed, however, suggests that extending the female's time of exposure on the nest does not necessarily result in its death, although the risk is probably increased.

Period Survival and Weather

Females, because of larger body size and associated heat dynamics (Calder 1974), are better able to withstand sub-zero temperatures and sparse foods in spring (Gregg 1984) than are males (Mendall and Aldous 1943; Alison 1976; Longcore et al. 1996). No females starved during this study, but two males did (Longcore et al. 1996). In Maine in 1989, when the minimum, mean daily temperature in April was the lowest (-2.5 °C) among years (Figure [*b*]), Vander Haegen et al. (1993) reported that body weights of females that he collected were lower, females contained less food (especially earthworms), and they delayed nesting for 3–4 weeks. Survival of females we marked, however, was highest (0.900) in 1989. In contrast, in 1986 when the mean, minimum daily temperature in April was the highest (-0.18 °C) among years, survival (0.700) was the lowest, but based on a sample of 11 birds. Although deep frost caused by lack of snow and sub-zero temperatures in early winter (Vander Haegen et al. 1993) and spring snowstorms can limit food availability and cause females to delay nesting, survival of females in 1989 was not adversely affected. This high survival rate may have been related to reduced nesting effort. Furthermore, the energetic advantages of larger body size and not engaging in energetically costly display flights, as do males, probably contributes to higher survival rates for females (0.900) than for males (0.690, Longcore et al. 1996), especially in years with inclement spring weather (i.e., 1989).

Body Weight and Survival

The relation of survival to capture weight is confounded because weight at capture is associated with reproductive status, which changes by date and breeding chronology. Female body weight increases from the period of rapid follicular growth to laying, but declines from laying to hatching (Wenstrom 1973; Vander Haegen 1992). Because our birds were captured over an extended period they were in various reproductive stages when weighed. Body weight at capture was not associated with deaths of female woodcock and, unless the reproductive status of all females is known, weight was an inappropriate variable for predicting death. Furthermore, weights of 6 of the 11 females that died equaled or exceeded the mean ± SE weights for respective years or age classes, which suggested that birds that died were in good health based on weight. The lower weights of the five females whose weight fell below the mean ± SE are explained by reproductive stage; three were associated with nests or a brood and would be expected to weigh less (Vander Haegen 1992) and two were SY birds.

Effects of Habitat Use on Survival

The relation between death of female woodcock and habitat use is confounded with the predominant use of certain forest types and the obligate use of habitat surrounding the nest site selected by the female. McAuley et al. (1996) reported that of 86 nests at Moosehorn National Wildlife Refuge, 73.2% were in hardwoods types, 13.9% in conifer types, 11.6% in alder, and 1.0% in mixed types.

Numbers of females that died were associated with habitats in the same order but in different proportions; 4 in hardwoods, 3 in conifers, 1 in alder, and 1 with equal use of alder and conifers. Thus, although the statistical evaluation suggests a relationship between habitat use and survival, the confinement of a female to a nest site or a brood-rearing area influences the frequency of finding the female in a specific forest type. Furthermore, only three females were killed while on or near the nest. Although death of female woodcock seems to be associated with habitats used, as with male woodcock (Longcore et al. 1996), the interplay of habitat use, woodcock behavior, and predator density and behavior is not fully understood. Managing for hardwood types that are preferred by nesting females (McAuley et al. 1996) is appropriate. The use of hardwoods by woodcock that died was much less than expected largely because two of the four woodcock that died did so within six days of marking and did not have time to amass use days in the hardwood type.

Period Survival and Annual Survival

Our PSR estimate for immatures (0.810) for the breeding period when multiplied by the period survival estimate (0.693) of the summer-fall postbreeding period (Derleth and Sepik 1990) and a survival estimate (0.647) for W (Krementz et al. 1994) yielded a survival estimate of 0.363. The survival rate for the period that woodcock can be hunted (1 October–31 January) and the arbitrary H and FM period (21 October–14 December), which is only part of that exposure time, and the SM period (16 February–31 March) can only be approximated. We calculated an approximate PSR of 1.045 for the H and M period and 1.036 for the SM period for both adults and immatures (Table 5). These estimates are unrealistically high and highlight the potential pitfalls of attempting to associate data obtained by different methods, among different years, and at disparate geographical scales. Thus, these two calculated estimates indicate that one or more of the estimates for the other periods is too low or that the annual survival rate calculated from band recoveries (Krementz and Bruggink 2000) is too high and outdated.

Management Implications

Our data indicate that female woodcock at Moosehorn National Wildlife Refuge survive at a high rate during breeding. This high survival might be a result of the long-term management for optimal breeding habitat on the refuge (Sepik et al. 1981). The continuing decline of the woodcock population, however, suggests that survival rates during other periods (i.e., during SM or H and FM), or on a broader temporal and spatial scale, must be lower than the derived values of 1.036 and 1.045 as based on annual survival derived from analyses of band recoveries. To derive these values we are assuming, of course, that this annual survival estimate based on banding is correct. The declining recruitment indices (e.g., ratio of immatures to adult females is 1.3 in 1996), which have been below the long-term averages since 1992 in the Eastern Region and since 1987 in the Central Region (Bruggink 1997), however, suggest that changes have occurred in productivity, survival of immatures, or both. Also, female survival in poor quality habitat, which may be influencing current population trends, is unknown and may be substantially lower than our estimates in what we consider good quality breeding habitat at Moosehorn National Wildlife Refuge (Sepik and Dwyer 1982). Also, the effect of harvest on the woodcock population is poorly understood, but is now under investigation (U.S. Geological Survey, Patuxent Wildlife Research Center, unpublished data).

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References

Alison, R. M. 1976. Late snowstorm causes woodcock mortality. Ontario Field Biologist 30:51–52.

Bailey, A. M. 1929. Bird casualties. Wilson Bulletin 41:106–107.

Bortner, J. B. 1990. American woodcock harvest and breeding population status, 1990. U.S. Fish and Wildlife Service, Laurel, Maryland. 12 pp.

Bruggink, J. G. 1997. American woodcock harvest and breeding population status, 1997. U.S. Fish and Wildlife Service, Laurel, Maryland. 14 pp.

Calder, W. A. 1974. Consequences of body size for avian energetics. Pages 86–151 *in* R. Paynter, Jr., editor. Avian energetics. Nuttall Ornithological Club, Number 15, Cambridge, Massachusetts.

Derleth, E. L., and G. F. Sepik. 1990. Summer-fall survival of American woodcock in Maine. Journal of Wildlife Management 54:97–106.

Dobell, J. V. 1977. Determination of woodcock habitat changes from aerial photography in New

Brunswick. Pages 73–81 *in* D. M. Keppie and R. B. Owen, Jr., editors. Proceedings of the sixth woodcock symposium. Fredericton, New Brunswick.

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.

Dwyer, T. J., and J. D. Nichols. 1982. Regional population inferences for the American woodcock. Pages 12–21 *in* T. J. Dwyer and G. L. Storm, technical coordinators. Woodcock ecology and management. U.S. Fish and Wildlife Service Wildlife Research Report 14. Washington, D.C.

Dwyer, T. J., G. F. Sepik, E. L. Derleth, and D. G. McAuley. 1988. Demographic characteristics of a Maine woodcock population and effects of habitat management. U.S. Fish and Wildlife Research 4, U.S. Fish and Wildlife Service, Washington, D.C. 29 pp.

Forbush, E. H. 1916. The domestic cat—bird killer, mouser and destroyer of wildlife—means of utilizing and controlling it. Commonwealth of Massachusetts, State Board of Agricultural, Economic Bulletin 2, Wright and Potter Printing Company, Boston, Massachusetts. 112 pp.

Gilmer, D. S., L. M. Cowardin, R. L. Duvall, L. M. Mechlin, C. W. Shaiffer, and V. B. Kuechle. 1981. Procedures for the use of aircraft in wildlife biotelemetry studies. Research Publication 140, U.S. Fish and Wildlife Service, Washington, D.C.

Godfrey, G. A. 1974. Behavior and ecology of American woodcock on the breeding range in Minnesota. Ph.D. Dissertation, University of Minnesota, Minneapolis. 333 pp.

Gregg, L. 1984. Population ecology of woodcock in Wisconsin. Wisconsin Department of Natural Resources, Technical Bulletin 144. Madison. 51 pp.

Hess, I. E. 1910. One hundred breeding birds of an Illinois ten-mile radius. Auk 27:19–32.

Hudgins, J. E., G. L. Storm, and J. S. Wakely. 1985. Local movements and diurnal-habitat selection by male American woodcock in Pennsylvania. Journal of Wildlife Management 49:614–619.

Kaplan, E. L., and P. Maier. 1958. Nonparametric estimation from incomplete observations. Journal of the American Statistical Association 53:457–481.

Kendall, W. L., and J. G. Bruggink. 1994. American woodcock harvest and breeding population status, 1994. U.S. Fish and Wildlife Service, Laurel, Maryland. 14 pp.

Krementz, D. G., and J. G. Bruggink. 2000. Sources of variation in survival and recovery rates of American woodcock. Pages 55–64 *in* D. G. McAuley, J. G. Bruggink, and G. F. Sepik, editors. Proceedings of the ninth American woodcock symposium. U.S. Geological Survey, Biological Resources Division Information and Technology Report USGS/BRD/ITR–2000-0009, Patuxent Wildlife Research Center, Laurel, Maryland.

Krementz, D. G., J. T. Seginak, D. R. Smith, and G. W. Pendleton. 1994. Survival rates of American woodcock wintering along the Atlantic coast. Journal of Wildlife Management 58:147–155.

Krohn, W. B., F. W. Martin, and K .P. Burnham. 1974. Band-recovery distribution and survival estimates of Maine woodcock. Pages 1–8 *in* Proceedings of the fifth woodcock workshop, University of Georgia, Athens.

Liscinsky, S. A. 1972. The Pennsylvania woodcock management study. The Pennsylvania Game Commission, Research Bulletin 171. 95 pp.

Longcore, J. R., D. G. McAuley, G. F. Sepik, and G. W. Pendleton. 1996. Survival of breeding male American woodcock in Maine. Canadian Journal of Zoology 74:2046–2054.

Martin, F. W. 1964. Woodcock age and sex determination from wings. Journal of Wildlife Management 28:287–293.

Martin, F. W., S. O. Williams, III, J. D. Newsom, and L. L. Glasgow. 1969. Analysis of records of Louisiana-banded woodcock. Proceedings of the Annual Conference of the Southeast Association of Game and Fish Commissioners 23:85–96.

McAuley, D. G., J. R. Longcore, and G. F. Sepik. 1990. Renesting by American woodcocks (*Scolopax minor*) in Maine. Auk 107:407–410

McAuley, D. G., J. R. Longcore, and G. F. Sepik. 1993a. Behavior of radio-marked breeding American woodcocks. Pages 116–125 *in* J. R. Longcore and G. F. Sepik, editors. Proceedings of the eighth American woodcock symposium. Fish and Wildlife Service Biological Report 16. Washington, D.C.

McAuley, D. G., J. R. Longcore, and G. F. Sepik. 1993b. Techniques for research into woodcocks: Experiences and recommendations. Pages 5–11 *in* J. R. Longcore and G. F. Sepik, editors. Proceedings of the eighth American woodcock symposium. Fish and Wildlife Service Biological Report 16. Washington, D.C.

McAuley, D. G., J. R. Longcore, G. F. Sepik, and G. W. Pendleton. 1996. Habitat characteristics of American woodcock nest sites on a managed area in Maine. Journal of Wildlife Management 60:138–148.

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. 201 pp.

Milliken, G. H., and D. E. Johnson. 1989. Analysis of messy data. Volume 2, Nonreplicated experiments. Van Nostrand Reinhold, New York. 199 pp.

Nichols, J. D., and F. A. Johnson. 1989. Evaluation and experimentation with duck management strategies. Transactions of the North American Wildlife and Natural Resources Conference 54:566–593.

Pettingill, O. S. 1936. The American woodcock *Philohela minor* (Gmelin). Memoirs of the Boston Society of Natural History 9:169–391.

Pollock, K. H., S. R. Winterstein, C. M. Bunck, and P. D. Curtis. 1989. Survival analysis in telemetry studies: The staggered entry design. Journal of Wildlife Management 53:7–15.

SAS Institute Inc. 1989. SAS/STAT User's Guide, Version 6, Fourth Edition, Volume 2, Cary, North Carolina. 846 pp.

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., 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. Woodcock ecology and management. U.S. Fish and Wildlife Service Wildlife Research Report 14. Washington, D.C.

Sepik, G. F., R. B. Owen, Jr., and M. W. Coulter. 1977. Experimental woodcock management at the Moosehorn National Wildlife Refuge. Pages 83–92 *in* D. M. Keppie and R. B. Owen, Jr., editors. Proceedings of the sixth woodcock symposium. Fredericton, New Brunswick.

Sepik, G. F., R. B. Owen, Jr., and M. W. Coulter. 1981. A landowner's guide to woodcock management in the northeast. Miscellaneous Report 253. Life Science and Agricultural Experiment Station, University of Maine, Orono. 23 pp.

Sheldon, W. G. 1956. Annual survival of Massachusetts male woodcocks. Journal of Wildlife Management 20:420–427.

Sheldon, W. G. 1960. A method of mist netting woodcocks in summer. Bird-Banding 31:130–135.

Sheldon, W. G. 1967. The book of the American woodcock. First edition. The University of Massachusetts Press, Amherst. 227 pp.

Society of American Foresters. 1975. Forest cover types of North America. Society of American Foresters. Bethesda, Maryland. 67 pp.

Straw, J. A., Jr., 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.

Vander Haegen, W. M. 1992. Bioenergetics of American woodcock during the breeding season on Moosehorn National Wildlife Refuge, Maine. Ph.D. Dissertation, University of Maine, Orono. 103 pp.

Vander Haegen, W. M., W. B. Krohn, and R. B. Owen, Jr. 1993. Effects of weather on earthworm abundance and foods of the American woodcock in spring. Pages 26–31 *in* J. R. Longcore and G. F. Sepik, editors. Proceedings of the eighth American woodcock symposium. Fish and Wildlife Service Biological Report 16. Washington, D.C.

Wenstrom, W. P. 1973. Habitat utilization and activities of female American woodcock (*Philohela minor* Gmelin) in northeastern Minnesota during spring and summer. Ph.D. Dissertation, University of Minnesota, Minneapolis. 203 pp.

White, F. B. 1933. Birds and motor cars. Auk 50:236.

Direct Recoveries From In-season Banding of American Woodcock in South-central Louisiana

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Abstract: The characteristics and direct recovery rates were assessed for American woodcock (*Scolopax minor*) banded on publicly owned land in south-central Louisiana that received heavy hunting pressure. Woodcock were captured mostly during the hunting season in fields at night and marked with U.S. Fish and Wildlife Service aluminum leg bands. During the six winters spanned by 1990–96, 1433 woodcock were captured a total of 1753 times. Juvenile males were captured most often followed by juvenile females, adult males, and adult females. Based on our best fit logistic regression model, juvenile woodcock were about 2.5 times more likely to be shot and reported than adults ($P = 0.020$). Recovery rates varied significantly among years ($P = 0.0001$) and declined at about 2.9% per day, but no difference ($P > 0.1$) in vulnerability was detected between sexes. Raw annual direct band recovery rates (unadjusted for banding date or age) during the hunting seasons ranged from 0.3 to 11.2% , whereas predicted values ranged between 0.6 and 31.6% for juveniles and between 0.2 and 15.8% for adults. Although the process of adjusting in-season banding records of woodcock to a common start seems reasonable, we caution that actual recoveries of bands were rare enough in our study that each recovery probably exerted considerable influence on our estimates.

Key words: American woodcock, banding studies, direct recoveries, hunting, Louisiana, mortality, recovery rates, *Scolopax minor*.

Although Louisiana supports high concentrations of wintering woodcock and is important wintering habitat (Glasgow 1958; Straw et al. 1994), no significant banding studies have been conducted in the state since the early 1970s. Banding potentially offers the best method to study annual survival and the influence of harvest on woodcock, though serious concerns exist about reporting rates and crippling loss (Straw et al. 1994). Banding studies in Louisiana are limited largely to the hunting season (in-season banding) because woodcock do not arrive in significant numbers until late November and early December and, since 1991, hunting seasons have commenced by 28 November. Although in-season banding can complicate estimation procedures for survival (Brownie et al. 1985), direct recovery rates may provide a useful index to hunting deaths (Dwyer and Nichols 1982), even with limited knowledge of crippling loss and reporting rates.

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Previous banding studies from Louisiana were conducted primarily in the south-central part of the state (Glasgow 1958; Williams 1969). Most sites were widely scattered, mostly privately-owned, and received variable hunting pressure. Public hunting lands offer the opportunity to study an extreme in woodcock harvest rates because they often have high concentrations of hunters and high harvests. Our objective was to estimate recovery rates of woodcock banded on a heavily hunted public land complex and use these estimates to index hunting mortality.

Methods

Study Area

The Sherburne Wildlife Management Area and Atchafalaya National Wildlife Refuge complex (hereafter Sherburne) is located in three south-central parishes of Louisiana and within the Atchafalaya River Basin Flood Control Project. Sherburne consists of about 17,000 ha of bottomland hardwood habitat and early successional fields. There are seven major bayous, numerous sloughs, and many minor drainages. Access is provided by a north-south road near the western boundary, a levee road near the eastern boundary, and a few interior roads constructed to access oil and gas leases or private in-holdings.

Dominant timber types are cottonwood–sycamore, oak–gum–sugarberry–ash, willow–cypress, and overcup oak–bitter pecan. Most forest stands are of low quality because of poor logging practices before acquisition by the Louisiana Department of Wildlife and Fisheries, U.S. Fish and Wildlife Service (USFWS), and U.S. Army Corps of Engineers. Understory condition varied from open to very thick and included blackberry (*Rubus* spp.), elderberry (*Sambucus canadensis*), rattan vine (*Berchemia scandens*), trumpet creeper (*Campsis radicans*), and Virginia creeper (*Parthenocissus quinquefolia*). Much of the understory was dominated by ferns (Pteridophyta).

About 300 ha of Sherburne consists of old field habitats concentrated in the north-central portion of the area. Old fields were formerly in agriculture. About 100 ha were reforested and the remaining area was managed to maintain old-field early-successional conditions. We burned approximately 80–120 ha annually to maintain open fields for nocturnal woodcock habitat and to facilitate banding. In addition to burning, we mowed 10-m strips spaced roughly 50 m apart in banding fields to facilitate our movement and bird capture during banding operations.

Banding and Analysis

We captured woodcock in fields at night using long-handled nets. We initially used nightlighting techniques described by Glasgow (1958; i.e., 6-volt headlights and walking). Beginning in 1992, we used 200,000–600,000 candlepower spotlights for lighting and all terrain vehicles (ATV) for travel. The latter method appeared to improve success as succession of the fields proceeded from cropland to old-field habitat. Spotlights made it easier to see birds and ATV engine noise seemed to make birds "hold" better. We assigned age (adult or juvenile) and sex according to wing plumage characteristics (Martin 1964) and banded each bird with a uniquely-numbered, aluminum USFWS leg band. Banding was initiated in November (18 Nov–30 Nov) in most years and continued through January.

We acquired recovery data from USFWS Bird Banding Laboratory (Laurel, Maryland) and cooperative hunters who reported their harvest at check stations. Voluntary hunter check stations were established in 1991 at entrances used by woodcock hunters and Sherburne headquarters. Beginning in 1992, woodcock hunters were required to obtain a daily permit and report their harvest. We tallied hunting reports by year for the four hunting seasons 1992–96 to estimate hunting effort.

We used loglinear modeling methods calculated by PROC CATMOD (Stokes et al. 1995) to analyze capture frequencies by sex, age, and banding year. We defined a banding year as the 3 consecutive months from 1 November to 31 January and labeled as direct recoveries any within season recovery. We calculated banding date as the number of days between 28 November (normal start of the Louisiana woodcock season) and a bird's first capture within a banding year. We used logistic regression (Hosmer and Lameshow 1989) as calculated by PROC GENMOD (Stokes et al. 1995) to test for banding date, age, sex, and year effects on the prediction of recovery rates. We selected variables in a hierarchal fashion by first including all predictors and their interactions in a logistic regression model and then removed groups of same-level interactions or single predictors that added little to overall fit (improvement χ^2, $P > 0.1$). Samples for each year included all birds captured that year. Unless otherwise noted, estimates are reported as estimate + standard error.

Results and Discussion

Banding and Recovery

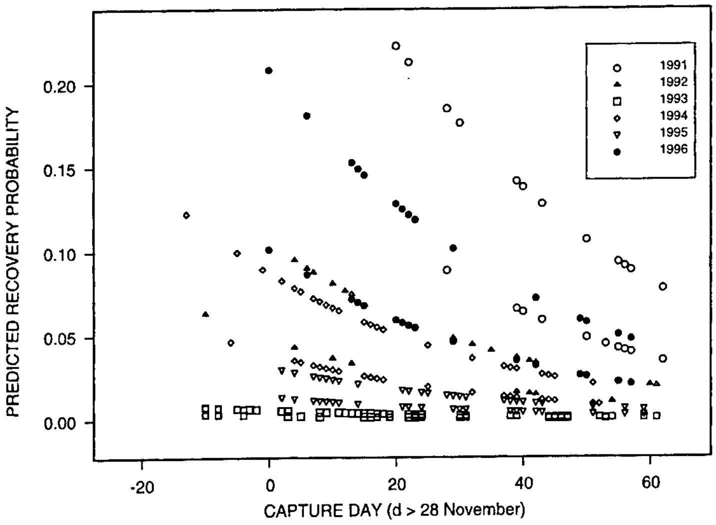
From December 1990 through January 1996, we banded 63–330 birds per banding year for a total of 1753 woodcock captures representing 1433 individuals. The earliest capture date was 18 November and the latest was 28 January. Forty-three captures of birds banded in previous years increased the available sample size to 1476 (Table 1). Overall median banding date of first captures within a banding year was 24 December and half of the woodcock were captured between 15 December and 7 January. Mean banding date varied among years principally due to a 13 December first capture during 1990 (Table 1). Number of birds banded varied significantly among years ($\chi^2 = 121.85$, 5 df, $P < 0.0001$) but, conditional on the number of birds caught within a year, the proportion of birds banded in each age class was independent of sex (reduced model goodness-of-fit $\chi^2 = 10.22$, 6 df, $P = 0.116$). We caught more males (61.1 + 1.3%) than females and more juveniles (77.9 + 1.1%) than adults (Table 1). Juvenile males (48.6%) were most frequently captured, followed by juvenile females (29.3%), adult males (12.5%), and adult females (9.6%). Our data were consistent with Britt (1971), Clark (1979), and Connors and Doerr (1982) who reported that juvenile males were the most frequent sex–age class captured in fields at night. However, we observed an even higher fraction of juvenile males and unequal fractions of other sex–age groups when compared to those studies. The dominance of males in our sample was different from the 42.8% males reported by Glasgow (1958) for a sample of 6,347 woodcock captured at night from fields in Louisiana during winter from 1948–57.

During 6 seasons, 108 banded woodcock were reported harvested by hunters. Of these, 73 (1–33 per year) were direct recoveries within Louisiana. Mean number of days from banding to harvest was 22.4 + 1.47 (2–56 days). Our final logistic regression model for predicting direct recovery probability included age ($\chi^2 = 5.411$, 1 df, $P = 0.020$), year ($\chi^2 = 34.632$, 5 df, $P < 0.0001$) and banding date ($\chi^2 = 10.546$, 1 df, $P = 0.001$) as predictors and fit our banding data well (Hosmer and Lameshow goodness-of-fit $\chi^2 = 8.280$, 8 df, $P = 0.407$). No difference ($P > 0.1$) in vulnerability

Table 1. Woodcock banding and recovery data on Sherburne Wildlife Management Area/Atchafalaya National Wildlife Refuge in south central Louisiana during the 1990–1991 through 1995–1996 hunting seasons.

	Juvenile		Adult			
Year	Male	Female	Male	Female	Total	Banding date[a] ± SE
1990–91	27	18	7	10	62	43 ± 2
1991–92	149	72	19	6	246	28 ± 2
1992–93	176	113	16	25	330	24 ± 1
1993–94	137	81	57	32	307	23 ± 1
1994–95	84	70	41	42	237	26 ± 1
1995–96	145	79	44	26	294	25 ± 1
Total	718	433	184	141	1476	

[a] Days after 28 November, the start of the Louisiana hunting season, calculated as least square means.



Subadult probability trend is always above the adult trend for a given year.

Figure. Predicted direct recovery probabilities for 1476 American woodcock banded mostly in-season during six winters of November–January, 1990–1996, on Sherburne Wildlife Management Area/ Atchafalaya National Wildlife Refuge, Louisiana.

was detected between sexes, and predictors were consistent (i.e., no interactions). Juveniles were 2.5 times as likely as adults to be shot and reported within the same banding year. Direct recovery probabilities declined at about 2.9% per day (Figure). Predicted recovery rates ranged between 0.6 and 31.6% for juveniles and 0.2 and 15.8% for adults and increased raw estimates by at least 40% (Table 2).

Heterogeneity among direct recovery rates was reported for woodcock (Dwyer and Nichols 1982) and is a common phenomenon observed in waterfowl banding studies (Johnson et al. 1992). We observed among year heterogeneity which we suppose to be 2 years of low, moderate, and high harvest each based on hunter reports. We observed a decline in recovery probability with increasing banding date that we expected a priori. So long as birds show site fidelity within the hunting season, days of exposure to the risk of hunting mortality are greater for birds banded earlier than those banded later in the hunting season.

Our findings about the relative vulnerabilities of sex and age groups to hunting mortality were different from the regional band recovery rates reported by Dwyer and Nichols (1982). We observed higher vulnerability of juveniles than adults, whereas they found no clear pattern of difference in recovery rates by age. We observed no sex differences, whereas they found that the recovery rate for juvenile females in the Eastern Region was significantly higher than that for young males and that females generally had higher recovery rates than males in both regions. Our mean predicted adult recovery rate (6.1%) was generally in line with that for adult males (3.1%) and adult females (4.7%) reported by Dwyer and Nichols (1982) for the Central Region. They reported recovery rates of 2.5% for juvenile males and 3.2% for juvenile females in the Central Region. However, our across year mean predicted recovery rate for juvenile woodcock (13.1%) was four to five times greater.

Table 2. Direct recovery rates for juvenile and adult banded woodcock on Sherburne Wildlife Management Area/Atchafalaya National Wildlife Refuge in south central Louisiana during the 1990–1991 through 1995–1996 hunting seasons.

	Juveniles				Adults			
Year	Predicted[a]	LCL[b]	UCL	Raw[c]	Predicted	LCL	UCL	Raw
1990–91	31.6	14.3	56.2	13.3	15.8	5.2	39.1	5.9
1991–92	11.4	6.3	19.8	6.3	5.0	1.9	12.2	0.0
1992–93	0.6	0.1	4.0	0.3	0.2	0.0	1.9	0.0
1993–94	10.2	5.8	17.3	6.4	4.4	1.9	10.0	1.1
1994–95	3.2	1.0	9.8	1.3	1.3	0.3	4.9	1.2
1995–96	21.6	14.3	31.4	12.5	10.0	4.6	20.6	7.1
All Years				5.6				2.4

[a] Predicted recovery probabilities with a baseline banding date of 28 November.
[b] LCL and UCL are computed at the 95 % level.
[c] Raw recovery rate not adjusted for banding date.

A potential explanation for differences in recovery rates is reporting rates. Any comparison of recovery rates assumes similar reporting rates. We believe that we had high band reporting rates because of the rarity of shooting a banded woodcock, heightened hunter interest during the study period, and the convenience of reporting banded birds at major points of entrance and exit. Any differences between our reporting rate and those of Dwyer and Nichols (1982) are not known. Because reporting rate for woodcock in general is thought to be very high, differences may not be great. Regardless, this explanation does not adequately address why only juvenile cohorts are drastically different from Dwyer and Nichols (1982).

Difference in time lag between banding and harvest seems a better explanation for the apparent age effect. Dwyer and Nichols (1982) analyzed preseason bandings from birds on the breeding grounds and significant mortality may occur between banding and the hunting season. In contrast, we predominantly banded during each hunting season and thus had almost no lag time between banding and hunting. If significant losses occur to the banded sample prior to the onset of hunting, recovery rates estimated from preseason banding would be biased low (Nichols et al. 1982). Survival of juvenile woodcock during the summer is less than that of adults (Derleth and Sepik 1990).

Many of our annual predicted recovery rates were higher than any preseason banding estimate for hunting that we found in the literature. (Whitcomb [1974] reported recovery rates of 33–43% on High Island, Michigan, but these were not a result of recreational hunting.) However, we believe our predicted recovery rates for Sherburne were a worst case scenario and did not reflect the hunting mortality risk woodcock incurred throughout Louisiana. The higher recovery rates at Sherburne were expected because we accounted for the effect of decreasing probability for recovery during the banding period in our estimates. Less than 10% of the woodlands in Louisiana are publicly-owned and most of these offer poor woodcock habitat or are not within the region of the state with a tradition of woodcock hunting. As a consequence, woodcock hunters by necessity concentrate on public lands that winter good numbers of woodcock. Nevertheless, the higher predicted recovery rates were largely limited to the juvenile birds. This suggests that harvests rates on Sherburne, a relatively high-use area by southern standards, may have had harvest rates similar to the average rate across northern breeding ground states such as Michigan, Minnesota, and Wisconsin. Williams (1969) observed a direct recovery rate of only 0.15% from over 17,000 banded woodcock in Louisiana. Those bandings were conducted over an extended period of years and mostly on widely-scattered, private properties.

The ratio of juveniles to adult females (production index) for Louisiana is high relative to other states in the Central Region (Bruggink 1996). If our banding data reflect actual proportion of adult females available to hunting (we have no evidence for or against) and we couple that with higher vulnerability of juveniles to harvest, we would predict a high production index.

Hunting Effort and Bag

From the 1992–93 through 1995–96 hunting seasons, annual hunter-days ranged from 145 to 330 days and harvest per hunter-day ranged from 0.23 to 1.32 birds (Table 3). Ostensibly, observed effort over a 65-day season was 2.2–5.0 hunters per day for a relatively large tract of land. But, access to much of Sherburne was limited and most hunting occurred within 1–2 km of the banding fields. Further, the study area is closed to woodcock hunting about 4 days during late November and early December when either-sex deer hunts occur. Bucks-only deer hunts occur during late December through early to mid-January. Although Sherburne is not closed to woodcock hunting during bucks-only hunts, few woodcock hunters participated during that time. Thus, little to no woodcock hunting occurs on Sherburne for about one-third of the 65-day hunting season. Public hunting for woodcock on Sherburne, measured in terms of bag per hunter-day, is quite poor when compared to published reports of localized hunting success in other areas (Pace and Wood 1979). We suspect that hunter participation increases in areas

Table 3. Hunter effort and woodcock harvest reported on the Sherburne Wildlife Management Area/ Atchafalaya National Wildlife Refuge in south central Louisiana during the 1992–1993 through 1995–1996 hunting seasons.

Year	Hunter Efforts	Bag	Bag / Effort[a]	SE[b]
1992–93	209	74	0.35	0.06
1993–94	278	139	0.52	0.08
1994–95	145	32	0.23	0.06
1995–96	330	421	1.32	0.14

[a] Effort = hunter-day and ratio estimate based only on hunting permits with complete data.

[b] Standard error of a ratio estimate (Cochran 1977) assuming an infinite sampling frame.

like Sherburne as hunters relate their success to others.

Although the sample is small (4 years), both juvenile and adult predicted recovery rates were correlated with bag per hunter day with ρs of 0.949 ($P = 0.05$) and 0.963 ($P = 0.04$), respectively. Band recoveries per hunter-day have gone from 0.005 during 1992 to 0.1 during 1995. Hunters have begun to find birds in some of the old field habitats that we manage which are adjacent to the banding fields and are concentrating their hunting efforts in these areas.

Conclusions

The distribution among sex and age groups of woodcock banded at Sherburne differed from other reports. Considerable variation in hunting mortality occurred at Sherburne during this 6-year study. Juvenile birds were more vulnerable than adult birds to hunting mortality. Our methodology coupled with the uniqueness of Sherburne (public area, modest hunting pressure, permit required for woodcock hunting) produced some apparently higher juvenile recovery rates relative to other studies. We cannot, however, measure the relative influence of study area versus methodology on these apparently high rates of hunting mortality. We believe that in-season banding can provide a reasonable index to hunting mortality as long as recovery probabilities reflect the entire time at risk. Others investigating hunting mortality through banding should strive to appropriately adjust the banded sample to the number of birds at risk when hunting commences.

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References

Britt, T. L. 1971. Studies of woodcock on the Louisiana wintering ground. M.S. Thesis. Louisiana State University, Baton Rouge.

Brownie, C., D. R. Anderson, K. P. Burnham, and D. S. Robson. 1985. Statistical inference from band recovery data—a handbook. U.S. Fish and Wildlife Service, Resource Publication 156.

Bruggink, J. G. 1996. American woodcock harvest and breeding population statistics, 1996. U.S. Fish and Wildlife Service, Laurel, Maryland. 14 pp.

Clark, J. M. 1979. Population dynamics of breeding woodcock in the Canaan Valley, West Virginia. Proceedings of the Annual Conferance of Southeastern Association of Fish and Wildlife Agencies 33:288–295.

Cochran, W. G. 1977. Sampling techniques. Third edition. John Wiley & Sons, New York.

Connors, J. I., and P. D. Doerr. 1982. Woodcock use of agricultural fields in coastal North Carolina. Pages 139–147 *in* T. J. Dwyer and G. L. Storm, technical coordinators. Woodcock ecology and management. U.S. Fish and Wildlife Service Wildlife Research Report 14. Washington, D.C.

Derleth, E. L., and G. F. Sepik. 1990. Summer-fall survival of American Woodcock in Maine. Journal of Wildlife Management 54:97–106.

Dwyer, T. J., and J. D. Nichols. 1982. Regional population inferences for the American woodcock. Pages 12–21 *in* T. J. Dwyer and G. L. Storm, technical coordinators. Woodcock ecology and management. U.S. Fish and Wildlife Service Wildlife Research Report 14. Washington, D.C.

Glasgow, L. L. 1958. Contributions to the knowledge of the ecology of the American woodcock, *Philohela minor*, on the wintering range in Louisiana. Ph.D. Thesis. Texas A. & M. University, College Station.

Hosmer, D. H., Jr., and S. Lemeshow. 1989. Applied logistic regression. John Wiley & Sons, Incorporated, New York.

Johnson, D. H., J. D. Nichols, and M. D. Schwartz. 1992. Population dynamics of breeding waterfowl. Pages 446–485 *in* B. D. J. Batt, A. D. Afton, M.G. Anderson, C. D. Ankey, D. J. Johnson, J. A. Kadlec, and G. L. Krapu, editors. Ecology and management of breeding waterfowl. University Minnesota Press, Minneapolis.

Martin, F. W. 1964. Woodcock age and sex determination from wings. Journal of Wildlife Management 28:287–293.

Nichols, J. D., S. L. Stokes, J. E. Hines, and M. J. Conroy. 1982. Additional comments on the assumption of homogeneous survival rates in modern bird banding estimation models. Journal of Wildlife Management 46:953–962.

Pace, R. M., III, and G. W. Wood. 1979. Observations of woodcock wintering in coastal South Carolina. Proceedings of the Southeastern Association Fish and Wildlife Agencies 32:72–80.

Stokes, M. E., C. S. Davis, and G. G. Koch. 1995. Categorical data analysis using the SAS system. SAS Institute, Incorporated, Cary, North Carolina.

Straw, A. S., 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.

Whitcomb, D. A. 1974. Characteristics of an insular woodcock population. Wildlife Division Report 2720. Michigan Department Natural Resources, Lansing.

Williams, S. O. 1969. Population dynamics of woodcock wintering in Louisiana. M.S. Thesis. Louisiana State University, Baton Rouge.

Gonadal Condition of American Woodcock Harvested in Louisiana During the 1986–1988 Hunting Seasons

by

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Abstract. During the 1986–88 hunting seasons, gonadal condition was determined for 273 woodcock (*Scolopax minor*) collected from 14 parishes. Females comprised 56% of the sample. Female woodcock were shot from 6 December to 11 February. No females were in breeding condition (follicles ≥5 mm). Collection period for males was 7 December–12 February. The earliest date a male in breeding condition (left testis measurement ≥6 mm) was collected was 18 December. However, it was not until late January that most birds had a testis measurement ≥6 mm.

Keywords: American woodcock, hunting, gonadal recrudescence, Louisiana, *Scolopax minor*.

Among southern states, Louisiana ranks high in terms of harvest of American woodcock (*Scolopax minor*) and importance as a wintering area (Straw et al. 1994). During the late 1970s and early 1980s, there was a proliferation of studies addressing the reproductive status of woodcock during the hunting season. Breeding biology of woodcock was examined in Alabama (Roboski and Causey 1981; Walker and Causey 1982), North Carolina (Stamps and Doerr 1977; Rushing and Doerr 1984), South Carolina (Pace and Wood 1979; Ingram and Wood 1983), Tennessee (Roberts and Dimmick 1978), and Texas (Whiting and Boggus 1982). They reported highly variable results ranging from 0 to 50% of female woodcock in breeding condition. During years with mild winter temperatures, the incidence of advanced recrudescence in female woodcock was higher. Causey et al. (1987) correlated the number of days during January with mean daily temperature >4.4°C with increased nesting activity in Alabama. The 50% incidence recorded for North Carolina was during extremely mild years.

Whiting et al. (1985) estimated that 1,840 gravid adult female woodcock would be harvested annually during February based on an average gravid rate of 35.3%. They expressed concern that if the popularity of woodcock hunting increased a significant adverse effect on woodcock populations might occur. At the time Louisiana accounted for 50% of this harvest and Mississippi for about 10%. Although data on harvest from Louisiana and Mississippi were used to estimate potential harvest, only a small portion (25 of 304) of the data on female condition was from those two states. Olinde and Prickett (1991) determined age and gonadal stage for 638 woodcock taken in Louisiana during the 1–15 February portion of the 1980–82 hunting seasons. They found only 2.4% of the 376 female woodcock examined to be gravid. The purpose of our study was to examine gonadal condition of woodcock in Louisiana throughout the hunting season to better define the period when gonadal maturation is initiated.

Methods

Louisiana Department of Wildlife and Fisheries personnel and volunteers collected woodcock throughout the 1986–88 hunting seasons (extreme dates = 6 December–12 February) from across the state using legal hunting methods. Carcasses, generally with the breast or legs removed, were frozen until processed. For females, I measured the largest ovarian follicle from each specimen to the nearest 0.1 mm using vernier calipers and noted the presence or absence of an egg in an oviduct.

For males, I measured the left testis. Females with follicles ≥5.0 mm (Whiting et al. 1985) and males with a left testis length ≥6.0 mm (Roberts 1980) were considered in or approaching breeding condition. I assigned age of the birds using wing characteristics (Martin 1964).

For this study, the state was divided into northern and southern regions at approximately 31 ° latitude along parish lines, roughly corresponding to a line at the "ankle" of Louisiana. Much of the southern region is generally outside the recognized breeding range for woodcock (Sheldon 1971). A 1985 survey suggested that the southern region accounted for 80% of the woodcock hunters and harvest (Louisiana Department of Wildlife and Fisheries, unpublished data).

I log transformed the data on follicle diameters from females. I tested data sets on gonadal size for age, collection period, regional differences, and their interactions using general linear models. I used month as the collection period for females because of the relatively large expected increase in follicle size but day was used for the males. For males the day variable was the number of days after 1 December. I only analyzed data from birds with sex, age, and region of harvest available and I analyzed sexes separately. Initial models used all main effects and their interactions. Models were reduced to significant elements based on Type III SS values and $\alpha < 0.05$ for significance. The final models were SIZE = MONTH AGE for females and SIZE = DAY REGION for males. Means (±SE) are presented as least-square means. I tested for regional difference in the proportions of males and females harvested before and after 20 January using Chi-square analysis. I chose the date 20 January for this analysis because most males (>80%) had follicles ≥6 mm after that date. I only used woodcock with sex and region of harvest available in this analysis.

Results

I determined gonadal condition of 273 woodcock shot during the 1986–88 hunting seasons. Birds were obtained from 14 parishes during the 3 hunting seasons (Figure 1). The sample included 104 (38%) birds collected in December, 128 (47%) in January, and 41 (15%) in February; 57% were shot in the southern region. Sixty percent of the birds came from two adjoining bottomland parishes (Concordia in the northern region and Pointe Coupee in the southern region.

Figure 1. Parish location and sample size for woodcock examined in Louisiana for gonadal condition during the 1986–1988 hunting seasons.

The 154 female specimens came from 14 parishes. The earliest collection date for a female woodcock was 6 December and the latest date was 11 February (Figure 2). Nearly half (47%) of the females were collected during January (72), 56 (36%) during December, and 26 (17%) were collected in February. No ovarian follicles were ≥5.0 mm (range: <1.0–4.2 mm) and only two were ≥4.0 mm. Mean size of follicles increased ($F = 80.12$, 2, 148 df, $P < 0.001$) each month. Follicle sizes in December, January, and February averaged 1.26 mm (± 0.05), 2.16 mm (± 0.08), and 2.82 mm (± 0.17), respectively. Mean follicle size of adults (2.10 mm ± 0.08) were larger than follicles of juveniles (1.86 mm ± 0.06; $F = 6.23$, 1, 148 df, $P = 0.014$). No regional differences were detected ($F = 1.4$, 1, 147 df, $P = 0.239$).

I obtained 119 males from 12 parishes. Collection period for males was similar to that of females. The

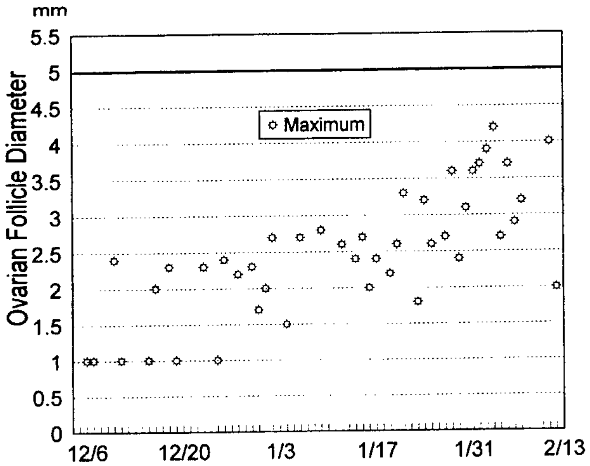
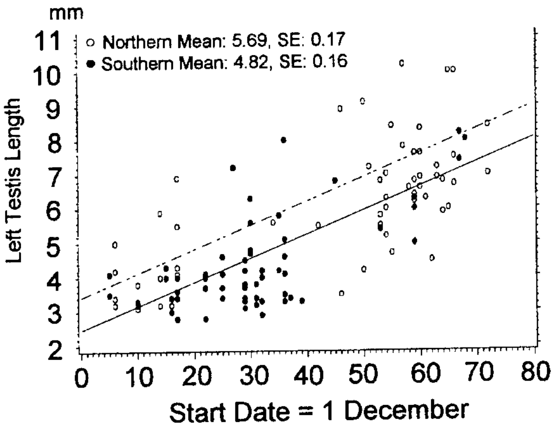


Figure 2. Distribution of maximum ovarian follicle sizes by date for woodcock collected in Louisiana during the 1986–1988 hunting seasons.

earliest date a male was collected was 7 December and the latest date was 12 February. The sample includes 48 (40%) taken in December, 56 (47%) in January, and 15 (13%) in February. Size of left testes increased ($F = 96.11$, 1, 114 df, $P < 0.001$) over the season at a daily rate of 0.06 mm (Figure 3). No males had a testis measurement ≥6.0 mm until 18 December (Figure 4). Males from the northern region of the state had larger ($F = 13.79$, 1, 114 df, $P < 0.001$) testes ($0 = 5.69$, SE = 0.17, $n = 56$) than males in the southern regions ($0 = 4.82$, SE = 0.16, $n = 63$).



Northern Region trend line on top.

Figure 3. Regression lines for left testis size by region for woodcock collected in Louisiana during the 1986–1988 hunting seasons.

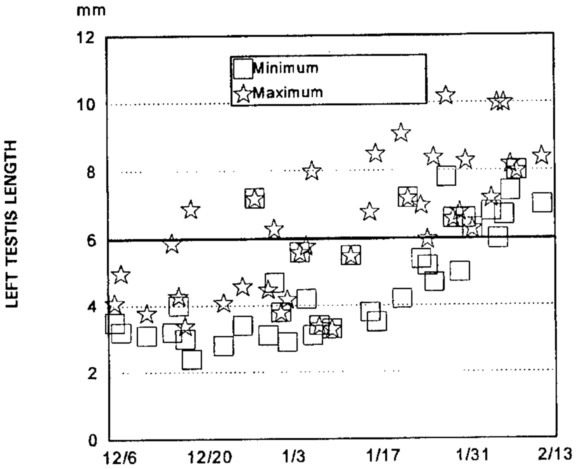


Figure 4. Distribution of minimum and maximum left testis sizes by date for woodcock collected in Louisiana during the 1986–1988 hunting seasons.

There was weak evidence that the male:female ratios were different by collection period in the southern region ($\chi^2 = 3.166$, 1 df, $P = 0.075$) but not in the northern region ($\chi^2 = 0.059$, 1 df, $P = 0.807$). The southern region male:female ratios for the pre- and post-20 January periods were 1:1.00 and 1:2.10, respectively. In contrast, the ratios for the pre- and post-20 January periods in the northern region were 1:1.20 and 1:1.11.

Discussion

Studies in other southeastern states have demonstrated high variability in size of ovarian follicles of woodcock among years (Stamps and Doerr 1977; Roberts and Dimmick 1978; Rushing and Doerr 1984; Whiting et al. 1985) and temperature was hypothesized as the controlling factor (Causey et al. 1987). Thus, the lack of females with follicles in the rapid development stage in my study was not unexpected. Olinde and Prickett (1991) reported relatively low rates of female woodcock in or approaching breeding condition in Louisiana during 1980–82 and their study included normal and warmer and colder than normal weather during collection years. Follicle development of female woodcock in my study was the same as those reported for South Carolina ($n = 38$) in 1977–81 (Pace and Wood 1979; Ingram and Wood 1983) and Mississippi and Louisiana

($n = 16$) in 1979 (Whiting et al. 1985) and similar to Alabama's 2.9% ($n = 35$) in 1977 (Whiting et al. 1985). Because female woodcock begin nesting in mid-February in the South, the later collection period in my study should have resulted in a higher proportion of birds with follicles undergoing recrudescence caused by continued maturation of follicles and the significant immigration of birds from the state during early to mid-February. Adults having larger follicles than juveniles were similar to findings of Whiting and Boggus (1982), Whiting et al. (1985), and Olinde and Prickett (1991). In Whiting et al. (1985), only 3.9% of the juvenile females were in breeding condition whereas 35.3% of the adults had reached this condition.

In contrast to females, I documented males in or approaching breeding condition as early as mid-December with significant numbers (> 80%) present by late January and early February. This is consistent with the findings of other researchers in southern states (Roberts and Dimmick 1978; Pace and Wood 1979; Whiting et al. 1985). The daily rate of growth (0.06 mm) in my study approximated that reported for North Carolina (Whiting and Boggus 1982). Similar to Olinde and Prickett (1991), I did not detect differences in the proportion of males in breeding condition based on age.

Initially, results of my regional analyses (i.e., no regional differences for females and regional differences for males) seem contradictory to those reported for Louisiana by Olinde and Prickett (1991). They found regional differences in the proportion of females in or approaching breeding condition but no differences for males. However, closer examination suggests that my findings are consistent with the previous study. Although no females were found in breeding condition during my study, only 2.4% ($n = 376$) were found with follicles ≥5 mm in the previous study (Olinde and Prickett 1991). Eight of the nine females in breeding condition used in the Olinde and Prickett (1991) analysis were collected in the northern portion of the state. An additional two gravid birds not used in the analysis also were collected from the northern portion of the state. My small sample size collected during February (26 vs. 376) could account for the lack of any female woodcock with follicles ≥5 mm collected. With regard to males, regional differences in the earlier Louisiana study (Olinde and Prickett 1991) were not detected ($P = 0.08$). However, my study suggests that regional differences for males may have been present in the earlier study, but their power to detect differences was low. In addition, analyses in the Olinde and Prickett (1991) study were based on proportions of birds in reproductive condition and not simply gonadal size.

Olinde and Prickett (1991) hypothesized that gonadal condition was a factor that influenced the timing of woodcock migration. The difference in gonadal size observed between regions as well as the male:female ratio in collections suggested early migration of woodcock during my study. These regional differences suggest that physiological condition as influenced by weather conditions and photoperiod affects the timing of migration and, in mild winters, results in increased nesting along migratory paths. Murton and Westwood (1977) associated *Zugunruhe* (migratory restlessness) with the beginning of gonadal recrudescence.

The low incidence I observed of females in or approaching breeding condition in Louisiana by mid-February (also Olinde and Prickett 1991) and the chronology of nesting for woodcock in Alabama (Roboski and Causey 1981) and Texas (Whiting and Boggus 1982)—egg-laying commences mid-February in most years—supports this hypothesis. Glasgow (1958) believed that woodcock were "regular, but uncommon" nesters in Louisiana. My data and that of Olinde and Prickett (1991) support this belief. It also supports Sheldon's (1971) breeding range description for Louisiana, which is the northern portions of most parishes east of the Mississippi River and north of a line roughly from the southwest corner of West Feliciana Parish to Lake Charles.

Management Implications

Under the present hunting season framework (31 January closing) as well as under the previous framework as applied in Louisiana (15 February), the likelihood of shooting a female woodcock in or approaching breeding condition in Louisiana is low in most years. A high proportion of males taken at the end of January are sexually mature. However, the biological significance of this is probably minor because of the polygamous breeding strategy of woodcock and females may ultimately determine when breeding occurs.

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References

Causey, M. K., M. K. Hudson, and T. P. Mack. 1987. Breeding activity of American woodcock in Alabama as related to temperature. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 41:373–377.

Glasgow, L. L. 1958. Contributions to the knowledge of the ecology of the American woodcock, Philohea minor (Gmenlin), on the wintering range in Louisiana. Ph.D. Thesis. Texas A. & M. University, College Station.

Ingram, R. P., and G. W. Wood. 1983. Characteristics of woodcock harvest data in coastal South Carolina. Wildlife Society Bulletin 11:356–359.

Kelly, S. 1986. American woodcock 1986 breeding population status. U.S. Fish and Wildlife Service Administrative Report. Laurel, Maryland. 14 pp.

Martin, F. W. 1964. Woodcock age and sex determination from wings. Journal of Wildlife Management 28:287–293.

Murton, R. K., and N. J. Westwood. 1977. Avian breeding cycles. Clarendon Press, Oxford, United Kingdom. 594 pp.

Olinde, M. W., and T. E. Prickett. 1991. Gonadal characteristics of February-harvested woodcock in Louisiana. Wildlife Society Bulletin 19:465–469.

Pace, R. M., III, and G. W. Wood. 1979. Observations of woodcock wintering in coastal South Carolina. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 33:72–80.

Roberts, T. H. 1980. Sexual development during winter in male American woodcock. Auk 97:879–881.

Roberts, T. H., and R. W. Dimmick. 1978. Distribution and breeding chronology of woodcock in Tennessee. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 32:8–16.

Roboski, J. C., and M. K. Causey. 1981. Incidence, habitat use, and chronology of woodcock nesting in Alabama. Journal of Wildlife Management 45:793–797.

Rushing, E. L., and P. D. Doerr. 1984. Breeding biology of the American woodcock in Piedmont North Carolina. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 38:142–152.

Sheldon, W. G. 1971. The book of the American woodcock. University of Massachusetts Press, Amherst. 227 pp.

Stamps, R. T., and P. D. Doerr. 1977. Reproductive maturation and breeding chronology of woodcock in North Carolina. Pages 185–190 *in* D. M. Keppie and R. B. Owen, Jr., editors.

Proceedings of the Sixth Woodcock Symposium. Fredericton, New Brunswick.

Straw, J. A., Jr., 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.

Walker, W. A., and M. K. Causey. 1982. Breeding activity of American woodcock in Alabama. Journal of Wildlife Management 46:1054–1057.

Whiting, R. M., Jr., and T. G. Boggus. 1982. Breeding biology of American woodcock in east Texas. Pages 132–138 *in* T. J. Dwyer and G. L. Storm, technical coordinators. Woodcock ecology and management. U.S. Fish and Wildlife Service Wildlife Research Report 14. Washington, D.C.

Whiting, R. M., Jr., R. R. George, M. K. Causey, and T. H. Roberts. 1985. February hunting of American woodcock: Breeding implications. Pages 309–317 *in* S. L. Beasom and S. F. Roberson, editors. Game harvest management. Caesar Kleberg Wildlife Research Institute, Kingsville, Texas.

Weight Variation Among American Woodcock Wintering In South-central Louisiana

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Abstract: Weight variation was examined among American woodcock (*Scolopax minor*; hereafter woodcock) captured in fields at night near Krotz Springs, Louisiana, during November–February 1991–1996. During the 5 winters of this study, 1,275 woodcock were weighed and 1,529 weights obtained. Weight varied modestly within sex with coefficients of variation of 7.15% for males and 7.16% for females and generally increased over time. Females were heavier (40.0 ± 1.2 g) than males ($P = 0.0001$) and adults were heavier (4.2 ± 1.1 g) than juvenile birds ($P = 0.0001$), but with a tendency for a greater difference (5.4 vs. 2.8 g) between females than males ($P = 0.06$). Analysis of covariance determined that weights differed among years ($P = 0.0004$) and increased with increasing banding date ($P = 0.0001$) but with a significant interaction ($P = 0.0001$). Increases in weight from early to late winter were predicted by the hypothesis that mid-winter fat stores and hence weights would be lower than those during fall or prior to spring migration because fat stores that are not needed to meet energy demands pose an unnecessary burden to flight. However, competing hypotheses may apply to woodcock. To understand the annual cycle and scale of fat and protein storage in woodcock, we will need better models of condition and the dynamics of body fat storage, and we need more refined measurements of environmental conditions.

Variations in body weight, fat deposits, and condition are well documented phenomena among individuals of various migratory birds, including shorebirds (Johnson 1985; Lindstrom and Piersnia 1993). Zoologists recognize that selection pressures may act toward optimizing fat stores and reserves because birds must trade off among three choices: (a) store fuel for migratory flights, (b) retain stored fuel as a hedge against the vagaries of food availability and weather (Davidson and Evans 1989), and (c) avoid increased wing loading (decreased flight efficiency) that accompanies increased body weight (McNeil and Cadieux 1972; Dunn et al. 1988).

Few publications about woodcock include measures of seasonal body fat or weight dynamics although authors often discussed the influence of

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weather on woodcock survival, especially singing males (Owen and Krohn 1973; Whitcomb 1974; Dwyer et al. 1988). Rochford and Wilson (1980) noted that body mass of European woodcock (*Scolopax rusticola*) has a seasonal pattern exhibited by many littoral scolapacids. Dwyer et al. (1988) reported mean weights of singing male woodcock for weekly periods during 1 April–2 June. They found "no significant weight changes for male woodcock during the courtship season," but went on to describe male weights as "lowest at about the midpoint of the breeding season." They failed to provide a specific test of this trend. No reports describe dynamics of body weight of woodcock on their wintering grounds where woodcock are likely to be in a baseline state (no breeding, migration, molt, growth, cold stress). We examined variation in weight among wintering American woodcock (*S. minor*) in south-central Louisiana to establish baseline data, to coarsely examine dynamics, and to stimulate other work on seasonal measures of condition.

This study was part of a long-term banding project sponsored by the Wildlife Division, Louisiana Department of Wildlife and Fisheries (Federal Aid Project W55-VI-VI). Additional support was provided by Louisiana Cooperative Fish and Wildlife Research Unit, U.S. Fish and Wildlife Service (USFWS) Office of Migratory Bird Management, the Cajun Becasse Chapter of the Ruffed Grouse Society and their parent organization through the Louisiana State University Agricultural Center (LSUAC), LSU Foundation, and the National Fish and Wildlife Foundation in support of associated research of RMP. Personnel at Sherburne Wildlife Management Area (SWMA) and administrators of Atchafalaya National Wildlife Refuge (ANWR) and U.S. Army Corps of Engineers (ACOE) were extremely cooperative with the field studies.

Study Area

We banded woodcock at the SWMA/ANWR/ACOE public land complex (hereafter Sherburne) in south-central Louisiana near Krotz Springs. Sherburne consists of about 17,000 ha of bottomland hardwoods and two complexes of early successional fields (300 ha). Banding operations were restricted to the fields that are in the north-central portion of Sherburne. A detailed description of Sherburne is provided by Olinde et al. (2000).

Methods

We captured birds during late November through February from 1991 to 1996 using nightlighting methods modified from Glasgow (1958). We determined sex and age (AHY [>1-year-old] or HY [<1-year-old]) of birds using wing plumage (Martin 1964), weighed them (±1 g) with a spring scale, and banded them with standard USFWS aluminum leg bands. Individuals captured more than once provided repeated measures that we used to examine change in weight. To examine associations between body size and weight, we measured wing length (±1 mm) from the notch in the manus to the longest primary and bill length (±1 mm) on a subset of females captured during 22 November through 10 January from 1992 to 1995.

We analyzed weight data using both graphical and ANOVA methods. We grouped weights according to sex and week of capture and produced box plots to search for trends in weights with either years pooled or treated separately. We also computed relative weights (condition) for sex and age classes by subtracting from each weight the median weight of all birds within the appropriate sex and age class, and examined box plots for trends in condition. Based upon these multiple graphical analyses, we used mixed-model ANOVA (PROC MIXED SAS v. 6.12; Littell et al. 1996) to test whether body weight at capture varied with sex, age, year, and banding date; the latter was treated as a continuous covariate computed as the number of days after 1 November. We treated banding day, year, sex, and age as fixed. We tested the year–sex–age interaction and all 2-way interactions assuming the covariance between any pair of measurements on individual birds (subject) was equal (compound symmetry), whereas the covariance between any two measurements on different birds was zero. We tested the reasonableness of the compound symmetry assumption and inclusion of interactions by building complex models and then reducing down to a final model by deleting nonsignificant terms. We performed these tests on two data sets: one included all weights and the other excluded any measurement taken on a bird in banding years subsequent to its initial capture. Unless otherwise noted, estimates were reported as least square means ±SE.

We used ANCOVA to test associations among weight, wing length, and bill length adjusted for age, year, or banding day if necessary. We used regression analysis in an attempt to associate changes in weight with monthly temperature and precipitation data provided by the Louisiana Agricultural Center, Baton Rouge, for the area near Sherburne.

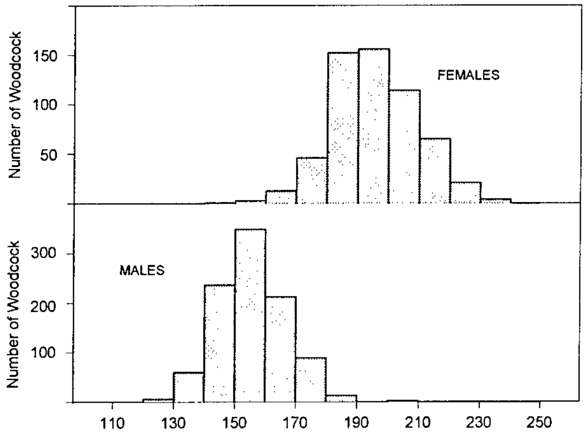

Figure 1. Distribution of weight among female and male woodcock captured in fields at night during five winters from 1991 to 1995 in south-central Louisiana.

Results

During 1991 through 1996, we obtained 1,529 weights from 1,275 woodcock (Table). Mean weights (unadjusted for variation through time or age) were 154.6 ± 0.4 g and 194.5 ± 0.5 g for males and females, respectively. Weights within sex varied modestly with coefficients of variation of 7.15% for males and 7.16% for females. Half of the weights were contained within a range of 14 g for males and a range of 18 g for females (Figure 1). An inspection of box plots revealed generally increasing weights over time (Figure 2), but this trend was inconsistent among years. Relative condition (weight–median weight) by week for each sex and age class seemed to increase gradually during the 12 week period starting in December (Figure 3), and among year inconsistencies paralleled those observed for weight data. Results of mixed model ANOVAs indicated that females were heavier (40.0 ± 1.2 g) than males ($F = 2909.7$; df = 1, 1275; $P = 0.0001$) and adults were heavier (4.2 ± 1.1 g) than hatch year birds ($F = 35.3$; df = 1, 241; $P = 0.0001$), but with a tendency toward a greater difference (5.4 vs. 2.8 g) between females than males ($F = 3.6$; df = 1, 241; $P = 0.0576$). Weights also differed among years ($F = 5.39$; df = 4, 241; $P = 0.0004$). Analysis of covariance confirmed that weight increased with banding date but inconsistently (i.e., significant interaction) among years ($F = 34.4$; df = 5, 241; $P = 0.0001$). During 1991, 1992, and 1994, woodcock increased in weight faster (0.34 ± 0.10 g/day, 0.29 ± 0.03 g/day, and 0.25 ± 0.04 g/day, respectively) than during 1993 and 1995 (0.12 ± 0.02 g/day and 0.14 ± 0.03 g/day).

For the subset of female woodcock ($n = 160$) used to collect measurements of body size, weight

Table. Numbers of individual American woodcock (*Scolopax minor*) weighed (total weights in sample) during November–February 1991–1996 banding operations conducted on Sherburne Wildlife Management Area, Louisiana.

	After hatch year		Hatch year	
Year	Male	Female	Male	Female
1991–1992	10 (10)	6 (6)	81 (89)	35 (35)
1992–1993	13 (16)	20 (27)	161 (199)	105 (125)
1993–1994	47 (59)	30 (35)	153 (201)	97 (112)
1994–1995	35 (43)	42 (43)	81 (111)	68 (73)
1995–1996	40 (46)	22 (27)	149 (183)	82 (89)
Total	145 (174)	120 (138)	625 (783)	387 (434)

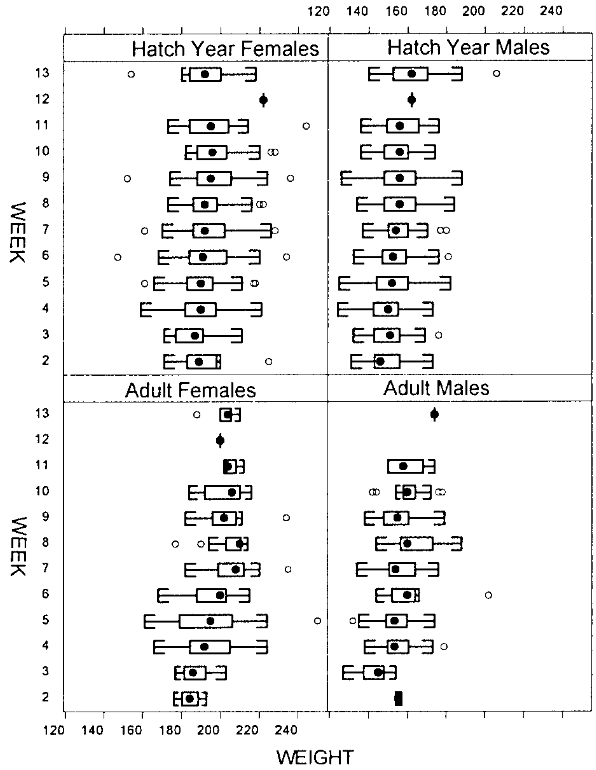

Figure 2. Box plots of weekly weight distributions among sex and age cohorts of woodcock captured in fields at night during five winters from 1991 to 1995 in south-central Louisiana. Bold dot is the median, the height of the box is the interquartile distance (IQD; the difference between the third and first quartiles) and the whiskers extend a distance of 1.5 IQD. The unfilled circles represent extremes in the data.

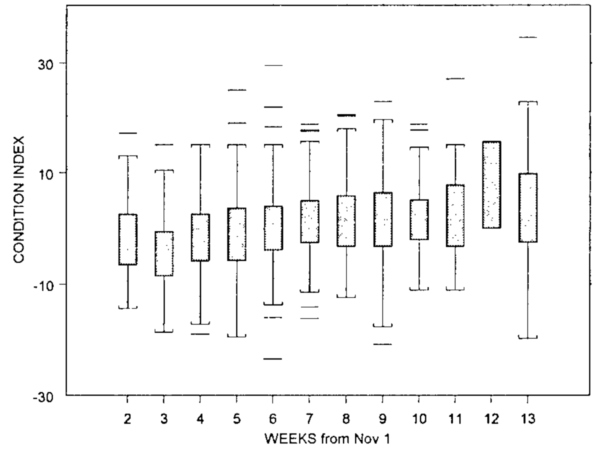

Figure 3. Box plots of the weekly condition index (weight - median weight), adjusted for age-sex, of 1275 woodcock captured in fields at night during five winters from 1991 to 1995 in south-central Louisiana. The dark central bar is the median, the height of the box is the interquartile distance (IQD; the difference between the third and first quartiles) and the whiskers extend a distance of 1.5 IQD. Horizontal lines outside the whiskers represent extremes in the data.

varied significantly with age (AHY > HY; $F = 11.97$; df = 1,155; $P = 0.0007$) but not year ($P = 0.91$) or day ($P = 0.34$). After adjusting for age, weight increased ($F = 5.35$; df = 1,156; $P = 0.022$) 0.62 ± 0.27 g/mm of wing length, which we interpreted as strong evidence that wing length is a good measurement for indexing body size in female woodcock. After adjusting for age, however, bill length was not predictive of weight ($P = 0.15$).

Although monthly summaries of minimum temperature and precipitation varied among months and years, these values were coarse measures (smoothed by averaging) of weather severity. Thus we were unable to explain the considerable variation in weight among months or years ($P > 0.1$).

Discussion

Weights of woodcock during winter vary among sex and age groups, and among years, but generally increase from December to February. We believe that most of this variation was attributable to variation in body stores and reserves although other sources of variation could be significant. Woodcock can ingest and hold up to 10% of their body weight in their esophagus (Vander Hagen 1992); and stomach (proventriculus plus ventriculis) contents reportedly vary as much as 6 g from sunset to midnight (Britt 1971). As with all vertebrates, variation in weights of birds should be related to variation in physical size at a baseline within same sex and age cohorts (Rochford and Wilson 1980; Lindstrom and Piersnia 1993). Because of a woodcock's ability to eat large amounts of food, a nearly uniform distribution of our sampling times from shortly after sunset to midnight, and size-related variation (R. M. Pace, unpublished data), we were surprised that the overall variation within sex and age groups was not larger.

Monthly summaries of minimum temperature and precipitation that we used as measures of weather severity were coarse. Monthly summaries were insufficient indicators of severe weather events that might influence food availability or times of high energy losses. Thus, we were unable to explain the considerable variation in weight among years. Relative to other shorebirds, woodcock have a lower basal metabolic rate (Vander Hagen 1992). Because of the capacity of shorebirds to make modest weight gains over a short term, the foraging capacity of woodcock, and metabolic rates of woodcock (Vander Hagen 1992), woodcock that survive several days of weight loss during severe weather will likely recover weight quickly provided food availability is adequate. If one or two severe weather events (near freezing temperature coupled with rain or periods of frozen ground) can influence among year weight dynamics of woodcock, researchers must gather refined environmental measures and, ideally, repeated measurements on individual birds before we can attempt to detect these influences. Also, to refine weight measurements for examining the effects of winter weather we should index body size by a set of measurements not affected by body stores (e.g., lengths of tarsi, bill, toes, and wings) as has been done for other shorebirds (Lindstrom and Piersnia 1993).

Increases in weight from early to late winter are somewhat predicted by hypotheses commending reduction in extra baggage (Dugan et al. 1980). These hypotheses suggest that it is optimal for the individual bird to keep fat stores small until just before spring migration. From the standpoint of woodcock bioenergetics, protracted harsh weather conditions are infrequent in south-central Louisiana; thus the need for large fat stores to buffer inclement weather is low whereas predator escape capability may be at a premium (R. M. Pace, unpublished data). If this is true, why should we observe any weight gains? Because woodcock are short hop migrants (Keppie and Whiting 1994), they may not need to acquire large fat stores for spring migration, at least to leave Louisiana. They may acquire some of the fuel necessary to complete migration en route. The increased weight changes we observed seemed meager (about 10 g median change) and gradual (Figure 3). Alternatively, woodcock might arrive at Sherburne in a fat depleted state, and gradually recover during winter. This scenario seems less likely given the tendency for shorebirds to accumulate excessive stores for fall migration (Lindstrom and Piersnia 1993; McNeil and Cadieux 1972). It is clear that our understanding of the dynamics of body stores in wintering woodcock is poor.

Unraveling the annual cycle and schedule of fat and protein storage in woodcock may have implications relative to management. When, where, how much, and what kind of body weight woodcock need to survive and breed can be influenced by habitat quality and quantity along migration paths as well as on breeding and wintering grounds. To establish the links between habitat quality and energy stores, we will need better models of condition. Herein, we demonstrated that wing length, but not bill length, may be a measurement useful for adjusting weight by body size to produce a more refined index of condition. The dynamics of body stores in wintering woodcock should be developed by measuring fat, adjusting for body size, and testing the sufficiency of weight-only data.

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References

Britt, T. L. 1971. Studies of woodcock on the Louisiana wintering ground. M.S. Thesis. Louisiana State University, Baton Rouge. 105 pp.

Davidson, N. C., and P. R. Evans. 1989. Pre-breeding accumulation of fat and muscle protein by Arctic breeding shorebirds. Proceedings International Ornithological Congress XIX:342–352.

Dugan, P. J., P. R. Evans, L. R. Goodyer, and N. C. Davidson. 1980. Winter fat reserves in shorebirds:

disturbance of regulated levels by severe weather conditions. Ibis 123:359–363.

Dunn, P. O., T. A. May, M. A. McCollough, and M. A. Howe. 1988. Length of stay and fat content of migrant semipalmated sandpipers in eastern Maine. Condor 90:342–352.

Dwyer, T. J., G. F. Sepik, E. L. Derleth, and D. G. McAuley. 1988. Demographic characteristics of a Maine woodcock population and effects of habitat management. U.S. Fish and Wildlife Service Research Report 4. 29 pp.

Glasgow, L. L. 1958. Contributions to the knowledge of the ecology of the American woodock, *Philohela minor*, on the wintering range in Louisiana. Ph.D. Thesis. Texas A & M University, College Station. 158 pp.

Johnson, C. 1985. Patterns of seasonal weight variation in waders on the Wash. Ringing and Migration 6:19–32

Keppie, D. M., and R. M. Whiting, Jr. 1994. American woodcock. *In* A. Poole and F. Gill, editors. The Birds of North America, Number 100. Academy of Natural Science of Philadelphia. 28 pp.

Lindstrom, A., and T. Piersnia. 1993. Mass changes in migrating birds: the evidence for fat and protein storage. Ibis 135:70–78.

Littell, R. C., G. A. Milliken, W. W. Stroup, and R. D. Wolfinger. 1996. SAS system for mixed models. SAS Institute, Cary, North Carolina. 656 pp.

Martin, F. W. 1964. Woodcock age and sex determination from wings. Journal of Wildlife Management 28:287–293.

McNeil, R., and F. Cadieux. 1972. Numerical formulae to estimate flight range of some North American shorebirds from fresh weight and wing length. Bird-banding 43:107–113.

Olinde, M. W., F. G. Kimmel, and R. M. Pace, III. 2000. Direct recoveries from in-season banding of American woodcock in south central Louisiana. Pages 77–83 *in* D. G. McAuley, J. G. Bruggink, and G. F. Sepik, editors. Proceedings of the ninth American woodcock symposium. U.S. Geological Survey, Biological Resources Division Information and Technology Report USGS/BRD/ITR–2000-0009. Patuxent Wildlife Research Center, Laurel, Maryland.

Owen, R. B., Jr., and W. B. Krohn. 1973. Molt patterns and weight changes of the American woodcock. Wilson Bulletin 85:31–41.

Rochford, J. M. and H. J. Wilson. 1980. Value of biometric data in the determination of age and sex in woodcock (*Scolopax rusticola*). Pages 154–167 *in* T. J. Dwyer and G. L. Storm, technical coordinators. Woodcock ecology and management. U.S. Fish and Wildlife Service Wildlife Research Report 14. Washington, D.C.

Vander Hagen, W. M. 1992. Bioenergetics of American woodcock during the breeding season on Moosehorn National Wildlife Refuge, Maine. Ph.D. dissertation, University of Maine, Orono. 103 pp.

Whitcomb, D. A. 1974. Characteristics of an insular woodcock population. Michigan Department of Natural Resources, Wildlife Division Report 2720. 78 pp.

Factors Influencing Recruitment and Condition of American Woodcock in Minnesota

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Abstract: Hunting regulations for American woodcock (*Scolopax minor*) are based on information on the status of the population from data collected during the previous hunting season and the following spring. No surveys, however, measured the status of the population through spring and summer prior to the hunting season. A model was developed to predict recruitment to the fall population based on weather during the spring and summer. Also determined was whether the condition of birds in fall reflected weather conditions prior to the hunting season. The model was based on Minnesota weather and the recruitment index (immatures–adult female). The model predictor was April mean minimum temperature. The model was tested using Maine and Wisconsin data and the predicted and estimated values for the recruitment index were correlated. The weights of birds shot in early October differed among years and were correlated with September mean maximum and mean minimum temperatures. The frequency of feather retention of adult females was correlated with the recruitment index. Weather during April had the greatest influence on the recruitment index.

Key words: American woodcock, hunting, Minnesota, recruitment, *Scolopax minor*, weather.

The U. S. Fish and Wildlife Service sets the maximum hunting season length, bag limits, and earliest opening and latest closing dates of the season (federal framework) for American woodcock based on information obtained from the Singing-ground Survey and the Wing-collection Survey (Bruggink 1996). The Singing-ground Survey provides a population index based on the number of courting male woodcock heard on randomly selected routes in the northern breeding range. The Wing-collection Survey is an age and sex stratified tally of wings collected from birds harvested during the hunting season. Cooperators provide and wing from each bird and information about their hunt. Indices to recruitment and hunter success are provided by this survey (Bruggink 1996).

These surveys provide an indication of the status of the population based on the number of males heard displaying in the spring and the previous year's recruitment. No surveys, however, measure the condition of populations through spring and summer. Extended periods of cold or snow during late winter and spring can adversely affect survival and recruitment (Mendall and Aldous 1943; Dwyer et al. 1982, 1988; Longcore et al. 1996). Summer

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[1] Deceased

drought also may increase mortality (Sepik et al. 1983). Thus, important components of population status before the hunting season may not be considered during the development of federal frameworks and state hunting regulations (Rabe et al. 1983).

Effects of weather on woodcock while they are on the breeding grounds may be reflected in the recruitment index (immatures–adult female ratio) of birds taken during the hunting season. Condition of harvested birds also may be indicative of weather conditions. Our objectives were to determine whether weather conditions could be used to predict the recruitment index and whether the condition of birds in the fall reflected weather conditions before the hunting season.

This work was supported by the Ruffed Grouse Society and the U. S . Fish and Wildlife Service. We acknowledge the Grand Rapids Chapter of the Ruffed Grouse Society and the staff of the Sawmill Inn for their support.

Methods

We used the recruitment indices estimated from information submitted by Minnesota hunters to the Wing-collection Survey from 1984–95 (Bruggink 1996 and previous reports) . We collected the same information from birds harvested at the National Ruffed Grouse and Woodcock Hunt sponsored by the Ruffed Grouse Society in Grand Rapids, Minnesota, from 1984–96. The 2-day hunt occurred in October (range = 10–16 Oct) with 74–102 (0 = 93) participants hunting within 80 km of Grand Rapids in Aitkin, Cass, and Itasca Counties. During 1989–96 we measured the weight of birds and, during 1992–96, we examined primary and secondary feathers of adults for presence of molt and for retention of feathers. Retained feathers were noticeably faded and worn.

Climatic data (daily precipitation [cm], snow [cm], maximum temperature [C], minimum temperature [C]) were obtained from the Earthinfo database (Earthinfo Inc., 5541 Central Ave., Boulder, Colorado 80301) of weather stations monitored by the National Climatic Data Center. Monthly means (temperature) or totals (precipitation and snow) were calculated for Minnesota, Wisconsin, and Maine and for Aitkin, Cass, and Itasca Counties in Minnesota.

We used stepwise multiple regression to test whether there were relations between climatic data (Mar–Sep) and the recruitment indices. Regression models were developed for Minnesota and the three counties encompassed by the National Hunt. Models were tested using Wisconsin and Maine weather and recruitment indices. The degree of association between estimated (Wing-collection data) and predicted recruitment indices was measured using the Pearson correlation test. The Pearson correlation test also was used to test for associations between weather during August and September and weights of males and females and between feather retention and recruitment indices.

We used ANOVA to test for differences in weights among immature and adult males and females and for differences of weights among years. The Bonferroni test was used to detect differences within groups. We used $P = 0.05$ as a level of significance for all tests.

Results

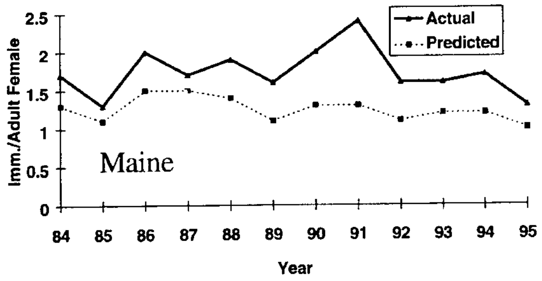
Weather and Recruitment

Using Minnesota climatic data, we found that April mean minimum temperatures (C) (APRMIN) provided the best fit for the relation between weather and the recruitment index (R) ($R^2 = 0.700$, $F = 9.618$, $P = 0.011$). We tested this model:

$$R = 1.277 - (0.198)(\text{APRMIN})$$

using Wisconsin and Maine weather data (Figure). The predicted values for the Wisconsin model were correlated with the estimated recruitment index ($r = 0.604$, $\chi^2 = 4.31$, df = 1, $P = 0.038$). However, the model underestimated the recruitment index at extremes of temperature. There also was a correlation between the predicted and estimated recruitment indices for Maine ($r = 0.661$, $\chi^2 = 5.46$, df = 1, $P = 0.019$). The predicted values were consistently below the estimated recruitment indices.

We found a relation ($R^2 = 0.894$, $F = 6.962$, $P = 0.014$) between the mean minimum and maximum temperatures (C) for August (AUGMIN



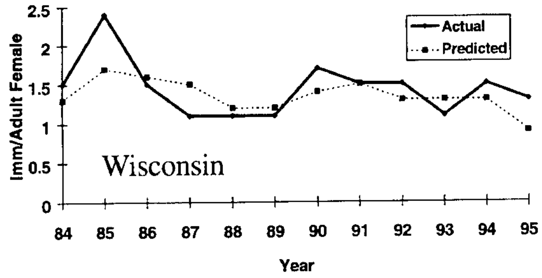


Figure. The estimated (from Woodcock Wing-collection Survey) and predicted immature–adult female ratios (recruitment index) of American woodcock for Maine and Wisconsin based on a model derived from recruitment indices and weather data from Minnesota. The model is: R = 1.277 - (0.198)(APRMIN) where APRMIN = April mean minimum temperature (C) and R = immature–adult female ratio.

and AUGMAX, respectively) and March (MARMIN and MARMAX, respectively) and the recruitment indices (R),

$$R = -4.307 + (0.281)(MARMAX) - (0.251)(MARMIN) + (0.218)(AUGMAX) - (0.245)(AUGMIN)$$

for the data from the National Hunt. We tested the model using Maine and Wisconsin weather data and found no significant correlations between predicted and actual recruitment.

Weather and Physical Condition

For female body weight there was no interaction between year and age ($F = 1.45$, df = 6, $P = 0.192$). Adult females (211.7 ± 0.740 g) were heavier than juveniles (207.7 ± 0.809; $F = 14.296$, df = 1, $P < 0.001$). There also were differences for weight among years ($F = 11.977$, df = 6, $P < 0.001$). Weights in 1992 and 1993 were greater than other years except 1991. Weights in 1989–91 and 1994–96 were not different (Table 1).

For male body weight there was no interaction between year and age ($F = 1.667$, df = 6, $P = 0.126$) and adults (166.1 ± 0.740 g) were the same weight as juveniles (166.6 ± 0.685 g) ($F = 0.327$, df = 1, $P = 0.568$). Weights varied among years ($F = 18.964$, df = 6, $P < 0.001$). Weights in 1991–93 were greater than other years except 1995 when weights did not differ from 1991. Weights in 1996 were less than 1995 (Table 1).

Mean weights of females were correlated with September mean maximum ($r = -0.866$, $P = 0.035$) and mean minimum temperatures ($r = -0.800$, $P = 0.009$), but not precipitation ($r = -0.133$, $P = 1.0$). There were no correlations between August weather and mean weights for males or females. High correlation coefficients were measured for mean weights of males for September mean maximum ($r = -0.700$, $P = 0.240$) and mean minimum ($r = -0.645$, $P = 0.352$) temperatures but

Table 1. Mean weights (g) of American woodcock harvested in Aitkin, Cass, and Itasca Counties, Minnesota during the National Hunt sponsored by the Ruffed Grouse Society.

	Males		Females	
Year	Weight (SE)	*n*	Weight (SE)	*n*
1989	163.4 (0.98)	140	207.9 (1.29)	136
1990	160.6 (1.28)	82	204.6 (1.56)	102
1991	171.7 (2.37)	24	212.5 (2.20)	47
1992	172.1 (0.91)	164	213.1 (1.06)	249
1993	169.3 (0.72)	258	215.3 (0.86)	341
1994	162.7 (0.78)	222	207.5 (0.94)	297
1995	165.3 (0.88)	173	208.0 (1.01)	259
1996	160.4 (0.91)	162	204.6 (1.04)	237

they were not significant. Male weights were not correlated with September rain.

The amount of feather retention by adult females varied among years ($\chi^2 = 23.58$, df = 4, $P < 0.001$; Table 2). Weight did not vary between females retaining feathers and those completing the molt ($F = 1.042$, $P = 0.384$). There were no significant correlations between weather and percent molt. There was no correlation between recruitment indices and molt when all years were included in the analysis ($r = 0.297$, $P = 0.63$). However, when data was excluded for 1992, there was a correlation ($r = - 0.974$, $P = 0.026$; Table 2).

Discussion

We chose Minnesota for which to develop a model to predict recruitment indices based on weather because of the availability of data on a state (Wing-collection Survey) and a local scale (National Hunt). We believed a model using National Hunt data would be a better predictor of recruitment indices because the harvest took place over a short period (2 days) and before significant migration occurred. Thus, local weather effects on recruitment should be more pronounced and easier to detect. The model we derived, however, did not predict either Maine or Wisconsin recruitment indices. In addition, some of the variables in the model (i.e., August mean maximum temperature) did not make biological sense; it is unlikely that the recruitment index would increase with increasing August temperatures. The problem may be small sample sizes during some years. Also, significant migration may have occurred during some years which could bias immature–adult female ratios if there is differential migration according to age.

Minnesota data provided a better model of the recruitment index. April mean minimum temperature was a realistic variable for predicting recruitment. Predicted recruitment indices using the model were correlated to the estimated indices obtained from the Wing-collection Survey, with Wisconsin data providing a relatively good fit. Maine predicted recruitment indices, however, were consistently below estimated values. Discrepancies between predicted values and estimated indices may be a function of the difference in chronology of nesting and hatch. Peak of hatch in Wisconsin is 8–14 May (Gregg 1984) compared to 8–29 May in Maine (Mendall and Aldous 1943; Dwyer et al. 1982) and 14–18 May in Minnesota (D. R. Dessecker, Ruffed Grouse Society, unpublished data). Weather during April also differs among the three states. The predictive capability of the model probably could be improved by using weather data that is within or brackets the peak of hatch for each state. Regardless, weather during early spring seems to be the key to predicting recruitment indices.

Mean weight of females, and probably males, was related to September temperatures. As temperatures increased, weights generally decreased. We expected the amount of precipitation to be correlated to weight because earthworm abundance is related to soil moisture (Phelps 1986). However, soil moisture decreases with an increase in temperature. Earthworm abundance also decreases with an increase in soil temperature (Phelps 1986).

Weight of females that retained secondary or primary feathers did not differ from birds that completed the molt. Apparently, molt ceases at some point insuring that sufficient resources are available for migration.

We expected the retention of feathers to be related to recruitment because poor weather in

Table 2. Frequency of retained secondary or primary feathers of adult female woodcock and immature/adult female ratio of woodcock harvested in Aitkin, Cass, and Itasca Counties, Minnesota, during the National Hunt sponsored by the Ruffed Grouse Society.

Year	Retained (%)	Immature/Adult female ratio
1992	49 (26)	0.73
1993	79 (35)	1.05
1994	92 (44)	0.86
1995	87 (48)	0.86
1996	65 (40)	0.90

spring causes nest and brood loss. This results in increased renesting and birds that renest have smaller clutches (McAuley et al. 1990). Renesting delays molt and could result in retention of some flight feathers. There was no correlation between feather retention and recruitment when all years were analyzed. When 1992 was eliminated from the analysis, however, there was a correlation. We are uncertain why recruitment and feather retention were both low in 1992.

Acknowledgments

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References

Bruggink, J. G. 1996. American woodcock harvest and breeding population status, 1996. U.S. Fish and Wildlife Service. Laurel, Maryland.

Dwyer, T. J., E. L. Derleth, and D. G. McAuley. 1982. Woodcock brood ecology in Maine. Pages 63–70 *in* T. J. Dwyer and G. L. Storm, technical coordinators. Woodcock ecology and management. U.S. Fish and Wildlife Service Wildlife Research Report 14. Washington, D.C.

Dwyer, T. J., G. F. Sepik, E. L. Derleth, and D. G. McAuley. 1988. Demographic characteristics of a Maine woodcock population and effects of habitat management. U.S. Fish and Wildlife Service Fish and Wildlife Research 4.

Gregg, L. 1984. Population ecology of woodcock in Wisconsin. Wisconsin Department of Natural Resources Technical Bulletin 144.

Longcore, J. R., D. G. McAuley, G. F. Sepik, and G. W. Pendleton. 1996. Survival in spring of male American woodcock in Maine. Canadian Journal of Zoology 74:2046–2054.

McAuley, D. G., .J. R. Longcore, and G. F. Sepik. 1990. Renesting by American woodcock (*Scolopax minor*) in Maine. Auk 107:407–410.

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.

Phelps, N. E. 1986. The influence of earthworm abundance on woodcock diurnal habitat use in Maine. M. S. Thesis. Pennsylvania State University, University Park.

Rabe, D. L., H. H. Prince, and E. D. Goodman. 1983. The effect of weather on bioenergetics of breeding American woodcock. Journal of Wildlife Management 47:762–771.

Sepik, G. F., R. B. Owen, Jr., and T. J. Dwyer. 1983. The effect of drought on a local woodcock population. Transactions of the Northeast Fish and Wildlife Conference 40:1–8.

The Woodcock Trail Demonstration Area in Pennsylvania

by

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Abstract: The Charter Oak area of the Stone Valley Experimental Forest in Huntingdon County, Pennsylvania, was the site of extensive research on the American woodcock (*Scolopax minor*) throughout the 1950–70s. However, the last active management of the area was done in the 1950s. Subsequent to this work, suitable woodcock habitat steadily deteriorated until little remained by the mid-1980s. In 1987 we attempted to restore the Charter Oak area to its former status as prime woodcock habitat. Along with habitat restoration, we initiated a program to educate resource managers, private landowners, and the general public about woodcock, their habitat, and habitat management techniques. We created a 1.6-km-long (1 mile) trail through the area with interpretive signs at points of interest along the way. The trail was linked to an extensive recreational trail system on the forest and set up to attract the many students and visitors to the adjacent Stone Valley Recreation Area. Thousands of individuals, including resource management consultants, outdoor writers, school children, and the general public, have used the trail and associated demonstration area since its completion.

Key words: American woodcock, demonstration area, habitat restoration, interpretive trail, *Scolopax minor*, Stone Valley Experimental Forest.

The American woodcock (*Scolopax minor*) is a secretive bird not usually amenable to close observation. During daylight woodcock are often found in dense thickets. Woodcock are camouflaged, move very little and, unless displaying, usually make no audible sounds. Woodcock move at twilight when the coming darkness hides them from predators. Viewing woodcock is difficult; consequently, the task of educating the general public about them is challenging.

For these reasons, endeavors to increase awareness about woodcock must be done with the understanding that showing a living specimen to a group of interested onlookers at the appointed time can be impossible. The best that we can do is provide people with a mounted specimen or vivid description of the bird, show them where it lives, and tell them what it takes to maintain woodcock habitat in a suitable condition.

Demonstration Area and Methods

The Woodcock Trail and Demonstration Area is located in the Charter Oak area of the Stone Valley Experimental Forest in Huntingdon County, Pennsylvania. The Experimental Forest is owned by The Pennsylvania State University and is administered by the School of Forest Resources. The Charter Oak area is abandoned agricultural lands that went fallow in the 1930s and 40s. The Charter Oak area of the forest was the site of research on woodcock conducted in the 1940s by Logan Bennett and P. F. English and in the 1950s by Steve Liscinsky (Liscinsky 1972). The last research on the area was in the mid-1970s (Coon 1977). Before 1988 the only habitat management was done in the mid-1950s (Liscinsky 1972). By 1980 gradual deterioration in habitat quality from forest succession was evident and little suitable habitat for woodcock remained. In addition, woodcock numbers seemed substantially reduced.

Habitat management

In 1988, we used funds provided by the Renewable Resources Extension Act to improve the woodcock habitat of Charter Oak and to create a demonstration area that would educate individuals about the habitat requirements of the American woodcock. During the summer of 1988, we initiated an annual program of habitat manipulation. After several years, funding to continue this project was provided by the Ruffed Grouse Society.

The management plan developed by Steve Liscinsky was adapted for use in the new demonstration area (Figure). Compartment and subcompartment designations conform to the Stone Valley Experimental Forest Management plan and Liscinsky's woodcock management plan. A 2 ha clearcut was completed in 1989 in compartment 2, subcompartment G. This area was old field dominated by large open-grown white pine (*Pinus strobus*). White pine were felled and chipped for pulp in conjunction with the clearcutting of an adjacent red pine (*P. resinosa*) plantation in winter 1989. One-third of this area was limed at the rate of about 3.7 tons/ha of ground limestone in an attempt to improve earthworm production.

Compartment 2, subcompartment B underwent a shrub release cut in 1993 with additional cutting in 1995. Beginning in 1994, we thinned compartment 2, subcompartment E to remove planted white spruce (*Picea glauca*), invading white and table mountain pine (*Pinus pungens*), and undesirable hardwoods (primarily black walnut [*Juglans nigra*]) to release grey dogwood (*Cornus racemosa*), hawthorn (*Crataegus* spp.), and crabapple (*Pyrus* spp.). This work is continuing.

We removed competing hardwoods and thinned hawthorns in compartment 2, subcompartments H and F in 1995 and 1996, and we clearcut a 30-m-wide strip through subcompartment F. In 1993 we also cut two 0.15-ha openings in subcompartment A. Where commercial whole tree logging has not been possible, all operations have required piling of stems and tops. Between 1987 and 1996 8.5 ha of the Charter Oak area has received some type of habitat manipulation for woodcock.

Interpretive Trail

To facilitate viewing of the area by the public and to increase understanding of life history of woodcock we developed an interpretive trail through the area (Table 1, Figure). We constructed an unimproved hiking trail, approximately 1.6 km in length, through the area in 1990. The trail has nine points of interest located along it (Table 1). At each point a sign describes information pertinent to that observation point including information on woodcock life history and habitat management practices. There is a parking area for trail users, and the trail head has a sign giving general life history information about woodcock and a map of the trail. Woodcock Trail brochures are also available. To reduce costs, signs are produced on computer disk and printed on a laser printer and are double laminated in plastic and stapled to sign posts made of pressure-treated lumber. These signs generally last several years.

The trail is designed to be self-guiding with redundancy built in to allow for successful completion of the trail in the event that brochures are not available or signs are absent. Either the brochure or the signs can be used to negotiate the trail. A listing of the points of interest is in Table 1.

Table 1. Points of interest along the Woodcock Trail, Charter Oak area, Huntingdon County, Pennsylvania.

Point of interest	Subjects viewed
1	mature forest and explanation of its low value for woodcock habitat
2	old field now a forest showing advanced succession and poor woodcock habitat
3	woodcock feeding and resting cover in reverting old field
4	old farmstead with remnant apple orchard and building foundations to illustrate farming history of the area
5	clearcut with openings for singing woodcock
6	small deer exclosure to promote growth of desirable vegetation
7	example of typical woodcock nesting habitat (edge)
8	example of old field succession in progress
9	shrub release cut and aspen planting along small stream

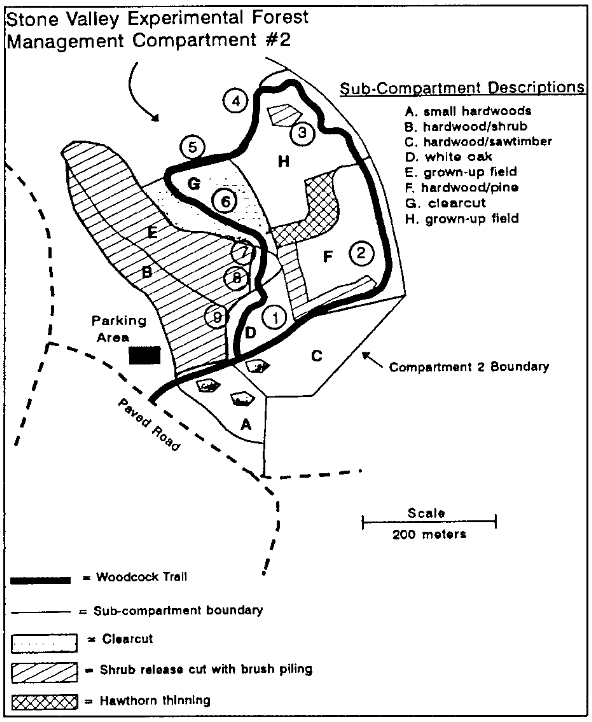

Figure. Schematic diagram of the Woodcock Trail Area of the Stone Valley Experimental Forest showing management subcompartments (letters) and recent habitat manipulations (shaded areas). Circled numbers along the Woodcock Trail indicate points of interest described in Table 1.

A more complete description of each point of interest is contained in the Woodcock Trail brochure (Sharpe and Brittingham 1992).

Visitor Use

We have a rough index of visitor use from the number of trail brochures removed from the box at the trail head. In addition, we maintained a list of organized tours we led on the trail.

Woodcock Population Monitoring

Our primary effort and funding went towards habitat management and development of the interpretive trail. Consequently, collecting data on woodcock population size was very limited. From 1994–96, observers with pointing dogs searched the area on 1–5 days during the spring and fall and recorded numbers of birds flushed per dog hour and numbers of nests and broods located. After a bird was flushed, we moved on to a new area, but we did not attempt to separate new flushes from reflushes. We also visited the area on 1–5 evenings each spring and recorded singing males using the large clearcut adjacent to point 5 (Figure). We did not collect any pretreatment data.

Results

Visitor Information

Approximately 1,500 pamphlets/yr are removed from the trail head. We consider this to be a minimum estimate of trail usage since many people will be in pairs or groups but take only one brochure or individuals may tour the trail by referring to the descriptive signs without use of a brochure. In addition, we have provided guided tours to over 1,200 individuals including natural resource professionals, students, and outdoor writers (Table 2).

Woodcock Population Indices

During fall 1994–96, we searched the woodcock demonstration area with pointing dogs for a total of 33.5 h and flushed 106 birds (3.57 ± 1.22 [$\bar{x}$ ± SE] birds/dog hour). In spring 1994–96, we searched a total of 26 h and flushed 63 birds (2.2 ± 0.4 birds/dog hour) and located 8 broods or nests (0.32 broods or nest/hr). During evening singing counts, we observed between one and six males displaying within the clearcut per evening count.

Discussion

Within the Eastern United States, most forest land is owned by private forest landowners (Birch 1989). Consequently, the fate of early successional forest birds like woodcock depends increasingly on management activities of this diverse group of individuals. In addition, public concerns over timber harvesting in general and clearcutting in particular are affecting the management of public forest land and the establishment and maintenance of early successional forest habitat (Williamson 1993). Increasing public awareness and knowledge about the habitat requirements of early successional species like the woodcock is extremely important. Information on habitat management for woodcock directed at private landowners has been available for a number of years (Sepik et al. 1981), but we are unaware of any demonstration areas that enable individuals to view woodcock habitat and actually see types of management practices and the effects these practices have on forest habitat. Demonstration areas are valuable ways of increasing knowledge and awareness and changing attitudes towards management practices such as timber harvesting (Harmon et al. 1997).

The high number of individuals who took self-guided tours of the woodcock demonstration area was probably influenced in part by the location of the trail in relation to other outdoor recreational opportunities and to Penn State University. The trail is located at the main entrance to the Stone Valley Recreation Area, which is located in the middle of the experimental forest. The recreation area is visited extensively by the student body of Penn State University; thus, there is a constant supply of potential visitors because the student

Table 2. Visitors to Woodcock Trail and Demonstration Area, Charter Oak area, Huntingdon County, Pennsylvania, 1990–1996.

Year	Activity	Attendance
1990	Continuing education for natural resource professionals	25
1991	Pennsylvania outdoor writers tour	14
1992	Continuing education for natural resource professionals	40
1992	Outdoor class for 7th graders	130
1993	Outdoor class for 7th graders	260
1994	Continuing education for natural resource professionals	80
1994	Outdoor class for 7th graders	250
1995	Continuing education for natural resource professionals	30
1995	Outdoor class for 7th graders	260
1996	Outdoor class for 7th graders	150
1996	Pennsylvania outdoor writers tour	10
1996	International resource professionals group	10

body turns over every 4 to 5 yrs. The trail head parking lot is also an attraction, because it is the only one available in the Stone Valley trail system.

In addition to self-guided tours, we have used the trail to give tours to groups ranging from junior high school students to natural resources professionals and outdoor writers. The scope of the tour varied depending on the group. Most of the junior high school students did not know what a woodcock was, much less the types of habitat it depended on. For these students, we started the tour by showing them a mounted specimen of the woodcock and discussing attributes of birds in general and of the woodcock in particular. This led to a discussion of woodcock life history and behavior. On the tour, we discussed the dynamic nature of forest habitat and the need for management to provide and maintain woodcock habitat. The concept of a real need for management was generally new to many students. By walking along the trail, they were able to observe what woodcock habitat looks like and to appreciate the value of this type of habitat. Finally, we emphasized the human history of the area and how this has influenced woodcock numbers.

Student evaluations have consistently been high as has change in knowledge. Students report that prior to taking the tour they did not know what a woodcock was and now they know what it is and the type of habitat it requires. Many said they planned to return with their families in spring to see displaying woodcock. Other comments included students saying that they understood that cutting trees could benefit some wildlife.

Tours for natural resource professionals were focused primarily on identifying potential habitat for woodcock and observing potential management practices that could be used to manipulate woodcock habitat. Most of these individuals worked directly with private landowners and were interested in knowing what types of habitat management practices to implement, where to implement them, and what to expect. In written evaluations, all said the tour was worthwhile and the majority said the information would be useful to them in their work with private landowners.

Tours with outdoor writers usually involved a discussion of woodcock life history and habitat management along with a photo opportunity. We tried to locate a woodcock nest prior to the tour so that the writers could photograph a female on the nest. Several follow-up articles by outdoor writers provided wider newspaper coverage of the trail and demonstration area and included management information.

Monitoring of woodcock populations on the demonstration area has been minimal, and we did not collect pretreatment data so we cannot directly assess the effects of our habitat management on woodcock populations. However, even with minimal monitoring, we have shown that woodcock are using the area in spring for both courtship and nesting and in fall for feeding and resting. Consequently, we believe that the habitat improvements made to the area have stopped the deterioration of woodcock habitat on the Charter Oak area. In addition, we are confident that the trail and demonstration area have helped to increase awareness of the American woodcock and increased management for this species on private land in Pennsylvania.

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References

Birch, T. W. 1989. Forest ownership in the northeastern United States. Pages 26–36 *in* J. C. Finley and M. C. Brittingham, editors. Timber management and its effects on wildlife. Proceedings of the 1989 Penn State Issues Conference.

Coon, R.A. 1977. Nesting habitat, fall migration, and harvest characteristics of the American woodcock in Pennsylvania. Ph.D. Thesis, The Pennsylvania State University, University Park. 131 pp.

Harmon, A. H., S. B. Jones, and J. C. Finley. 1997. Encouraging private forest stewardship through demonstration. Journal of Forestry 95(6):21–25.

Liscinsky, S. A. 1972. The Pennsylvania woodcock management study. Research Bulletin 171. The Pennsylvania Game Commission, Harrisburg. 95 pp.

Sepik, G. F., R. B. Owen, Jr., and M. W. Coulter. 1981. A landowner's guide to woodcock management in the Northeast. University of Maine, Orono. Life Sciences Agricultural Experiment Station Miscellaneous Report 253. 23 pp.

Sharpe, W. E., and M. C. Brittingham. 1992. Woodcock management demonstration area and trail. School of Forest Resources, College of Agricultural Sciences, The Pennsylvania State University, University Park. 9 pp.

Williamson, L. L. 1993. The American woodcock management plan: Can it work? Pages 105–108 *in* J. R. Longcore and G. F. Sepik, editors. Proceedings of the eighth American woodcock symposium. U.S. Fish and Wildlife Service Biological Report 16. Washington, D.C.

Land-use/Land-cover Changes Along Woodcock Singing-ground Survey Routes in West Virginia

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Abstract. Numbers of singing male American woodcock (*Scolopax minor*) counted during the annual singing-ground survey, an index of the breeding woodcock population, have declined range-wide and in West Virginia since 1968. Changing land-use/land-cover patterns are thought to play an important role in this apparent decline in the breeding population. Changes in land use/land cover along 37 singing-ground survey subroutes in West Virginia were quantified using digital land-use/land-cover data from the U. S. Geological Survey (USGS). Changes along a subset of these routes ($n = 14$) also were examined on aerial photographs. Aerial photographs provided an analysis more specific to woodcock habitat requirements, but were not available for all routes. Analysis of USGS data indicated that decreases occurred in the extent of agricultural land ($P < 0.01$) and urban and developed land ($P = 0.01$). The extent of deciduous forest increased ($P = 0.01$). Numbers of male woodcock counted in the same time periods decreased from 1.48 birds per subroute in 1976 to 0.49 birds per subroute in 1993 ($P < 0.01$). Analysis of aerial photograph data indicated that losses occurred in the extent of pasture/open land ($P = 0.01$). Number of woodcock counted averaged 1.45 birds per

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subroute in 1968–71 and 0.82 birds per subroute in 1990 ($P = 0.10$). Stepwise linear regression revealed that increased extent of deciduous forest ($P = 0.04$) and barren land ($P = 0.02$) were associated with woodcock call count numbers. Aerial photograph data also were analyzed using landscape metrics derived from the spatial analysis program FRAGSTATS. These metrics indicated that the landscape along singing-ground survey routes has become more fragmented and unevenly distributed among land-use types.

Keywords: American woodcock, land-use change, *Scolopax minor*, singing-ground surveys, West Virginia.

Each spring the U. S. Fish and Wildlife Service (USFWS) conducts counts of occupied American woodcock singing grounds along established routes throughout the breeding range that can be used to monitor trends in populations (Mendall and Aldous 1943). Long-term results indicate declines in the number of displaying woodcock counted annually in West Virginia (Bruggink 1996). Woodcock are an early successional species; this type of habitat has declined range wide because of degradation and loss of suitable habitat through natural succession, urbanization, fire control, intensive forest management, destruction of southern bottomland hardwoods, and a decrease in farm abandonment (Fenwood and Webb 1981; Gutzwiller et al. 1982; Sepik and Dwyer 1982; Dwyer et al. 1983).

West Virginia is characterized by rugged terrain and steep slopes. Woodcock probably were never abundant in the state before pioneer times; their numbers increased somewhat after colonization as agricultural and lumbering activities created more suitable areas (Kletzly 1976). Woodcock breed in suitable areas scattered statewide, but the best habitat and highest populations are found in the Canaan Valley in the northeastern part of the state (Kletzly 1976; Fenwood and Webb 1981; Webb and Samuel 1982).

Dwyer et al. (1983) analyzed habitats along singing-ground survey (SGS) routes in the northeastern United States and concluded that declines in woodcock numbers were related to increases in human developments. Similarly, Gutzwiller et al. (1982) examined habitats along SGS routes in Pennsylvania and concluded that increases in land-use/land-cover types not suitable for woodcock (urban and built-up areas, sawtimber) corresponded with declines in woodcock numbers. Earlier researchers in West Virginia (Kletzly 1976; Fenwood and Webb 1981) noticed and commented on the trend of human encroachment into woodcock habitat. This trend has probably continued and woodcock habitat in the state has been lost to human developments. Additionally, the forests of West Virginia have become increasingly mature since the last major cutting cycle at the turn of the century (DiGiovanni 1990). The objective of this paper is to examine relationships between changes in land-use/land-cover along SGS routes and changes in the number of woodcock heard along these routes in West Virginia.

Methods

Land-use/Land-cover Changes

West Virginia has 59 SGS routes; approximately 30–50% of these are surveyed annually, the remainder are classified as constant zeros. Land-use/land-cover changes along these routes were quantified using aerial photographs from 1968–71 and 1990, and digital land-use/land-cover data compiled by the USGS in 1976 and 1993. Aerial photographs allowed us to distinguish land-use categories at finer scales and land-use types that were more specific to the habitat requirements of woodcock than did the USGS data, but were not available for both time periods for every route. Routes were eliminated if photographs were not available for both periods or if no males were heard in both periods. To avoid including areas that never contained courting woodcock, and therefore may never have contained appropriate habitat, stops that never had woodcock present were dropped from analysis of the route. Suitable habitat for woodcock in West Virginia is found in small patches because of the rugged terrain, thus, many routes contained eight or nine stops where woodcock were never present. We eliminated these unused stops and termed the result a subroute; a subroute consisted of 1–10 stops. Thirty-seven subroutes consisting of a total of 137 stops were analyzed using USGS data; 14 subroutes with a total of 50 stops were analyzed using aerial photographs.

Digital land-use/land-cover data were obtained from the Earth Resource Observation Systems (EROS) Data Center in Souix Falls, South Dakota, and the National Cartographic Information Center (NCIC) in Reston, Virginia. A 1976 land-use coverage was compiled from manually interpreted National Aeronautic and Space Administration (NASA) high-altitude U-2 aerial photographs and the National High Altitude Program (NHAP) photograph source (Fegeas et al. 1983). All features and land-use/land-cover categories were described by straight or curved lines that depicted the actual boundaries of the areas. The minimum size of polygons depicting all human-created features was 4 ha; all other categories of land-use/land-cover had a minimum polygon size of 16 ha. This minimum mapping unit omitted very long, narrow features such as roads, streams, or utility rights-of-way.

The 1993 data set was compiled from leaves-on (summer) Landsat Thematic Mapper (TM) data acquired in 1991, 1992, and 1993 (Vogelman et al. 1996). Landsat TM has a resolution of 30 m and all features and land-use categories were described by 30- x 30-m squares. This minimal mapping unit also omitted long, narrow tracts and features smaller than 30 x 30 m.

In order to compare changes in two land-use/land-cover data sets, Campbell (1997) recommends that they be prepared at a level of detail consistent with that obtained from interpretation of the lowest quality, coarsest resolution data. Thus, the 1976 data set was converted to raster format before analysis.

The classification scheme of the 1976 data set followed that of Anderson et al. (1976) and included eight categories. The 1993 classification scheme was more detailed and included 10 categories. Therefore, we combined several habitat categories based on habitat structure to make them comparable with the 1976 categories. For example, urban or developed areas classed as either high intensity or low intensity in the 1993 data were merged into a single category because the 1976 data did not distinguish between high and low intensity. Coniferous forest and mixed forest also were combined into a single category because few stops contained coniferous forest; no stops contained wetlands. Six land-use/land-cover categories (Table 1) were used in the analysis.

Table 1. Land-use/land-cover categories used for USGS and aerial photograph data.

Land-use/land-cover category	Description	USGS data	Aerial photo data
Deciduous Forest	Areas > 75% covered by deciduous tree species	Yes	Yes
Shrubby	Areas > 75% covered by shrubs	No	Yes
Less Densely Stocked Forest	Areas < 50% covered by woody vegetation	No	Yes
Agricultural Land	Cropland, (also pastures and hayfields in the USGS data set)	Yes	Yes
Pasture–Open Areas	Grazed or mowed areas	No	Yes
Coniferous–Mixed Forest	Areas > 75% covered by coniferous or mixed deciduous/coniferous tree species	Yes	Yes
Urban–Developed	Areas covered by human constructed materials	Yes	Yes
Water	Open water	Yes	Yes
Barren	Areas covered with rock or gravel, quarries or strip-mined areas	Yes	Yes

Aerial photographs provided a more detailed analysis, but were only available for 14 subroutes. Black-and-white aerial photographs from May to October 1968–71 and 1990 were obtained from the EROS Data Center. This type of photograph was found by Fenwood and Webb (1981) to be the most satisfactory source of information for locating diurnal habitat available to woodcock in West Virginia. The early photographs were 23- x 23-cm paper prints at scales that varied from 1:35,000 to 1:20,000. The 1990 photographs were 50- x 50-cm paper prints at 1:20,000 scale. The minimum mapping area was approximately 0.5 ha for both sets of photographs.

Routes were hand drawn onto 1:24,000 scale USGS topographic maps and digitized into a Geographic Information System (GIS) using ARC/INFO software (ESRI 1996). A 333-m radius buffer was established around each stop used for analysis. This distance represents the maximum detection distance of singing woodcock (Dwyer et al. 1983). Each stop and buffer also were plotted from a GIS onto mylar sheets at the scale of the available aerial photograph. Photographs were overlaid with the mylar sheet and examined with a magnifying glass. Land-use/land-cover categories were outlined by tracing the edges of each with a colored pencil. These were digitized into a GIS for analysis. Land-use/land-cover categories generally followed those of Anderson et al. (1976) with a few differences to emphasize land-cover types important to woodcock (Table 1).

The USGS data classification scheme differed from the aerial photograph data classification scheme (Table 1) by having fewer land-cover categories specific to woodcock habitat requirements. The agricultural category in the USGS data included pastures or hayfields and crops, but included only crops in the aerial photograph data. Shrubby land and less densely forested areas could not be distinguished in the USGS data and probably were included in either deciduous or mixed forest categories.

The data generated from aerial photographs also were analyzed using the spatial analytical program FRAGSTATS (McGarigal and Marks 1995) to quantify landscape structure. We generated metrics for the entire landscape, defined as the area within the 333-m buffer around each stop. We recognize that although our landscape definition is bounded by the detection distance of the peent sound, it is an artificial boundary as far as woodcock are concerned and they are likely responding to variables at different spatial scales. Landscapes were composed of patches of each land-use type; patches varied in size, shape, and area. This program was not used for USGS coverages because of the different formats of the original data.

Woodcock Abundance

Singing-ground survey data were obtained from the USFWS Office of Migratory Bird Management. For analysis with aerial photographs, the mean number of woodcock counted on each subroute was calculated for a 5-year period centered on the year of the available photograph. For example, if a 1970 and a 1990 photograph were available for a given subroute, the mean number of displaying males counted in 1968–72 was used for the early period and the mean number counted in 1988–92 was used for the later period. Routes classified as constant zero were assumed to have no woodcock present. No attempt was made to correct for observer bias; however, 85% of the time the same observer conducted all counts in both 5-year periods for a given subroute and 93% of the time the same observer conducted all counts in either 5-year period.

For analysis with the USGS data, woodcock numbers were averaged for 1974–78 and 1991–95. Eighty-one percent of the time the same observer conducted all counts run in both 5-year periods and 93% of these counts were conducted by the same person during either 5-year period.

Statistical Analysis

Data were analyzed using the Statistical Analysis System (SAS Institute Inc. 1985). Results were considered significant at $P < 0.05$. Changes in numbers of peenting woodcock were examined using a matched-pairs t-test on the mean for all subroutes combined for each period. Land-use/land-cover changes were examined by comparing the mean difference in proportion of area in each land-use/land-cover type for all subroutes combined using a matched-pairs t-test. We then performed a stepwise multiple regression weighted by area of the subroute to relate changes in woodcock numbers to changes in land-use/land-cover. Thus, routes that included more stops, and therefore more area (and usually more woodcock), were weighted more heavily. Variables included in the regression models were subjected to individual simple regression to further explore the relationships between land-use change and woodcock changes for each class. Stepwise multiple regression also was performed on FRAGSTATS metrics to examine relationships with changes in woodcock numbers.

Results

Woodcock Population Changes

The mean number of woodcock per subroute decreased between the two time periods. For the time period corresponding to USGS data, the mean number of birds per subroute was 1.48 in 1976 and 0.49 in 1993 ($t = 4.05$, $P < 0.01$). Thirty-two subroutes had fewer woodcock in the later period and five had more. For the time period corresponding to aerial photograph data, the mean number of woodcock heard per subroute in the early period (1968–71) was 1.45, whereas in the later period (1990), the mean was 0.82 birds per subroute ($t = 1.31$, $P = 0.10$). Nine subroutes had fewer woodcock in the later period and five had more.

Land-use/Land-cover Changes

Five of 9 land-use/land-cover categories identified on aerial photographs along 14 SGS subroutes increased from 1968–71 to 1990, however none significantly (Table 2). Amount of deciduous forest had the greatest increase ($t = 1.59$, $P = 0.07$). Four categories decreased during the same period. Only the amount of pasture or open land declined significantly ($t = 5.98$, $P < 0.01$).

Similar changes were detected in the USGS data for 37 SGS subroutes. Two of six habitat categories increased and four decreased from 1976–93 (Table 3). The amount of deciduous forest ($t = 4.78$, $P = 0.01$) increased, whereas agricultural land, which included pastures and open areas in this data set ($t = 3.24$, $P < 0.01$) and urban or developed land ($t = 2.56$, $P = 0.01$) both decreased.

Table 2. Mean percentage change in land-use/land-cover along woodcock singing-ground survey routes in West Virginia based on the analysis of aerial photographs of 14 subroutes.

Land-use/land-cover category	1968–71 (%)	1990 (%)	Difference (%)	$P > t$
Pasture–Open Areas	9.66	4.40	-5.3	<0.01
Less Densely Stocked Forest	3.51	1.30	-2.2	0.14
Agricultural Land	21.58	20.24	-1.3	0.37
Coniferous–Mixed Forest	6.65	5.20	-1.5	0.35
Urban–Developed	9.07	9.22	0.2	0.44
Water	0.76	1.30	0.6	0.08
Barren	0.22	0.81	0.6	0.16
Shrubby	1.63	3.96	2.3	0.15
Deciduous Forest	46.90	53.45	6.6	0.07

Table 3. Mean percentage change in land-use/land-cover along woodcock singing-ground survey routes in West Virginia based on the analysis of USGS data for 37 sub-routes

Land-use/land-cover category	1976 (%)	1993 (%)	Difference (%)	$P > t$
Agricultural Land	41.09	34.11	-6.98	< 0.01
Urban–Developed	2.96	0.93	-2.03	0.01
Barren	0.42	0.18	-0.23	0.26
Coniferous–Mixed Forest	15.23	15.07	-0.16	0.48
Water	0.06	0.39	0.33	0.06
Deciduous Forest	40.24	49.32	9.08	0.01

Landscape Changes

Indices generated from class-level and landscape-level metrics indicated an increase in fragmentation of land-use/land-cover types between the time periods. We found a decrease in the Shannon's Evenness Index (e.g., domination by a single class or land-use category, $t = 2.94$, $P = 0.02$) and an increase in edge density, the amount of edge per hectare ($t = 3.03$, $P < 0.01$). Patch density, the number of patches per hectare, increased ($t = 3.88$, $P < 0.01$); correspondingly mean patch size decreased ($t = 3.75$, $P < 0.01$). Patch richness density, the number of land-use categories per 100 ha present along a given route, increased ($t = 4.16$, $P < 0.01$). Patch size coefficient of variation, the degree of variation in patch sizes, increased ($t = 4.01$, $P < 0.01$). These metrics indicate that the landscape along SGS routes has become composed of more patches and more types of patches and that these patches were smaller and more irregular.

Woodcock Call Count Changes Related to Changes in Land-use/Land-cover and Landscape Metrics

Simple regressions of changes in woodcock numbers against area-weighted changes in each variable revealed that no land-use/land-cover variable was individually associated with woodcock numbers for either data set. Similarly, no landscape metric was individually associated with woodcock numbers for the aerial photograph set.

Stepwise regression models were constructed using aerial photograph data to relate woodcock call count numbers to changes in amounts of each land-use/land-cover category and FRAGSTATS metric. Nine land-use/land-cover variables (Table 2) and 11 landscape metrics (Table 4) derived from aerial photograph data were considered in the first regression model ($r^2 = 0.61$, $P < 0.01$). One land-cover variable and one landscape metric were included in the final model. Woodcock numbers were associated with increases in the amount of barren land ($r^2 = 0.36$, $P = 0.02$) and edge density ($r^2 = 0.25$, $P = 0.02$). Woodcock numbers were not associated with declines in pasture or open areas ($r^2 = 0.10$, $P = 0.09$).

Nine land-use/land-cover changes (Table 2) were considered in the second regression model ($r^2 = 0.57$, $P = 0.01$); two variables were included in the final model. Increases in the amount of barren land ($r^2 = 0.36$, $P = 0.02$) and deciduous forest ($r^2 = 0.21$, $P = 0.04$) were associated with woodcock call count numbers. Using landscape metric changes alone, no variable remained in the model at $P < 0.10$.

Stepwise regression with the USGS data revealed that the increase in extent of deciduous forest was not associated with declines in woodcock numbers ($r^2 = 0.08$, $P = 0.09$). No other land-use/land-cover variables entered into the model. Woodcock numbers decreased at most subroutes whereas the amount of deciduous forest increased at some and decreased at others.

Table 4. Mean change in landscape metrics along woodcock singing-ground survey routes in West Virginia generated with FRAGSTATS software from aerial photograph data.

	1968–71	1990	Difference	*P* > *t*
Area-weighted Mean Shape Index	2.08	2.33	0.25	0.25
Edge Density	100.77	122.06	21.29	< 0.01
Interspersion and Juxtaposition	71.10	62.07	-9.03	0.06
Landscape Shape Index	5.61	6.41	0.80	0.09
Mean Patch Size	5.52	3.46	-2.06	< 0.01
Patch Density	22.77	32.21	9.44	< 0.01
Patch Richness Density	3.25	3.99	0.74	< 0.01
Patch Size Coefficient of Variation	144.51	182.19	37.68	< 0.01
Shannon's Diversity Index	1.03	0.90	-0.13	0.28
Shannon's Evenness Index	0.68	0.57	-0.11	0.02

Discussion

Woodcock habitat in West Virginia is unique; the state is on the southern edge of the major breeding range and is characterized by rugged terrain. Woodcock numbers in West Virginia probably have always been lower than in the rest of the region. The Eastern Region as a whole has experienced a significant decline in the number of woodcock counted during the USFWS annual spring singing-ground survey since 1968, and woodcock call count numbers declined in West Virginia during the same period (Bruggink 1996). Several researchers associated this loss with increasing amounts of urban or developed land and mature forests and decreasing amounts of younger forests, shrubby land, and open areas (Coulter and Baird 1982; Gutzwiller et al. 1982; Dwyer et al. 1983). Our data only partially support this. Using aerial photograph data, we found no changes in the extent of urban or developed areas or shrubby areas. A significant decrease occurred in the extent of pasture or open areas, but it was not associated with woodcock call count numbers. Data from the USGS revealed increases in the extent of deciduous forest and decreases in the extent of agricultural areas (including pasture or open areas) that were significant but not associated with declines in woodcock numbers.

In a heavily forested, mountainous state such as West Virginia, a roadside land-use/land-cover sample is not necessarily representative of the state. It is likely to overestimate amounts of agricultural land and urban or developed land present and underestimate amounts of forested land. For example, deciduous forests comprised about 40–50% of the land cover along subroutes in both data sets, whereas approximately 80% of the state is deciduous forest (DiGiovanni 1990). Both data sets indicated increases in the amounts of deciduous forest; for the USGS data set this increase was significant but not associated with declines in woodcock numbers. However, the area immediately adjacent to roads may represent a high proportion of suitable woodcock habitat. Tautin et al. (1983) suggested that a disproportionate amount of habitat may be found along roads where human activities serve to retard succession and create openings. Singing-ground survey routes are on roads and, particularly in West Virginia, may intersect a greater proportion of woodcock habitat than would randomly drawn lines (Shissler and Samuel 1985).

Dwyer et al. (1983), working in the northeastern United States, attempted to relate changes in SGS indices to changes in land-use/land-cover adjacent to SGS routes. They found an increase in urban or industrial areas along SGS routes was related to declines in woodcock heard along those routes. In our study, data from the USGS revealed a significant decrease in the amount of urban or developed areas. However, the resolutions of the original sources for these data (i.e. NASA photographs and Landsat TM) were too coarse to distinguish individual buildings, roads, or utility rights-of-way, features that comprised most of this category for the aerial photograph data set. Thirteen of 37 subroutes (35%) had urban or developed areas present in the USGS data set, whereas all subroutes (14) had urban or developed areas present in the aerial photograph data set. Using data from aerial photographs, we did not detect a significant change in the extent of urban or developed areas. On many subroutes, most of this category consisted of the road the SGS route followed and a few scattered homes. Roads are relatively permanent objects and thus we expected that the amount of urban or developed area would change very little when the road is a major component of the category. Further, we would expect a road to have little influence on the presence of displaying males as they are commonly detected along roads. Although an increase in traffic and noise could decrease detection of singing woodcock, we do not believe this to be a major factor in West Virginia. West Virginia has experienced slower rates of urbanization than the northeastern United States; the human population has actually declined in recent years (U. S. Bureau of Census 1990). Thus, woodcock populations in West Virginia may be less affected by human activities than populations in other states.

Both data sets indicated declines in the amount of agricultural and pasture or open land. The more specific aerial photograph data indicated that declines in pasture or open land were associated with changes in woodcock numbers. The SGS is a survey of singing woodcock and woodcock may use these pasture or open areas as singing grounds (Sheldon 1967; Liscinsky 1972; Paterson 1979). Thus, it is not surprising that the decline in pasture or open areas was associated with the decline in the number of birds heard displaying.

Finally, the aerial photograph data indicated that increased amounts of barren land were associated with woodcock numbers. In West Virginia, the majority of barren land consists of limestone quarries and coal mines, areas generally not suitable for woodcock. Thus, an increase in the extent of these areas along SGS routes should be associated with a decline in the number of woodcock heard displaying. However, there is evidence that these areas may eventually become suitable for woodcock (Gregg et al., 2000)

Although many researchers have described local habitat requirements of woodcock (e. g., Sheldon 1967; Gregg and Hale 1977; Sepik and Dwyer 1982; Sepik et al. 1989; McGinley 1996), little research has been done on landscape-level habitat requirements and composition for the species. Our data indicated that significant changes in the structure of the landscape occurred between 1968–71 and 1990. There was an overall increase in fragmentation, unevenness, and amount of edge, and an overall decrease in patch size. Fragmentation is a landscape-level process in which a given land-use category is progressively subdivided into smaller, geometrically more complex and more isolated patches. Fragmentation is increasingly becoming recognized as a major cause of declining biodiversity (Terborgh 1989); its effects on woodcock are not known. Our data indicated that one index of fragmentation, edge density, was significantly associated with woodcock call count numbers.

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References

Anderson, J. R., E. H. Hardy, J. T. Roach, and R. E. Witmer. 1976. A land-use and land-cover classification system for use with remote sensor data. U.S. Geological Survey Professional Paper 964, Washington, D.C.

Bruggink, J. G. 1996. American woodcock harvest and breeding population status, 1996. U.S. Fish and Wildlife Service, Laurel, Maryland.

Campbell, J. B. 1997. Land use and cover inventory. Pages 335–364 *in* W. R. Philipson, editor. Manual of photographic interpretation, American Society for Photogrammetric and Remote Sensing, Bethesda, Maryland.

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. Woodcock ecology and management. U.S. Fish and Wildlife Service Wildlife Research Report 14.

DiGiovanni, D. M. 1990. Forest Statistics for West Virginia- 1975 and 1989. U.S. Department of Agriculture, U.S. Forest Service Resource Bulletin NE-114.

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 (ESRI). 1996. The ARC/Info Geographic Information System. Version 7.1. Redlands, California.

Fegeas, R. G., R. W. Claire, S. C. Guptill, K. E. Anderson, and C. A. Hallam. 1983. U.S. Geological Survey digital cartographic data standards: Land-use and land-cover digital data. Geological Survey Circular 895-E.

Fenwood, J. D., and L. O. Webb. 1981. An aerial photograph inventory of woodcock habitat in West Virginia. Wildlife Society Bulletin. 9:306–307.

Gregg, L. E., and J. B. Hale. 1977. Woodcock nesting habitat in northern Wisconsin. Auk 94:489–493.

Gregg, I. D., P. B. Wood, and D. E. Samuel. 2000. American woodcock use of reclaimed surface mines in West Virginia. Pages 9–22 *in* D. G. McAuley, J. G. Bruggink, and G. F. Sepik, editors. Proceedings of the Ninth American Woodcock Symposium. U.S. Geological Survey, Biological Resources Division Information and Technology Report USGS/BRD/ITR–2000-0009, Patuxent Wildlife Research Center, Laurel, Maryland.

Gutzwiller, K. J., C. H. Strauss, K. R. Kinsley, J. S. Wakeley, and G. L. Storm. 1982. Relationships between land use and woodcock habitat in Pennsylvania, with guidelines for rangewide research. Pages 86–96 *in* T. J. Dwyer and G. L. Storm, technical coordinators. Woodcock ecology and management. U.S. Fish and Wildlife Service Wildlife Research Report 14.

Kletzly, R. C. 1976. American woodcock in West Virginia. West Virginia Division of Natural Resources Bulletin Number 8, Charleston, West Virginia.

Liscinsky, S. A. 1972. The Pennsylvania woodcock management study. Pennsylvania Game Commission Resource Bulletin 171.

McGarigal, K., and B. J. Marks. 1995. FRAGSTATS: Spatial pattern analysis program for quantifying landscape structure. General Technical Report PNW-GTR-351. U.S. Department of Agriculture, U.S. Forest Service, Pacific Northwest Research Station, Portland, Oregon.

McGinley, K. E. 1996. Habitat selection in spring by male American woodcock in Maine. M.S. Thesis, University of Massachusetts, Amherst.

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.

Paterson, R. L. 1979. Ecological factors affecting woodcock courting ground longevity. Jack-Pine Warbler 57:164–166.

SAS Institute Inc. 1985. SAS user's guide: Statistics. Version 5. SAS Institute Inc. Cary, North Carolina.

Sepik, G. F., and T. J. Dwyer. 1982. Woodcock response to habitat management in Maine. Pages 106–223 *in* T. J. Dwyer and G. L. Storm, technical coordinators. Woodcock ecology and management. U.S. Fish and Wildlife Service Wildlife Research Report 14.

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.

Sheldon, W. G. 1967. The book of the American woodcock. University of Massachusetts Press, Amherst.

Shissler, B. P., and D. E. Samuel. 1985. Effectiveness of American woodcock survey routes in detecting active singing grounds. Wildlife Society Bulletin 13:157–160.

Tautin, J., P. H. Geissler, R. E. Munro, and R. S. Pospahala. 1983. Monitoring the population status of American woodcock. Transactions of the North American Wildlife and Natural Resources Conference 48:376–388.

Terborgh, J. 1989. Where have all the birds gone? Princeton University Press, Princeton, New Jersey.

U. S. Bureau of Census 1990. 1990 census of population, West Virginia. U. S. Department of Commerce, Washington D.C.

Vogelman, J. E., S. M. Howard, and T. Sohl. 1996. Regional land-cover characterization using multiple sources of intermediate-scale data. Proceedings of the 1996 International Geoscience and Remote Sensing Symposium 1:246–247.

Webb, L. O., and D. E. Samuel. 1982. Woodcock habitat inventory and wetlands in Northern West Virginia. Symposium on Wetlands of the Unglaciated Appalachian Region, Morgantown, West Virginia.

Assessing Habitat Selection in Spring by Male American Woodcock in Maine with a Geographic Information System

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Abstract. Geographic information system (GIS) technology was used to identify habitats available to and used by male American woodcock (*Scolopax minor*) equipped with radio transmitters—54 in 1987, 51 in 1988, 46 in 1989—at Moosehorn National Wildlife Refuge, Maine. Woodcock were monitored from time of capture (25 March–15 April) to 15 June each year. To determine habitat selection by male woodcock, the following habitat characteristics were measured: land cover, age and stocking density of the forest overstory, soil drainage and texture, aspect, and percent slope. Habitat selection was examined as affected by the covariates weather and age-class of woodcock, and among years for diurnal and crepuscular periods of the breeding period. Multivariate techniques that compare use and availability of habitats were not available, so a statistical model was developed to rate importance of multiple habitat characteristics selected by woodcock. The most critical period for woodcock in terms of survival was from arrival to mid-April. Second-year and after-second-year woodcock did not select different ($P > 0.05$) habitat types, but they did select different types among years and within breeding intervals ($P < 0.05$). In years when weather was moderate, woodcock selected young, dense stands of speckled alder (*Alnus rugosa*) and hardwoods, interspersed with forest openings. Suitable habitat can be maintained by creating an uneven-aged forest managed in even-aged blocks composed of several hardwood species. Managers can now quantify suitable woodcock habitat in a GIS and plan large-scale forest-harvesting strategies using data on several habitat characteristics (e.g., land cover, stand age, stocking density, soil drainage and texture, and aspect).

Key words: American woodcock, GIS, habitat use, *Scolopax minor*, Maine

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13. ABSTRACT (Maximum 200 words)

Symposia and workshops on the American Woodcock have been held periodically since 1966. The Ninth Woodcock Symposium was held January 26–28, 1997 in Baton Rouge, Louisiana. This was the second symposium held during the 1990s . These meetings bring together researchers, managers, and administrators to discuss and report current information on the ecology and management of this fine species. Papers presented at the Ninth Symposium ranged from philosophical and descriptive to highly technical and included several presentations by colleagues from Europe on *Scolopax rusticola*. Habitat use and factors affecting woodcock survival continue to be a research priority and this is reflected by the number of papers dealing with these issues. Continuing the precedent set by the Sixth Woodcock Symposium, manuscripts published in this proceedings went through a formal peer review process before being accepted.

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