F. McKinney

WOOD DUCK MANAGEMENT AND RESEARCH:

a symposium

WOOD DUCK MANAGEMENT AND RESEARCH: A SYMPOSIUM

Theme:

Emphasizing Management of Forests for Wood Ducks

Co-sponsored by

Wildlife Management Institute

and

North Central Section

of the

Wildlife Society

Held in Conjunction with

the 27th Midwest Fish and Wildlife Conference

December 8-9, 1965

Jack Tar Hotel

Lansing, Michigan

Host

Michigan Department of Conservation

Published by the

WILDLIFE MANAGEMENT INSTITUTE

709 WIRE BUILDING

WASHINGTON, D. C. 20005

1966

Photo by Glenn D. Chambers
Missouri Department of Conservation

Additional copies may be purchased from:
WILDLIFE MANAGEMENT INSTITUTE
709 Wire Building
Washington, D. C. 20005
for $3.00 Postpaid

Printed by
MONUMENTAL PRINTING COMPANY
Baltimore, Md.

Arrangements Committee

BILL T. CRAWFORD, President (1965), North Central Section of the Wildlife Society, Missouri Department of Conservation, Columbia, Missouri 65201

HERBERT H. DILL, Wildlife Management Staff Specialist, Division of Wildlife Refuges, U.S. Bureau of Sport Fisheries and Wildlife, Minneapolis, Minnesota 55408

ARTHUR S. HAWKINS, Mississippi Flyway Representative, U.S. Bureau of Sport Fisheries and Wildlife, Minneapolis, Minnesota 55408

EDWARD J. MIKULA, Secretary, Mississippi Flyway Technical Section, Michigan Department of Conservation, Lansing, Michigan 48926

HARVEY K. NELSON, Director, Northern Prairie Wildlife Research Center, U.S. Bureau of Sport Fisheries and Wildlife, Jamestown, North Dakota 58401

LAURENCE R. JAHN (Chairman), North Central Field Representative, Wildlife Management Institute, Horicon, Wisconsin 53032

Acknowledgments

Local arrangements for this meeting were made by personnel of the Michigan Department of Conservation, particularly D. W. Douglas and E. J. Mikula.

CONTENTS

SESSION I

Natural Wood Duck Habitat—Existing and Anticipated Needs

SESSION II

Inventorying Wood Duck Habitat—Experiences and Needs

SESSION III

Habitat Management for Wood Ducks—Knowledge and Voids

SESSION IV

Group Dinner

SESSION V

Artificial Methods of Helping Breeding Wood Ducks—Approaches and Needs

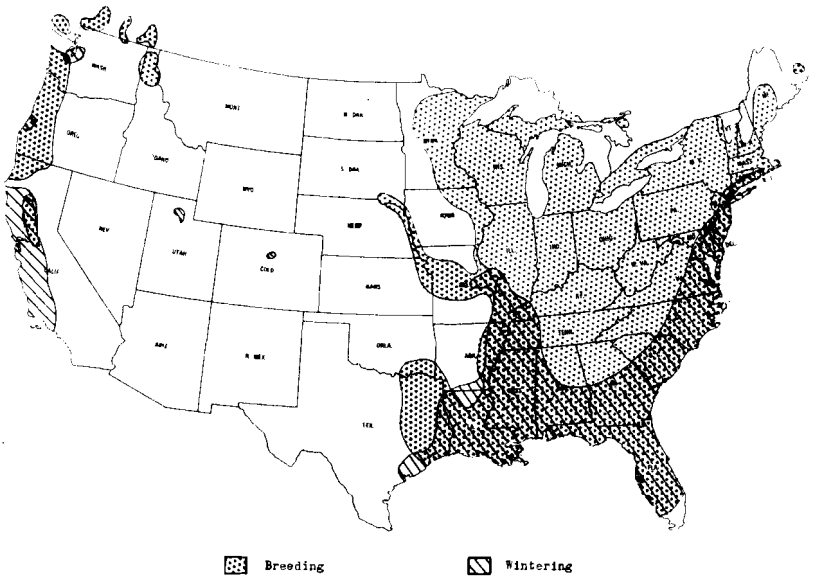
SESSION VI

Evaluating Wood Duck Population Shifts and Trends: Advances and Limitations

SESSION VII

Establishing the Status of Wood Duck Populations: Successes and Problems

SESSION VIII — SUMMARY



Principal Historical Breeding and Wintering Range of the Wood Duck, Based on Records Through 1938. Prepared by C. S. Robbins and J. W. Aldrich, Bureau of Sport Fisheries and Wildlife. There is evidence that wood ducks occurred adjacent to the delineated range along rivers and streams in the central prairies, as well as rarely in other western states. But few specific breeding records have been reported.

SESSION I

Wednesday, December 8

Chairman: F. C. BELLROSE, JR.
Illinois Natural History Survey, Havana

NATURAL WOOD DUCK HABITAT— EXISTING AND ANTICIPATED STATUS

OPENING REMARKS

L. R. JAHN

North Central Field Representative, Wildlife Management Institute, Horicon, Wisconsin

It is a distinct privilege and pleasure to formally open this Wood Duck Symposium. I welcome you on behalf of the Arrangements Committee and the co-sponsoring organizations, the Wildlife Management Institute and the North Central Section of The Wildlife Society.

In planning this meeting we attempted to bring together resource managers who, in one way or another, deal with wood ducks or the habitat required for their production and survival. Through your participation we hope to have an exchange and review of pertinent information on this important species of North American waterfowl.

As you know, the wood duck occupies a rather unique niche in waterfowl habitat. But complete understanding of this bird's ecological requirements, habitat, and population status is generally lacking. In particular, relationships of natural wood duck habitat to plant succession, timber management, and flood plain zoning are recognized only vaguely. This symposium is aimed at pooling available knowledge on the wood duck, thereby encouraging better definition of management guidelines and future research needs.

Wood ducks contribute importantly to sport hunting, and their esthetic value should not be underrated. Understanding individual and population characteristics of the wood duck is essential in order (1) to provide for its life requirements in broad land and water development and management programs and (2) to establish regulations that hold hunting mortality within reasonable limits.

We are at a point in history when uses of land and water are intense. With anticipated population growth, demands on all re-

sources will increase. Therefore, ecological requirements of creatures, such as the wood duck, must be planned for and be incorporated into development specifications. In this manner a sustained yield of wood ducks can be assured.

One land-use development will illustrate what the future holds and where attention must be focused. The United States, except for Alaska, has been divided into 12,781 watersheds, each of less than 250,000 acres (U.S. Dept. Agr., Soil and Water Conserv. Needs—A National Survey, 1965). Given for each watershed are existing land uses and acreages of lands that will be converted to other uses in the future. Wildlife is receiving general consideration in the planning. But there is great need to indicate the status of crucial habitat for specific species, such as flood plain forests for wood ducks. Within the remaining forests it is necessary to determine whether or not the habitat requirements of wood ducks will be maintained or provided.

We must all recognize that watershed management is needed to bring about improved use of soil and water, thereby helping to prevent erosion and pollution. But in realigning field patterns, how can trees be maintained that have proper characteristics to yield nesting cavities and mast crops for wood ducks?

Additional practical questions that we hope will be explored and answered, at least in part, at this symposium include the following. What is the current and expected future status of flood plain forests that provide nesting cavities and mast crops for wood ducks? What kinds of trees yield suitable nesting cavities? At what diameter breast height (d.b.h.) or age do trees yield suitable nesting cavities? Do current timber management plans call for harvesting trees before they have an opportunity to mature and serve as nesting sites? At roughly what density of trees do wood ducks refuse to use available cavities? What modifications in technique and classification are needed to enable one to delineate suitable wood duck habitat from standard, periodic forest inventories? Should artificial nesting boxes be erected where natural cavities are scarce or absent? What type of nesting box is both predator- and starling-proof? What type of habitat is best for rearing broods? Would addition of ravine-type ponds attract wood ducks to existing forests lacking surface water, but otherwise suitable for breeding, feeding, or both? How should water levels be fluctuated seasonally to encourage sustained high yields of mast? What is the best plan for harvesting timber to insure presence of trees yielding large mast crops? How can the habitat requirements of seasonal populations of wood ducks be provided for in basic land and water multiple-use programs, such as in watersheds?

By pooling knowledge of foresters, land- and water-use planners, and wildlife managers, we hope to identify (1) specific areas of management programs requiring realignment to provide habitat needed by wood ducks and (2) voids in our knowledge of the wood duck and its habitat. Hopefully, graduate students at colleges and universities will select important investigations on the wood duck for their personal research projects. With dedicated effort they can contribute essential knowledge required to meet practical management problems.

We have an outstanding group of speakers and discussion leaders to handle the eight sessions of this meeting. As you can see by the agenda, timing will be crucial to complete presentation of all reports within allotted periods. Session chairmen have been encouraged to adhere to strict schedules. Ample time must be provided for discussion and subsequent sessions. Speakers may have to summarize their written reports in order to finish on time. However, papers will be incorporated into the proceedings on the basis of written reports only.

Floor discussions will be taped, edited, and printed in the proceedings. Therefore, before giving remarks, state your name and agency. Copies of the proceedings will be available at a nominal cost from the Wildlife Management Institute.

Please remember that success of the meeting is not the sole responsibility of the Arrangements Committee and the participants listed on the agenda. In large measure the success will be judged by your participation in discussions. We urge each of you to participate. Challenge views expressed in reports and add pertinent supplementary information. Share your knowledge and experience to help improve understanding and management of wood duck habitat and populations.

Before turning this meeting over to the chairman, I have a few important announcements.

We want all people attending this symposium to register. Names will be published in the proceedings. A registration pad is being circulated. Please give your full name, agency, and mailing address.

We also want you to identify yourself at all times. It helps us become better acquainted.

Arrangements have been made for a group dinner this evening, starting promptly at 6:15 p.m. Our keynote speaker is Frederic Leopold, a man who has made valuable contributions to our knowledge of breeding wood ducks.

Printing of the attractive agenda for this meeting was sponsored by the Divisions of Research and Refuges of the Bureau of Sports Fisheries and Wildlife. We certainly appreciate this useful contribution.

Available knowledge on the historical distribution of wood ducks is summarized in the map presented in the front of the proceedings. Please note the absence of records for Canada.

Lack of consolidated information prevented preparation of a current (1965) distribution map for North America. There is a great need to develop a map showing present-day densities and distributions of seasonal wood duck populations. Authentic breeding and wintering records existing in files and in the minds of resource managers should be assembled. Your assistance can help fill this void in knowledge.

Steps will be taken through the Flyway Council Technical Committees to compile all information available on current distributions and densities of wood duck populations. Information on the proposed procedures will be presented later by Harvey K. Nelson in the discussion following the session on "Establishing The Status of Wood Duck Populations: Successes and Problems."

I will now turn this meeting over to the chairman of the first session. He is a well-known waterfowl biologist of the Illinois Natural History Survey who has completed a number of important investigations on the wood duck. Mr. Frank C. Bellrose of Havana, Illinois.

REMARKS OF THE CHAIRMAN

F. C. BELLROSE, JR.

It is a pleasure to see so many people interested in the wood duck. There was a time, not too many years ago, when we were concerned whether we would have any wood ducks at all to look at, let alone shoot.

Many of us have been following the status of the wood duck for the last couple of decades. We have been quite surprised at the resilience of the wood duck population in recent years. Whether the wood duck can continue to tolerate the high kill experienced recently remains to be seen.

The different forces that regulate the wood duck population are not now well understood. Back in the early 1950's we thought the raccoon was primarily responsible for a large decrease in breeding wood ducks in the Midwest. Yet, today we find that raccoons are almost as abundant as they were then.

The factors that have affected the changing status of the wood duck in the last couple decades are about as fully understood by us as the reason for the great raccoon population explosion that started in 1943. So I think we have to be very careful in continuing to permit a high kill of wood ducks. We have to follow population

trends closely. Otherwise we may find that the population has declined to the low levels of the early 1950's.

There is some evidence that wood duck populations in the Midwest have declined slightly in recent years. Nonetheless, when you consider that the wood duck is the number two or three duck in the bag in the Mississippi and Atlantic Flyways, one can only be much surprised by the numbers of this bird and the ability of the population to withstand heavy hunting. Only time will tell whether wood duck populations will continue to be able to withstand this large harvest.

There is much that we need to know about all facets of wood duck population and habitat management. We have, in effect, neglected the wood duck while showing great concern for the prairie nesting ducks. Perhaps this is right for a period of time. But I think that it is high time we give more emphasis to the wood duck. This is the only duck that nests in great numbers throughout the deciduous forests of eastern United States. It seems to be a species that is very amenable to management.

We must remember that as our waterfowl resource becomes more valuable, management procedures that at one time were not feasible become feasible. A duck today is worth much more than it was five years ago or ten years ago. I know hunters who have spent up to $100 per duck while enjoying the sport of waterfowling this fall. When we consider the fantastic prices people are willing to pay to enjoy the sport of waterfowling, we should not be too concerned about the reasonable cost of wood duck houses.

We must be constantly aware that research must precede the inauguration and the establishment of management practices. And so it is very fitting that today we meet here to discuss various management measures that might be incorporated into plans for watersheds, forests, wildlife refuges, state public shooting grounds, and other places of this kind.

The first speaker in this session on existing and anticipated status of natural duck habitat is Forest Stearns of the U.S. Forest Service. Mr. Stearns.

PRESENT AND FUTURE STATUS OF FORESTS ALONG SURFACE WATERS OF THE NORTH CENTRAL STATES

FOREST STEARNS

North Central Forest Experiment Station, Forest Service,
U. S. Department of Agriculture, Rhinelander, Wisconsin

The north central portion of the United States is blessed with abundant water in the form of lakes, both large and small, and of

numerous rivers and streams, Along these water courses and bodies of water one can find represented every plant community native to the area as well as many exotic species.

From south to north, the forests range from the cypress bottomlands in Missouri, southern Illinois, and the toe of Indiana through various combinations of elm, ash, sycamore, cottonwood, river birch, and silver maple to the white pine-hardwood stands along the Upper Wisconsin River and the cedar, fir, tamarack, and spruce swamps of the north (Table 1). From east to west the lakes and rivers may be bordered by communities as diverse as the mixed hardwoods of Ohio and the oak openings of Iowa.

In presettlement times, the wood duck had a choice of hundreds of thousands of acres of lowland forest with swampland and marsh, backwaters, bayous and abandoned river channels, and forest-fringed lakes green with aquatic plants. Adjoining the lowlands, they could choose among stands of oak-hickory, maple-beech, or northern hardwood in all stages of development but with a much greater complement of larger trees, often hollow or broken. All of these forests and wetlands served the wood duck in some measure as nesting, brood, migration, or winter habitat.

Settlement of the Midwest brought many changes in vegetation, some gradual and some abrupt. Vast areas of lowland forest, like the Great Kankakee Swamp of northern Indiana and Illinois, were cleared and drained and are now planted to corn, soybeans, mint, or potatoes. Similarly fertile, better-drained portions of flood plains along major rivers have been cleared and now produce abundant yields of corn and soybeans or, on occasion, jimson weed, smartweed, and ragweed. Earlier, the adjacent uplands had been cropped, leaving undisturbed forest only on steep bluffs or on back forties. White settlement thus reduced the forests adjacent to water to a fraction of their original area. With settlement and land clearing came floods, perhaps no greater than those of presettlement times, but carrying heavy loads of sediment from the cleared uplands. These floods scoured the stream channel of logs and aquatic vegetation.

The forests on the less well-drained and often flooded bottomlands fared better than those on the terraces and adjoining upland, and considerable acreages remain. Presumably the wood duck, now and in the future, will depend heavily on these lowland hardwood forests and associated communities. This discussion will be confined primarily to the lowland hardwood forests and to some of the biological and physical factors influencing their development and potential for change.

TABLE 1. LOWLAND FOREST AND ASSOCIATED TREE SPECIES.[1]

SOFTWOOD SPECIES	
Cypress	*Taxodium distichum*
Cedar (white)	*Thuja occidentalis*
Fir (balsam)	*Abies balsamea*
Hemlock (eastern)	*Tsuga canadensis*
Pine (white)	*Pinus strobus*
Spruce	*Picea* spp.
Tamarack	*Larix laricina*
HARDWOOD SPECIES	
Ash	*Fraxinus* spp.
Black ash	*F. nigra*
Green ash	*F. pennsylvanica*
Pumpkin ash	*F. profunda*
Red ash	*F. pennsylvanica* var *subintegerrima*
White ash	*F. americana*
Basswood	*Tilia americana*
Beech	*Fagus grandifolia*
Birch	*Betula* spp.
River birch	*B. nigra*
Yellow birch	*B. alleghaniensis*
Blackgum includes:	
Black tupelo	*Nyssa sylvatica*
Water tupelo	*N. aquatica*
Black walnut	*Juglans nigra*
Butternut	*J. cinerea*
Cottonwood (eastern)	*Populus deltoides*
Swamp cottonwood	*P. heterophylla*
Elm	*Ulmus* spp.
American elm	*U. americana*
Red elm	*U. rubra*
Hackberry	*Celtis occidentalis*
Hickory	*Carya* spp.
Yellowbud hickory	*C. cordiformis*
Honeylocust	*Gleditsia triancanthos*
Kentucky coffee tree	*Gymnocladus dioicus*
Maple	*Acer* spp.
Black maple	*A. nigrum*
Boxelder	*A. negundo*
Red maple	*A. rubrum*
Silver maple	*A. saccharinum*
Sugar maple	*A. saccharum*
Oak	*Quercus* spp.
Black oak	*Q. velutina*
Bur oak	*Q. macrocarpa*
Cherrybark oak	*Q. falcata* var. *pagodaefolia*
Chestnut	*Q. prinus*
N. red oak	*Q. rubra*
Overcup oak	*Q. lyrata*
Pin oak	*Q. palustris*
Post oak	*Q. stellata*
Shingle oak	*Q. imbricaria*
Shumard oak	*Q. shumardii*
S. red oak	*Q. falcata*
Swamp chestnut oak	*Q. michauxii*
Swamp white oak	*Q. bicolor*
White oak	*Q. alba*
Pecan	*Carya illinoensis*
Sweetgum	*Liquidambar styraciflua*
Sycamore	*Platanus occidentalis*
Tulip poplar	*Liriodendron tulipifera*
Willow	*Salix* spp.
Black willow	*S. nigra*
Sandbar willow	*S. interior*

[1] Common and scientific names of trees discussed in this paper are listed below based on Little (1953).

SITE AND COMPOSITION

While the upland forests of the North Central States have received considerable attention from both ecologists and foresters, the mosquito-ridden bottomlands, infested with poison ivy and nettle, have been somewhat neglected. The early travelers, many of whom journeyed by water, described the forest and have left us with a general picture of the original vegetation, but detailed phytosociologic studies are few and recent. This discussion draws in large measure on the comprehensive studies of Hosner and Minckler (1963) in southern Illinois; Lindsey, Petty, Sterling, and Van Asdall (1961) in Indiana; and Ware (1955) in southern Wisconsin and northern Illinois.

Characteristics of Lowland Forest Sites

Lowland forests are found on the flood plains of rivers and larger streams and along the shores of artificial and natural lakes. They also are found in areas without open water but with poor internal soil drainage and good opportunity for flooding. Although sandy flood-plain deposits may dry rapidly, especially on the surface, water supply is generally ample. The nutrient supply in lowlands is often better than in uplands, especially in fluvial forests. However, poor aeration may make some nutrients relatively unavailable.

Both Ware (1955) and Lindsey *et al.* (1961) emphasize the importance of Pleistocene glaciation in establishing the physiographic background which resulted in extensive lowland hardwood stands both on the flat beds of glacial lakes and the flood plains of northern rivers. Accumulations of lake clays, sandy outwash, and moraine all contributed to the presence of lakes and the great variety of conditions in river flood plains.

In studies to date, vegetational development and successional trends ". . . were found to be closely related to the nature of the alluvial substrate and to the water level relationships" (Lindsey *et al*, 1961). Lindsey *et al.* point out eight basic sites in the flood plains as follows: aquatic, water margin, backwater pockets, insular bars, point bars, cut banks, flood-plain surface, and flood-plain depressions or troughs. They did not include the deep sloughs and oxbows or the upper terraces and second bottoms, the latter now better drained as a result of the shifting or degrading action of the river.

Second bottoms (those flooded infrequently by major floods), although important originally to the wood duck, are very likely to have been cleared or logged. Likewise, in these areas no longer subject to annual flooding, the forest community is in a position to improve both soil and moisture conditions, paving the way for a change in composition to more mesic species. Such upper bottoms, where forested,

will be subjected in the future to more intensive forest management, which to the wood duck is likely to mean fewer nest cavities and reduced mast production from smaller trees.

Soils of flood plains are diverse; gravel beds, sandbars, silt or clay beds may occur within a few yards of each other. Lacustrine soils are generally more uniform and of heavier texture, although some develop on outwash sands.

Our interest lies chiefly in forests that are frequently flooded and usually have poor drainage. These forests afford the wood duck some of its most satisfactory and permanent habitat. Poor drainage may be due either to high water levels because of proximity to a river or lake, or to the presence of impeding clay layers. In soils where gley layers have developed, they lie within 3 feet of the surface.

Lowland Forests of Southern Illinois

Extending northward from the great swamp areas of Mississippi, Louisiana, and Arkansas, the southern flood-plain forest, characterized by oaks, gums, and cypress, reaches its northern limits in southern Illinois and the toe of Indiana. This lowland forest has a great variety of species and is an important source of hardwood timber.

Hosner and Minckler (1963) describe several stages and physiographic variants of lowland forests in southern Illinois. They found a great variety of combinations in which any one of 8 or 10 species might predominate over a rather wide range of moisture values. Two pioneer communities are evident: cottonwood-willow and buttonbush-tupelo gum-cypress. The cottonwood-willow type is found on newly formed land with generally sandy soils, fair to good drainage, and seasonal flooding. This cottonwood-willow stage is invaded at an early age by seedlings of silver maple, sycamore, and boxelder, which grow slowly under the overstory. Silver maple is least tolerant of shade and, although producing many seedlings, is often less abundant in the succeeding stand than are sycamore and boxelder. These species are augmented by hackberry and several species of ash and elm. These stands composed of "soft-hardwoods," generally maintain themselves indefinitely, with some variation in composition.

In poorly drained areas, such as swamps and sloughs, the initial forest community is more often tupelo gum, buttonbush, and cypress, with a sprinkling of other species, including willows, swamp cottonwood, and pumpkin or green ash. Slough areas fill gradually with fine alluvium, resulting in development of clay soils on which a mixed group of "hard-hardwood" species develop. Initially the invaders include pin oak, red maple, honeylocust, swamp chestnut oak, bur

oak, and overcup oak. These species may be followed later by red oak, red gum, American elm, and hickory. Here, as with the soft-hardwood community, the hard-hardwood group tends to maintain itself and shows little potential for progressing toward the upland oak-hickory forest except when gradual aggradation of the surface or changes in the course of the river result in major improvements in drainage. The description given by Hosner and Minckler (1963) coincides with that of Shelford (1954) for the Mississippi River lowlands of Missouri and Kentucky, while similar stand composition has been cited by Lindsey *et al.* (1961) in the Wabash bottomlands south of Vincennes, Indiana. Lindsey *et al.* (1961) quote from Ridgeway (1872) a description of the lower Wabash flood plain:

> "If the forest is viewed from a high bluff, it presents the appearance of a compact level sea of green, apparently almost endless, but bounded by the line of wooded bluffs three to seven miles back from the river; . . . the general level broken by occasional giant trees."

These authors also quote Ridgeway's description of the Little Cypress Swamp west of Mt. Carmel as follows: "The trees were growing so near together that the intervening spaces are entirely taken up by the knees, the whole surface thus being an irregular wooded one, with soil or water only in the depressions." Lindsey *et al.* note that giant tulip trees reported by Ridgeway in the bottomland forests no longer exist in the Wabash Valley, although cypress persists. Presumably, tulip trees were on higher and better drained portions of the flood plain, now grazed or cultivated, while cypress, adapted to wet sites unsuited to cultivation, remains.

Lowland Forests in Indiana

In their detailed description of bottomland communities of the Tippecanoe and Wabash Rivers of Indiana, Lindsey *et al.* (1961) suggest several successional schema. Along the lower Wabash River, succession leads to a stable silver maple-cottonwood-American elm community which may eventually give way, but only with better drainage, to a beech-black maple community. On the Tippecanoe River comparable lowland forest included silver maple, American elm, and black willow, with an appreciable admixture of river birch (Table 2).

The Tippecanoe River has generally sandier substrates, a much more regular stream flow, and a greater amount and variety of aquatic vegetation than the larger Wabash River. The latter is characterized by frequent large water-level fluctuations, relatively finer textured

TABLE 2. GENERALIZED COMPOSITION OF LOWLAND FOREST COMMUNITIES RELATED TO SUCCESSIONAL STAGE (LIGHT) AND PHYSIOGRAPHIC POSITION (DRAINAGE) FOR SEVERAL LOCATIONS IN THE NORTH CENTRAL STATES.

Location and Physiographic Position	Initial or Pioneer Community	Stable Lowland Forest	Associated Forest on Better Drained or Upland Soils
Southern Illinois (Hosner and Minckler, 1963)			
Newly formed land (bars, islands, etc).	Willow-cottonwood-sycamore.	Silver maple-elm-ash with boxelder and hackberry.	Oak-hickory
Poorly drained bottomland swamps and sloughs beyond natural levees.	Buttonbush-cypress-tupelo gum with willows and green and pumpkin ash and swamp cottonwood.	Pin oak, red gum, swamp chestnut and overcup oak, honeylocust and red maple.	Cherrybark oak, red oak American elm, and hickories.
Wabash River, Indiana (Lindsey *et al.*, 1961)			
Islands and bars.	Dianthera and willow spp. (Including interior willow).	Black willow-silver maple-cottonwood.	Black maple-American beech
Flood plain proper.	Grass, weeds, and forbs.	Silver maple-black willow-American elm.	or Oak-hickory.
Tippecanoe River, Indiana. (Lindsey *et al.*, 1961).			
Flood plain proper.	Grass and forbs.	Silver maple-black willow-river birch-American elm.	Sycamore, river birch American elm, hack berry, silver maple green ash, followed by n. red oak, swamp white oak, yellowbud hickory, and basswood.
Wisconsin River, Southern Wis. (Ware, 1955).			
Bars, islands and open wet sites.	Cottonwood-black willow.	Silver maple-red ash-American elm.	Oak-hickory or sugar maple-basswood.
Sandy open raised terraces or natural levees, ridges and slopes.	River birch-swamp white oak.	Silver maple-ash-elm.	Oak-hickory or sugar maple-basswood.
Better drained tertaces and elevations.	Corn, (crops) or weeds.	Basswood-red oak-hackberry.	Oak-hickory or sugar maple-basswood.
Northern Wisconsin. (Fassett, 1944)			
Lakeside or streamside bog.	Open bog followed by tamarack-black spruce.	White cedar-fir with black ash and red maple.	Basswood, ash, hemlock yellow birch, white pine.

alluvium (although this was not a major difference), and large numbers of weedy species along its banks. The abundance of weeds presumably results from more frequent erosion and deposition. The Wabash, being much the longer stream, also shows a great variation in species ranging from baldcypress and post oak in the south to beech and hard maple in the north.

Although most big timber was cut long since from the Wabash and Tippecanoe bottoms, there are still record trees present, including a sycamore 13.5 feet d.b.h., a silver maple 72 inches, a hackberry 69 inches, a cottonwood 67 inches and a northern red oak 56 inches d.b.h.

Lindsey (1962) reports 31 different species in a remnant of original flood plain forest on the lower Wabash near Mt. Carmel. Both basal area and importance, relative density + relative basal area) values designate this as an oak-gum-elm-hickory forest in which the silver maple, cottonwood, sycamore, and water pecan were confined to the lowest spots.

Lindsey *et al.* (1961) devised a flood-susceptibility continuum that classes species by their relative ability to survive submergence. The continuum ranges from bald cypress, best adapted to continuous flooding, to black maple and red oak, which are least tolerant of flooding.

In another study Lindsey (1961) used detailed soil maps and land survey records to determine the original extent of wetlands. Before settlement that portion of Indiana north of the Wabash River (approximately the northern third of the state) was approximately 50 percent wetland and included the famous Kankakee Swamp. Half of the wetland was in permanently ponded soils. Wet prairie and sedge meadow were present, as well as lowland forests, conifer swamp, and open marsh. In the hardwood forests, beech, swamp white oak, and American elm were the most important species and reached considerable size, judging from land survey records.

In northern Indiana, wetlands were generally located on valley trains, old lake beds, ground moraine, and outwash sediments, whereas oak-hickory forest and prairie were restricted to end moraines and well-drained sands. A similar situation existed in northern Ohio and adjacent Indiana in the bed of glacial Lake Maumee.

Interdigitation of sand, silt, and muck soils resulted in close juxtaposition of lowland forests, water, swamp, and marsh as well as dry prairie and oak-hickory. Further evidence for widespread wetlands exists in records of large lakes long since vanished and of numerous streams now largely converted to drainage ditches. Drainage has reduced this wetland mosaic to a fragment of the original, and there is little hope that much of the area will revert to forest in the near future.

Lowland Hardwood Communities of Northern Illinois and Southern Wisconsin

Forests of poorly drained soils, both flood plain and lacustrine, in southern Wisconsin and northern Illinois have been described by

Ware (1955) and Curtis (1959). Their delimitation of several communities is based partly on the nature of the substrate and partly on the relative degree of flooding.

Using data from 114 stands, Ware developed a compositional gradient which shows some similarity to the flooding-tolerance gradient of Lindsey *et al.* (1961). He uses this compositional gradient to compare and interpret various vegetational features (basal area, tree density versus sapling density, etc.) and edaphic factors (nutrients, moisture-holding capacity, etc.).

In the compositional gradient several readily recognized spectra are evident, although there is almost continuous intergradation of species between them. These identifiable bands can also be related to common physiographic features of the flood plains.

The black willow-cottonwood community results from germination phenomena. Both species require exposed moist soil for germination, and the dominance of one or the other depends upon moisture conditions following germination. With drying, cottonwood, aided by its taproot system, predominates; with continued moisture, willow, with its fibrous root system, prevails. Noted also by Hosner and Minckler (1963) and others, this competitive relationship holds over much of the range of the two species. The willow-cottonwood community is commonly found on exposed lacustrine and fluvial sands and silts throughout the North Central States and beyond.

Ware (1955) demonstrates that river birch and swamp white oak form another natural segment of the gradient. Both species tend to become established in open places somewhat higher above the river than is the case for cottonwood and willow. River birch favors sandy areas and abandoned fields, whereas swamp white oak is common along marshes and sloughs but also favors sandy areas. The birch is never found in lacustrine swamps and the oak rarely; but both thrive in flood plains where unevenness of terrain provides favorable elevated sites.

Cottonwood, black willow, swamp white oak, and river birch can each originate forest communities that are converted, especially along rivers, to a silver maple-green ash-American elm forest. To these forests a few other species, such as basswood, red oak, hackberry, and yellowbud hickory, are usually added. Ware suggests that the "overwhelming importance of silver maple-green ash-American elm combinations is partially explained by the homogenizing nature of the river." Within a single river system lowlands are exposed to similar periods of flooding and sedimentation, similar water levels, and similar patterns of seed distribution. Flood plain vegetation, whether marsh or forest, exists under much the same moisture conditions, which

are maintained irrespective of the type of vegetation. Thus, Ware (1955) concluded that change in composition of lowland forest toward more mesic upland types must await physiographic changes such as land aggradation, river deepening, or major shifts in stream channels.

Aggradation and degradation processes will in time produce variation in terrace levels within flood plains. Ware suggests several species combinations which occur on better drained or less frequently flooded sites (Table 2). These include a red oak-basswood-hackberry grouping on the lower Wisconsin River and a sugar maple-red elm-hackberry community along the Pecatonia River in northern Illinois.

Ware (1955) points out that, because of longer periods of lesser sedimentation, and a generally fixed low water level, lacustrine swamps are more stable than those along rivers. As a result of this stability the cottonwood-willow and river birch-swamp white oak combinations are uncommon, and the swamp forest is generally a silver maple-green (or black) ash-American elm community. Gently sloping shorelines also permit a gradation into more mesic upland forests.

Ware illustrates a close relationship between lowland hardwoods of Wisconsin and the forest of the Mississippi Valley to the south. He also indicates relationships to major post-Pleistocene tree migration routes and shows a gradual reduction in species numbers northward (Table 3). Ware reports on hybrids between several lowland species, one of particular interest being that between red maple and silver maple. He further suggests that similarities between hardwood swamps of northern Ohio and eastern Wisconsin may indicate that these areas and the intervening portion of Indiana and Lower Michigan represent a single major lowland hardwood complex.

One lowland forest type not present in Wisconsin or previously noted in Indiana (although it exists there) is a pin oak-red maple-sour gum community described for Ohio by Shanks (1938). This forest follows marsh vegetation in succession in northwestern Ohio.

Lowland Forests West of the Mississippi River

Westward from the Mississippi there is a gradual reduction in species number and some changes appear in composition of flood plain forests. Aikman and Gilley (1948) list several willows, cottonwood, silver maple, American elm, boxelder, Kentucky coffee tree, and black walnut as constant members of the forests along the Missouri River; in addition, river birch, sycamore, and butternut, and several additional species of willow are found along the Des Moines River.

Westward along the Missouri River between Missouri and Nebraska, flood plain forests consist largely of willow and cottonwood, with the higher bottoms often occupied largely by prairie (Weaver, 1960). On

TABLE 3. COMPOSITION OF FLOOD PLAIN FOREST STANDS OF THE UPPER MISSISSIPPI AS INDICATED BY PERCENT DENSITY VALUES (ADAPTED FROM WARE, 1955).

Species[1]	Location North to South				
	Wyalusing State Park, Wisconsin[2]	Jo Daviess County, Illinois[3]	Mouth of Illinois R., Illinois[4]	Kalkaskia River, Illinois[3]	Cache River, Illinois[3]
Silver maple	52	39	33	13	—
American elm	24	22	17	11	10
River birch	11	12	2	3	—
Cottonwood	4	—	1	3	4
Ash spp.	4	6	9	25	6
Swamp white oak	2	—	—	—	2
Honeylocust	1	—	—	0.3	0.1
Boxelder	1	—	2	—	—
Black willow	—	14	2	—	1
Pin oak	—	7	6	11	3
Hackberry	—	—	4	2	1
Sycamore	—	—	0.5	3	0.5
White oak	—	—	—	14	5
Hickory spp.	—	—	—	13	2
Red gum	—	—	—	—	10
Black oak	—	—	—	4	4
Black walnut	—	—	—	3	—
Oak spp. (includes *Q. lyrata*, *Q. falcata*, *Q. shumardii*, *Q. prinus*, *Q. stellata*, *Q. imbricaria*)			—	—	0.5
Tupelo	—	—	—	—	22
Swamp cottonwood	—	—	—	—	0.5
Cypress	—	—	—	—	0.2

[1] Occurrence and percentage density of other species are: At Wyalusing—*Tilia americana* 1; At the mouth of the Illinois—*Quercus macrocarpa* .5, *Carya pecan* 5, *Forestiera acuminata* 5, *Diospyros virginiana* 5, *Gleditsia aquatica* 4, *Cratagus spp.* 3, *Morus rubra* .1, *Ulmus rubra* .1, *Gymnocladus dioicus* .1, *Cercis canadensis* .1; At the Cache River—*Quercus macrocarpa* .1.
[2] Data from Ware, 1955.
[3] Data from Telford, 1926.
[4] Data from Yeager, 1949.

better drained areas small forests of red and white ash, red and American elm, boxelder, hackberry, and walnut may occur. Southward along the Missouri sycamore is frequent, as are silver maple, honeylocust, and Kentucky coffee trees. Red oak and basswood may be found along protected slopes.

In the Missouri River bottoms, open marsh and reed-cattail swamps interspersed with open water were common. As Weaver points out, however, the wide flood plain of the Missouri is no longer forest and marsh: ". . . drainage districts were formed. Lakes and marshes at the margins of the flood plain were filled by soil from the uplands . . . modern machinery was used in clearing away trees and digging deep drainage ditches. Native vegetation throughout the bottomland, except near the river channel, has been almost completely replaced by farm crops."

Northern Lowland Forests

Lowland forests in the northern part of the North Central States are predominantly coniferous. Although considerable areas of lowland

hardwood are present, they more often intergrade into upland stands. The commonest lowland hardwood combination includes hemlock, yellow birch, red maple, elm, and often white pine (Fassett, 1944; Curtis, 1959). In the conifer lowlands the white cedar–balsam fir communities, often with a hardwood intermixture, predominate in some areas. Black spruce-tamarack combinations cover vast acreages elsewhere. The northern lowland forests, especially the cedar-fir-hardwood mixtures may be used to some extent by wood ducks but are of less importance than those types previously discussed. These northern forests have been disturbed but little, and their future is perhaps more secure than those to the south. However, the former white pine-hemlock-yellow birch mixtures along the major rivers have been largely converted to stands of little value to the wood duck.

Past and Present Area of Lowland Hardwood Forest

The area in lowland hardwood forests has changed drastically following white settlement. Cultivation, lumbering, and drainage greatly reduced acreages in forests and open water and modified the swamp components of wood duck habitat.

More recently some land has reverted to lowland forests. This shift may continue, although it is of less magnitude than the earlier destructive one.

Acreages of commercial lowland hardwood in the North Central States are shown in Table 4. Obviously not all lowland hardwood acreage serves as wood duck habitat, but the estimates shown are the best available. Some recent increases in commercial forest acreage result from regrowth on land earlier classed as brush or non-stocked. There are now approximately 9.7 million acres of lowland hardwoods, 610,000 acres of oak-gum-cypress, and 1.5 million acres of cedar in the eight North Central States (Table 4).

CHARACTERISTICS OF BOTTOMLAND HARDWOOD SPECIES

As indicated by Ware (1955), Lindsey *et al.* (1961), Hosner and Minckler (1963), and numerous others, there is considerable leeway in the amount of moisture that most lowland species will tolerate. Likewise, gradation in tolerances among species covers the entire range of moisture conditions within the flood plain. Species of lowland forest communities discussed in this paper are all characterized by considerably more tolerance to flooding and saturated soils than are typically upland species.

Most lowland species are capable of rapid growth and may reach great size in the presence of ample water and light. These species can be arranged in a sequence in relation to tolerance to shading.

TABLE 4. PAST AND PRESENT ACREAGE OF LOWLAND FOREST IN THE NORTH CENTRAL STATES[1]

State	Year of Forest Survey	Commercial Forest Acreage		
		Lowland Hardwoods[10]	Oak-gum Cypress[11]	White Cedar[12]
Michigan[2]	1935	683,000		639,000
	1955	974,000		886,000
Wisconsin[3]	1936	674,000		201,000
	1956	941,000		223,000
Minnesota[4]	1936	607,000		374,000
	1953	1,145,000		284,000
	1962	1,502,000		417,000
Iowa[5]	1954	1,219,000		
Illinois[6]	1948	777,000		
	1962	1,442,000	16,800	
Indiana[7]	1950	993,000	138,000	
Ohio[8]	1952	454,000	46,000	
Missouri[9]	1965	2,180,000	410,000	

[1] Data from current state forest survey reports and from unpublished data of North Central Forest Experiment Station.
[2] Findell *et al.*, 1960.
[3] Stone and Thorne, 1961.
[4] Cunningham, Horn, and Quinney, 1958.
[5] Thornton and Morgan, 1959.
[6] King and Winters, 1952.
[7] Hutchinson, 1956.
[8] Hutchinson, 1954a and 1954b.
[9] Ganser, 1965.
[10] Ash-elm-cottonwood type in which 50 percent or more of the stand is ash, elm, or cottonwood, singly or in combination. In Wisconsin this type is designated as the ash-elm-soft maple type. In Illinois the 1948 figure includes cypress.
[11] Bottomland stands containing at least 50 percent tupelo, black gum, sweet gum, oak or cypress or any combination of them. In Ohio only oak and gum are included.
[12] Swamp conifer forest in which 50 percent or more of the stand is white cedar (associated with balsam fir, tamarack, and swamp hardwood).

Species such as cottonwood, willow, river birch, swamp white oak, boxelder, and silver maple are less tolerant of shade than are elm, ash, hackberry, basswood, and trees of better drained sites, such as red oak, black maple, and beech. In general, the lowland forests are subjected to sufficient disturbance so that the less shade-tolerant species can sustain themselves (Ware, 1955; Hosner and Minckler, 1963).

Lowland species vary considerably in wood characteristics. They span a range from the relatively hard and strong wood of hickory, oak, elm, and hackberry to the weak and softer wood of soft maple, cottonwood, and willow. Specific gravity also varies and is only partially related to strength or hardness. Most lowland species have one characteristic in common: They are not durable and do not persist under situations favorable for decay either as fallen logs or as lumber.

The exceptions, few but notable, include the highly durable cypress and swamp white oak and the moderately resistant elms and hackberry.

Most observers of lowland forests have remarked on the spreading form of the trees, a characteristic which probably contributes to splitting, breakage, etc., and hence to formation of nesting hollows. The low wood strength of many species—willows, cottonwood, sycamore, and soft maples—also contributes to the development of cavities, as does the lack of decay resistance.

Fibrous and taproot systems are represented in approximately equal proportions among lowland species. Windthrow is frequent, particularly among those species with fibrous root systems, like the willows. Actual breakage is more common with tap-rooted trees. Both types of damage help to provide the limbs and other woody debris in the water which serve as loafing sites for wood ducks and provide protection for the feeding brood.

DYNAMICS OF LOWLAND FORESTS

In presettlement times the lowland forests, as well as the associated uplands, were subjected to a variety of disturbances. These disturbances permitted frequent replacement both of species and of individuals if the community remained intact, or the replacement of entire communities after a major castastrophe.

Fluvial forests were and are subjected to the rigors of yearly flooding, varying in depth, duration, and timing, but inevitably bringing a period of inundation and of alluvial deposition. When flooding occurs in winter or late spring, the ice carried downstream often causes extensive damage to trees and aquatic vegetation (Lindsey *et al.*, 1961). Shelford (1954) provides a detailed picture of vegetational changes resulting from major channel alterations in the Mississippi River.

To these hazards must be added wind and fire. Wind damage has been discussed previously. In the past, fire occurred more often in lowland forests than is generally known. Ware (1955) notes that fire was common in most lowland forest areas bordering marshes; as evidence he cites the fire scarred, spreading open-grown swamp white oaks, now being replaced by other species. Ware observed fire scars also in many stands protected by backwaters and sloughs. In addition to oak, large river birch, silver maple, and red ash are somewhat resistant to fire. The cessation of marsh fires after settlement presumably has resulted in less decay and fewer dead trees as well as minor compositional changes.

Lacustrine swamps are subjected to similar disturbance by flooding,

fire, and wind. The flooding tends to be limited in depth, depending on the level of outflow, but lasts longer and deposits less sediment than on flood plains.

The Wisconsin River provides an example of the influence of recent human activity on flood plain forests. Post-settlement logging was accompanied by severe river fluctuations; however, logging was soon followed by an intensive period of dam building, and today the Wisconsin River is ponded for a considerable portion of its length. In the last century major changes in river channel have been few (Ware, 1955), and the previously rapid turnover of pioneer tree communities has apparently slowed. Cottonwood-willow communities may, therefore, become less abundant but of greater age. There is little indication that drainage conditions below the flowages will change; consequently, present areas of lowland forest will not progress rapidly to other types. At the same time, changed moisture conditions along flowage areas above dams will, in some cases, create more wetland, but more often forested sites will be permanently flooded.

In rich bottomlands of rivers like the Wabash, intensive agriculture has produced drastic changes in plant cover. The once endless seas of forest are now similarly endless acres of corn or soybeans, with a narrow fringe of forest along the river bank and on the islands. In Ohio, Indiana, or Illinois, there is little likelihood that these areas will once again be wooded. On the other hand, improvements in land management practices may help in the bluff forests. If pasturing is eliminated, the bluff communities along the flood plain may again become producers of mast and serve as nesting sites for wood ducks.

Lumbering has been a factor in reduction of lowland forests in the past, and it is expected that this will continue. Fortunately, the wet flood plain is less amenable than upland to modern logging methods and machinery, and probably, as in the past, much of the logging will be on a relatively small scale to satisfy local needs. Local logging is unlikely to reduce habitat drastically since, save for firewood, the better formed trees would be taken and others left. However, where logging is done under modern management concepts, the misconception that removal of every spreading, aged, and broken specimen is essential to timber stand improvement may prevail and nesting potential will be reduced. In the lowland, in contrast to the upland, fire control will have little more effect than it has had to date.

Artificial flooding, especially where the water level may vary greatly, will have considerable impact on lowland forests. This is evidenced in many areas in the Midwest.

Recreational development can also cause serious damage to lowland forest if it brings clearing, building, streamside "improvement," and

chemical insect control. Streamside recreation reservations may be beneficial if they result in increased stand age, "natural" conditions along the streams, and maintenance of forest and aquatic vegetation.

Recently elm mortality has been heavy, and its final influence on the lowland hardwood forests cannot be predicted. Phloem necrosis and Dutch elm disease, singly and in combination, have killed large numbers of vigorous and mature elms. It is doubtful that elm will be eliminated from the lowland hardwood type; however, it is diminishing in importance. Unpublished data from recent surveys indicate a significant drop in volume of elm over the past 20 years in Illinois, Indiana, and southern Michigan. This drop in volume appears directly related to a decrease in the number of elms of saw timber size. The abruptness of the change demonstrates the dynamic nature of the forest community and the speed at which unexpected changes can occur. Susceptibility of elm to disease, especially to Dutch elm disease, is a factor which must be considered in management of lowland woods, whether for timber or wood duck habitat.

A similar but less pronounced decline has occurred in the volume of oak saw timber in some areas. This loss is blamed in part on "oak wilt" to which pin oak is particularly susceptible. The disease is spotty in distribution but it can cause total loss of oaks in a particular stand. Oak wilt occurs in all of the North Central States, as does Dutch elm disease.

CONCLUSION

A few generalizations on the lowland hardwood forest types will serve to summarize this paper.

Floristic variety in lowland forests diminishes rapidly northward; it also diminishes westward from the Mississippi River. Flood plain forests generally are dense, vigorous, and fast growing, and include many trees of spreading form subject to breakage and decay.

River-bottom forests may show considerable uniformity over long distances for several reasons: (a) river valleys were migration routes for a number of tree species during post-glacial times, (b) the vegetation of a river valley is subject to essentially the same disturbances for long distances and (c) flood plain soils show essentially the same soil moisture values for long distances. Gradation in soil moisture would be outward from the river, with the backwater area also being moist.

Rapid plant succession in river bottoms results from changes in availability of light. A terminal forest, in the sense of climatically adapted upland stands, is not reached since river-bottom species have little influence on the soil or on soil moisture conditions. Lowland

forests cannot cause appreciable soil drying; the water table established by the river and frequent flooding are the major controls. Likewise, because of deposition of alluvium and scouring or washing of organic materials, etc., river-bottom forests rarely effect much change in soil fertility. Thus, succession in river-bottom forests is from pioneer light-demanding species to those more tolerant of shade, but still tolerant of flooding.

There is considerable similarity from Ohio to Wisconsin in the present composition of the swamp forests and in the points of origin of the tree species. Differences in species composition are most likely to result from differences in substrates—for instance the swamp white oak-river birch combinations on sands, in contrast to the ash-maple-elm group on finer textured soils. Components of these forests show great structural and ecologic similarity. Principles applying to development of forests and to habitat management within lowland hardwoods can be applied within reason throughout most of the North Central area.

In evaluating the future of river-bottom forests, changes since settlement must be taken into consideration. These include cessation of fires in the marshes, gradual removal of older, larger trees and the consequent reduction in average forest age, control of river flows by dams, and regulation of lake water levels.

The difficulties of lowland existence apparently encourage great genetic and ecological variability so that identification of species alone is often not enough to document the differences in composition and behavior. Physiological differences among tree species and varieties are paramount.

Although the area of lowland forest and thus of favorable wood duck habitat has declined greatly in the past 150 years, there are indications that this decline has been reversed. These forests are now at least holding their own.

The function of this paper has been served if the reader has obtained some insight into the variety of forest communities which border surface waters in the North Central part of the United States, and at the same time has noted the parallel developmental patterns and compositional similarity of the various communities classed as lowland hardwood forest, currently the most persistent and useful forest vegetation for wood duck habitat.

LITERATURE CITED

Aikman, J. M., and C. L. Gilley
1948. A comparison of the forest floras along the Des Moines and Missouri Rivers. Iowa Acad. Sci. Proc. 55: 53-73.

Cunningham, R. N., A. G. Horn, and D. N. Quinney
1958. Minnesota's forest resources. U. S. Forest Serv., Lake States Forest Expt. Sta., Resource Rept. No. 13. 52 p.

Curtis, J. T.
1959. The vegetation of Wisconsin. Univ. Wis. Press, Madison, 657 p.
Fassett, N. C.
1944. Vegetation of the Brule Basin, past and present. Trans. Wis. Acad. Sci., Arts and Letters 36: 33-56
Findell, V. E., R. E. Pfeifer, A. G. Horn, and C. H. Tubbs
1960. Michigan's forest resources. U. S. Forest Serv., Lake States Forest Expt. Sta., Station Paper No. 82. 46 p.
Gansner, D. A.
1965. Missouri's forests, U. S. Forest Serv., Resource Bull. No. CS-2. Central States Forest Expt. Sta., Columbus, O. 53 p.
Hosner, J. F., and L. S. Minckler
1963. Bottomland hardwood forests of southern Illinois—regeneration and succession. Ecology 44: 29-41.
Hutchinson, O. K.
1954a. Forest statistics for the glaciated region of Ohio. U. S. Forest Serv., Central States Forest Exp. Sta., Forest Survey Release No. 16. 28 p.
———
1954b. Forest statistics for the hill country of Ohio. U. S. Forest Serv., Central States Forest Expt. Sta., Forest Survey Release No. 17. 44 p.
———
1956. Indiana's forest resources and industries. U. S. Forest Serv., Central States Forest Expt. Sta., Forest Resource Rept. No. 10. 44 p.
King, D. B., and R. K. Winters
1952. Forest resources and industries of Illinois. Univ. Ill., Agr. Expt. Sta., Bull. No. 562. 95 p.
Lindsey, A. A.
1961. Vegetation of the drainage-aeration classes of northern Indiana soils in 1830. Ecology 42: 432-436.
———
1962. Analysis of an original forest of the Lower Wabash floodplain and upland. Ind. Acad. Sci. Proc. 72: 282-287.
———, R. O. Petty, D. K. Sterling, and W. Van Asdall
1961. Vegetation and environment along the Wabash and Tippecanoe Rivers. Ecol. Monograph 31: 105-156.
Little, E. L., Jr.
1953. Check list of native and naturalized trees of the United States (including Alaska). U. S. Dept. Agr. Handbook 41. 472 p.
Ridgeway, R.
1872. Notes on the vegetation of the Lower Wabash Valley. Amer. Naturalist 6: 658-665, 724-732.
Shanks, R. E.
1938. The original vegetation of a part of the lake plain of northwestern Ohio: Wood and Henry Counties. Ohio State Univ., Abstracts of Doctoral Dissertations 29: 115-122.
Shelford, V. E.
1954. Some Lower Mississippi Valley floodplain biotic communities; their age and evaluation. Ecology 35: 126-142.
Stone, R. N., and H. W. Thorne
1961. Wisconsin's forest resources. U. S. Forest Serv., Lake States Forest Expt. Sta., Station Paper No. 90. 52 p.
Telford, C. J.
1926. Third report on a forest survey of Illinois. Ill. Nat. Hist. Survey, Bull. No. 16: 1-102.
Thornton, P. L., and J. T. Morgan
1959. The forest resources of Iowa. U. S. Forest Serv., Central States Forest Expt. Sta., Forest Survey Release No. 22. 46 p.
Ware, G. H.
1955. A phytosociological study of the lowland forests in southern Wisconsin. Ph.D. Thesis. Univ. of Wis. 115 p.
Weaver, J. E.
1960. Flood plain vegetation of the Central Missouri Valley and contacts of woodland with prairie. Ecol. Monograph 30: 37-64.
Yeager, L. E.
1949. Effect of permanent flooding in a river-bottom timber area. Ill. Nat. Hist. Survey, Bull. No. 25: 33-65.

IMPACT OF FOREST MANAGEMENT AND OTHER HUMAN ACTIVITIES ON NORTHERN WOOD DUCK HABITAT

W. A. AULTFATHER

Regional Forester, U.S. Bureau of Sport Fisheries and Wildlife, Minneapolis, Minnesota

Conservationists are alarmed at the rapid rate at which prairie pothole waterfowl production areas are being lost through drainage and other uses of land. Unless and until this trend can be reversed, the prairie pothole-nesting waterfowl will continue to be in trouble. But there is encouragement in at least one segment of the waterfowl population, the tree-nesting, woodland-inhabiting wood duck.

This report is aimed at emphasizing (1) trends in forest acreages, (2) factors influencing wood duck habitat, (3) opportunities for managing wood ducks, and (4) information required to improve wood duck management.

TRENDS IN FOREST ACREAGES

The wood duck has a distinct advantage in being less disturbed by human activities and in being adapted to a type of habitat which probably has increased rather than decreased in acreage during the past 10 years. This is reflected in timber trends (U.S. Dept. Agr., 1965). According to a recent report the national commercial forest area has increased at the rate of 1.5 percent over the past 10 years. Nationally, there are now 7,585,000 acres more commercial forest land than 10 years ago. It is unlikely that all commercial forests are prime wood duck habitat. Pine stands are considered relatively poor habitat, even though Bent (1923) gives two instances of wood ducks nesting in pine trees.

Generally, biologists have not identified the tree species and timber types which are actually preferred by wood ducks. Lacking definite information on forest types preferred or used and which tree species are favored, I will merely summarize changes occurring in forests of the northern part of the wood duck range: the New England Region, Mid-Atlantic States, Lake States, and Central States.

Altogether these regions have a current inventory of 168,166,000 acres of commercial forest land (Table 1). Associated with this forest land, according to the 1955 survey, are 14 and ⅓ million acres of wetlands. The total commercial forest land of the area is actually 2/10 of 1 percent lower than it was in 1953.

Largest losses of commercial forest land were in two groups: (1) the spruce-fir group, which declined 1,821,000 acres, and (2) the

ABLE 1. COMMERCIAL FOREST TYPES BY REGIONS (1963) AND CHANGES IN AREA, 1953-63 (In THOUSANDS OF ACRES)*

Type	New England		Mid-Atlantic		Lakes States		Central States		Total	
	Present Area	10-Year Change	Present Area	10-Year Change	Present Area	10-Year Change	Present Area	10-Year Change	Present Area	10-Year Change
, red and jack pine	4,094	+676	1,683	+34	4,435	−10	108	+77	10,320	+777
lly and shortleaf pine	180	+15	2,734	−38	—	—	904	+324	3,818	+301
e-fir	10,094	−466	778	−90	8,751	−1,265	—	—	19,723	−1,821
ine	61	+12	701	+137	—	—	1,504	−218	2,266	−69
ickory	3,963	+783	20,245	+1,621	6,170	−273	27,400	−1,594	57,778	+537
um-cypress	—	—	931	−1,785	—	—	747	−536	1,678	−2,321
sh-cottonwood	1,156	+332	1,884	+460	4,705	+96	8,533	+895	16,278	+1,783
e-beech-birch	9,323	−1,235	11,873	+1,141	9,630	+322	1,986	−76	32,812	+152
-birch	2,580	+676	3,059	+183	17,882	−569	72	−12	23,593	+278
AL	31,451	+793	43,888	+1,663	51,573	−1,699	41,254	−1,140	168,166	−383

igures for the New England States are for all of the New England States. The Mid-Atlantic States are Delaware, Maryland, New Jersey, New York, ylvania and West Virginia. The Lakes States are Michigan, Minnesota, and Wisconsin. The Central States are Illinois, Indiana, Iowa, Missouri, Ohio, entucky.

oak-gum-cypress type, which declined 2,321,000 acres. The reduction of spruce-fir probably is of little importance to wood ducks, but decline of the oak-gum-cypress type is an important loss. However, this loss could very well be offset by gains of 537,000 acres in oak-hickory and 1,787,000 acres in the elm-ash-cottonwood bottomland types. There also were gains of 152,000 acres in the maple-beech-birch hardwood type and 278,000 acres in the aspen-birch type. By regions, the change in commercial forest acreage is roughly a 1.4 percent increase in New England, a 3.9 percent increase in the Middle-Atlantic States, a net loss of 1.1 percent in the Lakes States, and a net loss of 2.2 percent in the Central States.

Assuming that the 2,321,000 acres of oak-gum-cypress lost in the northern portion of the United States are most important to waterfowl, understanding what happened to these stands is essential. The six-county Bootheel area of Missouri provides a good example of high losses of this commercial forest land. Here, extensive land clearing converted rich bottomlands to farm lands. These areas now support grain and other crops, many of which furnish food for waterfowl. Many trees remaining in woodlots, in fence rows, and around rural and urban dwellings can be expected to have natural cavities. Available food in the bottomlands and nesting cavities in remaining trees will very likely continue to encourage traditional waterfowl use of the area.

FACTORS INFLUENCING WOOD DUCK HABITAT

After considering gross areas of potential wood duck habitat it is helpful to examine what is happening in these forests and what opportunities exist for preserving and improving habitat for wood ducks. But, first, basic facts must be recognized. Land is valuable. Increasing human populations create increasing pressures for use of land. Forestry is a business. Consequently, foresters are employed to perform forestry operations in a business-like manner. It is significant that forestry is in an age of specialization, similar to the status of many professions today. The forester, too, finds that his employer wants specific and different things from different areas. It is reasonable to assume that the forester's assignment will be oriented first to the landowner's primary objective. But there are many opportunities for a forester to accomplish more than one objective with the same operation, or by several differing methods.

To date the forester has had little or no influence on the withdrawal of commercial forest lands. This decision is made by the engineer, developer, planner, and farmer. But the forester retains some managerial responsibility for forest land that remains after attrition.

Not all forest land is in commercial use, and not all commercial

forest lands are under management. Over 70 percent of the commercial forest land in the north is in farm and miscellaneous private ownership.

Public forest lands and those owned by forest industries amount to about 26 percent of the total commercial forest of the North and most of these lands are under some form of management. Forest management on industry lands, quite obviously, is directed toward supplying wood requirements of the owner. The objective of management has been and will undoubtedly continue to be maximum production of wood. Quality, size and species of tree used may change. Indications are that intensive management will not overcome the trend toward a gradual decrease in the average diameter of trees being cut for sawlogs and veneer on these lands. On three-fourths of the industrial forests managed for pulp and paper, trees will usually be harvested before they reach a size or condition capable of providing suitable nesting cavities.

OPPORTUNITIES FOR WOOD DUCK MANAGEMENT

Industrial forest lands present two opportunities for wood duck management.

1. On poor sites capable of only low-grade timber production, the sites may be left to produce cavity forming trees and mast crops.
2. On sites under intensive timber management, nest boxes may be erected without impairing wood production.

Economics frequently encourage foresters to focus management efforts for wood products on the more productive sites. Here, intensive management pays off. Nevertheless, industrial foresters can be expected to welcome opportunities to cooperate in benefiting wood ducks along the lines outlined above.

Public forest lands have been managed in the past for a multitude of dominant uses. Some areas that have potential for integrated management have already become "multiple use" forests. Public forest management is in a transition period. Many areas are no longer classified as commercial forests because they are being reserved for recreation. Aesthetics and recreation are considered of equal or higher value than tangible products or services on some public areas. Such areas are being set aside as natural or wilderness areas. New roadside parks, and city, county, state, and national parks are being established, as well as scenic corridors adjacent to public highways. These areas also offer the wood duck nesting sites and possibly other types of suitable habitat. Those areas in public ownership which have potential for wood duck habitat are ripe for development. All

that is needed is some information which the forester can use in his management plans.

Small private woodlands offer a problem for the forester. Management of these areas usually starts with cut-over, virtually high-graded stands. Nationally these areas supply about one-half the harvest of growing stock. Intensive programs to encourage management of small private woodlands have been carried on by the U. S. Department of Agriculture through the Forest Service, Extension Service and Soil Conservation Service, and by incentive payment programs available through the Agricultural Stabilization and Conservation Service. Private forest industries and state forest departments, through activities such as the Tree Farm Programs and Farm Foresters, have also encouraged management of small private woodlands. In spite of these aids, there has been less response to this phase of woodlot management than fire protection.

The paradox of this poor forest management is that in the high-grading type of harvest, cavity trees are usually left because of their low timber yield. Other necessary wood duck habitat improvement measures will probably be as difficult to implement in these small holdings as good forest management practices have been. Assuming that wood ducks prefer hardwoods to conifers, these predominantly hardwood forests may be worthy of considerable attention. Foresters, frequently called "farm foresters," working to attain management of woodlots, are generally very dedicated conservationists. They can be expected to make use of any helpful information on wood duck management whenever the opportunity arises.

Another category of timbered lands seems to have value for nesting wood ducks. Areas classed as productive reserved and non-productive forest lands are not managed for timber production. They amount to over 6½ million acres in the North. Involved are roadside, streamside, and shelterbelt strips of timber with less than 120 feet in crown width, and yard trees. With the current growing interest in natural beauty, it is safe to assume that maintenance of trees in these classifications will be encouraged.

Although some of these trees are located close to people, it is unlikely that human disturbance has, or will have in the foreseeable future, an adverse influence on nesting wood ducks. Accounts show woodies nesting within 12 feet of a ship being built (Wilson and Bonapart, 1831), in village commons, school yards, apple orchards, and near farm houses (Ayars, 1943). There is a movie about woodies nesting in a yard (Breckenridge, 1956). Many photographs show occupied nest boxes located in close association with people. Tolerance of human disturbance will benefit the wood duck as woodlands are used

more and more by people seeking recreation. But it does not seem likely that human activities, even if increased, will have an adverse effect on the use of northern habitat by wood ducks.

The wood duck is a colorful and exciting creature to observe. Yard trees, shelterbelts and other trees in small groves, if acceptable to woodies for nest sites, would provide many opportunities for personal satisfaction. If cavity trees are needed, they will be left—if people are aware of the need. If nesting boxes must be erected, the problem will not be one of getting permission to erect them. Rather, it will be to discourage improper placement of the houses.

INFORMATIONAL NEEDS

Before significant progress can be made by foresters in encouraging management of woodlands to benefit wood ducks, biologists must supply some basic information on needs of the bird. Habitat requirements of the wood duck should be defined in terms of optimum and minimum conditions. These conditions should be in terms the forester understands: what forest types the wood duck prefers or will accept; which species of trees and associations are best; and the sizes, age classes, and densities of trees that provide useable nesting cavities. Tree densities should be expressed either in basal area per acre or percentage of crown closure. Definitions and guidelines should include types of acceptable terrain, distances of nesting habitat from water, and types of vegetation required to attract and hold wood duck broods. If a predator-proof nest box program is necessary, proper environments for erecting these boxes should be defined in similar terms.

SUMMARY

The prognosis for northern wood duck habitat is encouraging for several reasons. First, although there have been some changes in size class and species distribution of the commercial forest, there has not been a significant change in total area. Further, little change in total commercial forest area is expected to the year 2000. Trees for beauty and those for shelter are increasing in numbers, and this trend can be expected to continue. Thus, potential nesting habitat can be assumed to be increasing. The growing use of the forest for recreation does not appear to conflict with use of the same area for wood duck nesting, although it may affect some other phases of the wood duck life cycle. Foresters and the general public are generally willing to assist in increasing and improving wood duck habitat. But the degree of accomplishment depends largely upon biologists providing some basic biological and ecological information for guidance.

LITERATURE CITED

Ayars, J. A.
1943. Woodies are queer ducks. Sat. Evening Post. July 31.

Bent, A. C.
1923. Life histories of North American wild fowl. U. S. Natl. Mus., Smithsonian Institution, Bull. 126. 250 p.

Breckenridge, W.
1956. Wood duck ways. (A film) Minn. Nat. Hist. Mus. and Audio-visual Educ. Serv., Univ. Minn., Minneapolis.

U. S. Department of Agriculture
1965. Timber trends in the United States. U. S. Forest Serv., Forest Resource Rept. No. 17. 235 p.

Wilson, A. and C. L. Bonapart
1831. American ornithology, or the natural history of the birds of the United States. Vol. III. Edinburgh. 320 p.

IMPACT OF FOREST MANAGEMENT AND OTHER HUMAN ACTIVITIES ON WOOD DUCK HABITAT IN THE SOUTHEAST

D. J. HANKLA AND V. E. CARTER

U. S. Bureau of Sport Fisheries and Wildlife, Atlanta, Georgia

Forest management and other land use activities are having an impact on wood duck habitat in the Southeast. But because wood duck populations defy inventory, and their habitat has not yet been defined quantitatively and qualitatively, there is no way of accurately assessing the impact of forest management and other human activities on wood duck habitat. It is possible, however, to assess, in general terms, the magnitude of some of the practices that are affecting what we consider to be wood duck habitat in the Southeast. From available information some general conclusions can be drawn regarding the impact of forest management and other human activities on the bird and its habitat.

Much of the supporting information for this report was obtained through personal contact with several resource managers. To each we express deep appreciation for their assistance.

SOUTHEASTERN WOOD DUCK HABITAT

In order that a discussion of practices and activities relating to wood duck habitat might have meaning, we believe it is necessary first to establish a concept of what constitutes wood duck habitat. A search of the literature revealed about as many terms used to describe wood duck habitat as there are biologists and naturalists who have written about this web-footed bird of the wetland forests. Phrases such as "overflow hardwood bottomlands," "margins of sounds," "open places in swamps," "ricefield ditches," "sequestered forest ponds," "brushy timbered sloughs," "shallow marshes," "shrubby swamps," "woodland ponds," "old mill ponds," "beaver ponds,"

and other similar terms describe what is generally recognized as habitat preferred by wood ducks (Kortright, 1943; Wray and Davis, 1959). If this is a true reflection of the variety of ecological types preferred by wood ducks for feeding, nesting, rearing, resting, and roosting, then the impact of forest management and other human activities on southern wood duck habitat is staggering.

Habitat losses of both a direct and indirect nature have been occurring at a rapid rate, particularly since the end of World War II. Drainage, clearing, flood control, pollution, and intensive forest management are responsible for a widespread reduction in wood duck habitat in the Southeast.

ADVERSE HABITAT FACTORS

Drainage

This is thought to be the undisputed worst enemy of the wood duck. Drainage is directly responsible for the destruction of oxbow lakes, sloughs, swamps, beaver ponds, woodland ponds, and marshes that are so necessary for rearing, resting, and roosting. Where drainage does not directly affect such surface water areas, it can and often does reduce or eliminate seasonal flooding which is so necessary to replenish these wetland water supplies following periods of drought.

Drainage also affects wood duck habitat by reducing the frequency and duration of flooding, and by lowering the groundwater table. Timber stand conversion is encouraged, usually toward forest types which are tolerant of, or require drier soil conditions. Hardwood sites may be converted to pine sites, and lowland swamp type hardwoods are replaced by hardwoods which respond to better-drained soils. In local situations this can be beneficial, particularly when stands of cottonwood and willow are succeeded by heterogeneous stands of hardwoods which contain Nuttall oak (laurel oak in the Southeast), sweet gum, willow oak, water oak, green ash, red maple, elm, and sycamore. Most often, however, losses from stand conversion exceed gains. Stands of cypress and tupelo gum, which often provide quality wood duck habitat, are lost because these species fail to reproduce under better drained soil conditions. Drainage promotes stand conversion, and it also promotes land clearing.

Clearing

Clearing ranks high as an enemy of the wood duck. Hardwood timber is one of the most important ingredients of wood duck habitat. The removal of hardwoods through clearing effectively destroys the potential of an area to provide nest sites and important food in the

form of mast, both of which are necessary components of wood duck habitat.

Flood Control

Flood control adversely affects wood duck habitat in the Southeast, both directly and indirectly. Flood control reservoirs strategically located in major drainages reduce flooding in downstream areas, thus reducing the frequency and duration of inundation on large acreages of flood-plain hardwoods. Hardwood mast, an important winter food for wood ducks, cannot be utilized because shallow flooding is necessary to make the mast available. Flood control is also a major factor contributing to clearing and removal of these bottomland hardwoods. Landowners are encouraged to clear woodlands for agricultural uses because flooding following reservoir development occurs less frequently in the flood plain below the reservoir. Reservoirs also flood out habitat within their immediate basins, thus removing trees that provide nest sites and inundating shallow surface water areas that are valuable for rearing and roosting.

Pollution

Pollution in the form of chemical effluents, municipal sewerage, and/or silt, effectively renders many backwater sloughs, sluggish streams, rivers, and bays unsuitable as rearing habitat for wood ducks. Chemical wastes and turbid waters eliminate or seriously reduce aquatic plants and associated insect life that are the primary source of food of young wood ducks during the first several weeks following hatching.

Another form of pollution which is believed to affect duck habitat is the concentration of pesticides in streams and rivers. Many natural drainageways in the Southeast carry agricultural and industrial pesticides from a wide area of influence and concentrate them in a relatively small area. There is strong evidence that food-chain organisms in pesticide-laden streams are adversely affected, a phenomenon which can in turn affect higher organisms such as the young wood duck.

Forest Management

This activity is treated last because it is difficult to appraise as a factor bearing on wood duck habitat in the Southeast. In a general survey of timber interests, we noted that several timber products companies are conducting little more than a high grading program, which in its present form is actually beneficial to the wood duck. Other companies are managing more intensively but admit that it is not economically feasible to remove all cull trees and grow only straight-

stemmed sound trees with no cavities. Still other companies have engaged in drainage and hardwood removal in an effort to convert low-grade hardwoods to pine. This type of management is the most damaging to the wood duck, for it results in the complete destruction of habitat even though such habitat may be only of a seasonal nature.

EFFECTS OF LAND AND WATER USE ACTIVITIES

In gathering data which relate to the magnitude of the practices just discussed, our efforts were largely confined to the Bureau of Sport Fisheries and Wildlife 12-state southeastern area, which includes Louisiana, Arkansas, Kentucky, Virginia, Maryland, and all states located to the south and east. Within this area, alluvial bottoms, hammocks, and swamps, which support practically pure stands of hardwood timber, constitute the best remaining wood duck habitat. Wooded wetlands also provide fair to good-quality habitat during years when above-normal rainfall produces shallow flooding. The impact of drainage, clearing, flood control, pollution, and forest management on this habitat can best be assessed by reviewing some of the programs of public and private land and water management agencies.

Drainage of Industrial Forest Lands

Timber companies and private landowners are engaged in a massive program in the Atlantic and Gulf coastal plains to place certain less productive wetland types in commercial timber production. Klawitter (1965) states that the practice of woodland drainage in the coastal plain began only about 18 years ago when a ditch was dug through low-value brush, hardwoods, and cypress to demonstrate that the removal of surface water would permit slash pine seedlings to grow in areas formerly too wet for them. From that beginning, woodland drainage in the Atlantic and Gulf coastal plains has increased, until now an estimated two million acres of wetlands are under this form of management. An additional four to five million acres of low-value coastal plain wetland forests exist that offer drainage and conversion opportunities, with certain limitations. These types provide only marginal habitat for wood ducks, being used largely during spring and fall migration. While the impact of their loss would not appear to be great, the cumulative value of these areas as feeding, resting, and roosting habitat may be surprisingly high. Drainage of this type will continue as the demand for forest products increases and creates a more favorable benefit-cost ratio.

Small Watershed Program

Programs of greater magnitude which have the potential for influencing virtually all wood duck habitat in the Southeast are the

Small Watershed Program authorized under the Watershed Protection and Flood Prevention Act, P.L. 566, and its predecessor, the Pilot Watershed Program. These programs authorize the Secretary of Agriculture to cooperate with state and local agencies in planning and carrying out works of improvement for soil and water conservation. These works include flood-retarding structures, stream channelization, clearing and snagging stream channels and banks, and land treatment measures for maximum control of runoff. As of November 1, 1965 in the 12-state Southeast area, a total of 382 applications covering 23,169,400 acres—nearly seven percent of the total land—had been authorized for planning assistance under the small watershed program (U. S. Dept. Agr., 1965). Of this number, 262 plans covering 15,045,500 acres have been approved for operations (construction). Under the Appalachia Program, the Department of Agriculture plans small watershed developments on more than 400 Appalachian watersheds.

Drainage is an important aspect of the program, and in many instances the lands to be drained provide at least seasonal, if not year-round, habitat for wood ducks and other waterfowl. Unless adequate provision is made to mitigate losses sustained from drainage, the Small Watershed Program will be very damaging to the wood duck.

The North Carolina Wildlife Resources Commission made a study of three P.L. 566 projects which were installed in the eastern part of their state and reported that each has been highly destructive to wetland wildlife (Barick, 1965). According to the Commission, "Of several projects currently in the planning or active state, we can point to none for which the final approved plans include adequate provision for the protection of wetland wildlife resources." The Commission report suggests that, if the same pattern of operation continues in the future, P.L. 566 projects scheduled for eastern North Carolina threaten extensive and serious damage to several species of wildlife important to the recreational potential and economy of the region.

Clearing by Public and Private Agencies

Another factor which has been identified as destructive of wood duck habitat is clearing. The magnitude of this practice is not easily assessed, although its influence is totally adverse to the wood duck. In the Southeast as a whole, it has been estimated that by the year 2000, 13.4 million acres of existing forested wetlands will be converted to cropland and pasture. In Arkansas, Louisiana, and Mississippi, the clearing of hardwood bottomlands is particularly extensive. A Department of Agriculture report revealed that of 1,939,600 acres of

bottomland hardwoods presently occurring in the White River Basin in Arkansas, only about 740,100 acres, or 31 percent, will remain in this type by the year 2000. Landowners in the White River Basin, as well as elsewhere in Arkansas, Louisiana, and Mississippi, are clearing bottomland hardwoods to plant soybeans. Growing soybeans on lands previously occupied by bottomland hardwoods is a change brought about by recent advances in soil technology. Soybeans provide a greater economic return than timber and are an important export product. Unfortunately, they are not a substitute for hardwoods, and the loss of excellent wood duck habitat in the three-state area will be extensive.

Corps and Private Flood Control Projects

The impact of flood control on wood duck habitat is probably greater in the Southeast than in any other section of the nation. According to a 1956 survey, there are 59 lake and reservoir projects in the 12 southeastern states that have flood control as either a primary or secondary function (Thomas and Harbeck, 1956). These do not include municipal, power, or navigation reservoirs which also function, at least in part, as flood control projects. Additional projects are planned under the Appalachia Program.

The 59 areas collectively cover about 2,420,720 surface acres and influence an area in the downstream flood plains several times greater. The area occupied by lakes and reservoirs is largely lost as wood duck habitat, and the habitat in the flood plain is greatly reduced, both in quality and quantity.

The influences of flood control in various flood plains are manifest by reduction in frequency and duration of flooding, clearing of hardwood bottomlands, and reduction in size or complete elimination of oxbow lakes, sloughs, and swamps that serve as wood duck production and wintering habitat. These losses are considered to be irretrievable.

Pollution

While the impact of pollution as a factor affecting wood duck habitat is very difficult to measure, there is little doubt that it has made serious inroads into otherwise suitable wood duck habitat. In the Southeast, there are hundreds, or perhaps thousands, of miles of streams that would be suitable as rearing habitat for wood ducks if they were not polluted with various dyes, detergents, and other chemical compounds. While a concerted effort has not been made to appraise the extent of pollution of wood duck habitat, we have observed several miles of polluted streams uninhabited by wood ducks during the spring when broods should have been present. Broods were observed on unpolluted streams with similar habitat characteristics. During

the migration and wintering season, wood ducks and other migrants seem to show no particular preference between polluted and non-polluted streams. An encouraging aspect of the pollution problem is that habitat losses as a result of this factor may be regained once the pollution has been abated. Because of the need for clean water for human consumption and other uses, it is expected that pollution, as it now affects wood ducks, will be less of a problem in future years.

Forest Management

The impact of forest management on wood duck habitat is not of great significance except where hardwood lands are converted to the production of pine. As previously mentioned, it is estimated that two million acres of low-value hardwood lands have been drained in the Atlantic and Gulf coastal plains and converted to pine. The actual value of these lands as wood duck habitat varies from one locality to another, and the total impact of the program on wood duck habitat is a matter of conjecture.

In general, the owners of hardwood bottomlands have not yet begun broadscale intensive management of the type that will adversely affect wood duck habitat. Management practices, such as the removal of all trees that contain cavities, drainage to improve site classification, and drainage of woodland ponds and swamps, could do great harm to the habitat. Fortunately, it is not economically feasible to enter into this type management at this time.

SUMMARY

Destruction of wood duck habitat has come about as a result of changes in the environment that man has promoted in an effort to better himself through more intensive utilization of certain resources. These changes, of necessity, came about at the expense of other resources, which in man's judgment were of lesser value. In many instances, man's judgment regarding the relative values of various resources has been misguided. Some of his efforts have been successful, and some have compounded his problems. Change, however, is the story of America and one reason for this country's greatness. To keep pace with the times, more changes are in order and will continue to be made.

We think it is time to take stock of what is left in the way of wood duck habitat and make an all-out effort to convince those persons responsible for land and water management that wetland habitat is valuable and is worth preserving. To do less is to contribute to the loss of the wood duck—the Southeast's only widely distributed native species of waterfowl. To accomplish this goal, values will have to be

given to fish, wildlife, hardwood timber, and water; values that are high enough to deter drainage, clearing, flood control, and pollution of wood duck habitat.

LITERATURE CITED

Barick, F. B.
1965. Statement regarding adverse effects of P. L. 566 projects on wildlife resources in Eastern North Carolina and suggestions for prevention. N. C. Wildl. Resources Comm. 27 p. (mimeo.)
Klawitter, R. A.
1965. Woodland drainage in the Southeast. Southeastern Forest Expt. Sta., Forest Serv., U. S. Dept. Agr. Charleston, S. C. 8 p.
Kortright, F. H.
1943. The ducks, geese and swans of North America. Amer. Wildl. Inst., Wash., D. C. 476 p.
Thomas, N. O., and G. E. Harbeck, Jr.
1956. Reservoirs in the United States. Geological Survey Water-Supply Paper 1360-A. 99 p.
U. S. Department of Agriculture
1965. Status of watershed protection program (P.L. 566). Soil Conserv. Serv. Nov. 1. 5 p. (mimeo.)
Wray, D. L., and H. T. Davis
1959. Birds of North Carolina. N. C. Dept. of Agr. Raleigh, N. C. 434 p.

INFLUENCE OF FLOOD-PLAIN PLANNING, ZONING AND MANAGEMENT ON WOOD DUCK HABITAT

F. W. COLLINS AND C. BROWN

U. S. Army Corps of Engineers, Rock Island, Illinois

The concept of planning, zoning and management discussed in this paper is currently being implemented on government lands along the Upper Mississippi River from St. Paul, Minnesota to St. Louis, Missouri. Detailed discussions throughout this paper are directed toward a segment of the upper river from Guttenberg, Iowa (dam number 10) to Saverton, Missouri (dam number 22). This reach of the river is within the Rock Island District of the U. S. Army Corps of Engineers.

We emphasize that planning for management of Corps-owned lands along the Upper Mississippi River must be comprehensive. In keeping with the concept of multiple land use, consideration is given to all existing resources and anticipated uses. The planning and management of one resource may be adjusted to complement, either directly or indirectly, another resource. A case in point is the relationship of land use zoning and forest management to wood duck habitat.

MAN'S IMPACT ON THE RIVER HABITAT

The Upper Mississippi River has experienced marked ecological changes since white men came to the valley. These changes have resulted from man's continuous attempt to harness the river for transportation purposes. As early as 1830, improvements were made in the interest of navigation. Snags were removed and rocks excavated

in several sections of rapids. This was followed by a 4½-foot channel project in 1878 and a 6-foot channel project in 1907. All of these earlier navigation projects were primarily concerned with the removal of obstructions or the construction of "wing dam" structures to restrict low flows. Consequently, these projects probably had little effect upon existing wood duck habitat. As reported by Dr. W. E. Green, biologist with the Bureau of Sport Fisheries and Wildlife, ecological condition of the river bottoms at this time was one of wooded islands, deep sloughs, and hundreds of small bottomland lakes and ponds. Small hay meadows were scattered throughout the flood plain.

In 1930 the Corps of Engineers initiated work on the 9-foot navigation channel project for the Upper Mississippi River. Through construction, a series of 26 locks and dams were added to create a series of slack-water pools. These different water levels stimulated significant changes in the ecological conditions of the river. Many of the bottomlands previously subjected to flooding and drying were now inundated to various depths. Conditions favored marsh development. In addition, considerable acreage of land within the pools, along the shores, and throughout the river terrace came under government ownership. Prior to Corps acquisition, the Bureau of Sport Fisheries and Wildlife had acquired lands for the Upper Mississippi River Wildlife and Fish Refuge. A total of 185,532 acres of land was acquired for project purposes, in addition to 86,000 acres already owned by the Bureau.

MANAGEMENT OF RIVER LANDS

With acquisition of these lands came the responsibility of administration and resource management. Administration is normally a function of the Management and Disposal Branch of the Real Estate Division within a Corps District office. But administrative action is based upon an approved master plan. Responsibility for preparing master plans in the Rock Island District is in the Recreation Section of the Engineering Division.

Initial project master plans were relatively general in nature, but adequate for land administration during the early years of project operation. Earlier master plans gave consideration to the forestry resource through a highly selective timber harvest program. Through the forest management program some consideration was given to indigenous types of wildlife by reserving den trees and mast-producing species.

Aside from, but in conjunction with, the project master plan, and under authority of the Fish and Wildlife Coordination Act, a general plan and cooperative agreement was consummated between the Corps of Engineers and the Bureau of Sports Fisheries and Wildlife. This

plan and agreement, prepared in the mid-50's and revised in 1961, gave administrative responsibility for fish and wildlife resources of the Upper Mississippi River to the Bureau.

Prior to the early 50's, collateral use of the project land and water was relatively limited and of a local nature. But by the late 50's it became obvious to administrators of the Corps and Bureau that actual use and demand for use of government land was rapidly increasing. The existing master plan and administrative procedures were found to be inadequate. New planning concepts, coupled with improved methods of presentation, were required to protect and use the resources, to assure compatibility of uses, and to meet increasing demands for use of lands and waters. Above all, a philosophy of planning was necessary that would give primary consideration to existing resources and secondary consideration to their use. The master plan reflecting this philosophy must be flexible but firm, detailed but simple, and, above all, practical and workable.

PREPARATION OF KEY MAPS

The revision of the master plan had to begin by preparing an updated base map clearly showing the land and water areas under government administration. As mapping proceeded, it was not surprising to find radical changes had occurred in water areas and land forms since inception of the project in 1930. With multiple use in mind and to assist in evaluating resources and resource use, man-made and other significant features were added to the base map. Therefore, in addition to having a base map for master planning, these updated maps provide a much-needed recreational map of the river. These recreational maps, or navigation charts are now available to the public.

In the revision of the master plan, two overlay sheets are used in conjunction with the base map. One overlay indicates the vegetative cover of government-owned land and is referred to as the "Forestry Overlay." The second overlay reflects zoned use of government land and is referred to as the "Land Use Overlay."

The first step in preparing the forestry overlay consists of making broad determination of vegetative cover, or in the case of forested area, crown cover. This is accomplished by careful study of aerial photographs, supplemented with spot-checks in the field. Three broad classifications, (1) dense or medium, (2) sparse, and (3) open are used to denote total vegetative cover and are presented on the overlay by use of topographic symbols (Fig. 1).

The second step in preparing the forestry overlay consists of developing broad associations of tree species and evaluating the understory by type and density. These associations were derived from field

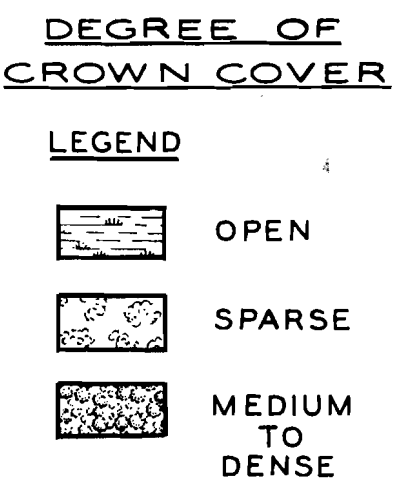


Figure 1. Topographic symbols used to denote degree of vegetative crown cover on the forestry overlay of the base map for the Upper Mississippi River master plan for resource protection and use.

observations and by using standard forestry techniques. The various associations are delineated on the overlay by a broken line and are identified in the management code with Roman numerals. Composition of understory is determined by field observations and is shown by a letter. Understory is broadly classified without individual species being identified. The density of the understory is rated as sparse, medium, or dense and is presented as a number. No attempt was made to evaluate or classify vegetative cover of open areas.

Above the symbols for timber association and type and density of understory, is a symbol to indicate basic management objective (Fig. 2). Broad classifications of management objectives have been developed for (1) timber, (2) wildlife, and (3) recreation. These classifications are broken down, as shown in Figure 3, to give better definition to management objectives. The narrative portion of the master plan will outline the management objectives. Acreage figures will be determined for each density of cover, timber association, and specific management objective.

The land-use overlay provides for the zoned use of each acre of government land and may have considerable significance in effecting wood duck habitat. The zoning classifications, shown in Figure 4, were developed jointly by the Corps and Bureau of Sport Fisheries and Wildlife.

An explanation of each zoning classification will be given in the narrative portion of the master plan. As can be seen in Figure 4,

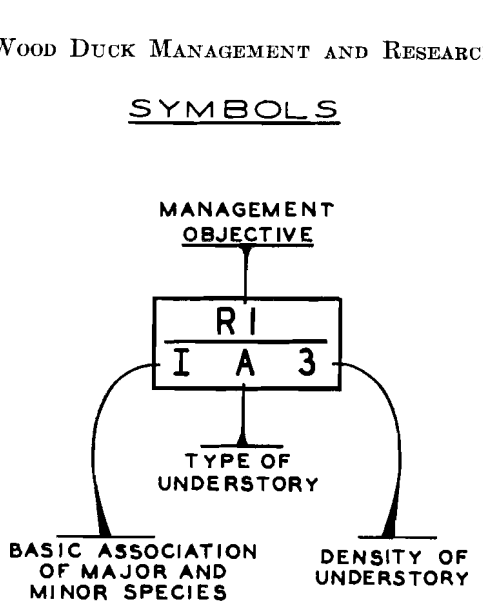


Figure 2. Arrangement of symbols used to denote management objective, timber association, and type and density of understory on the forestry overlay of the base map for the Upper Mississippi River master plan for resource protection and use.

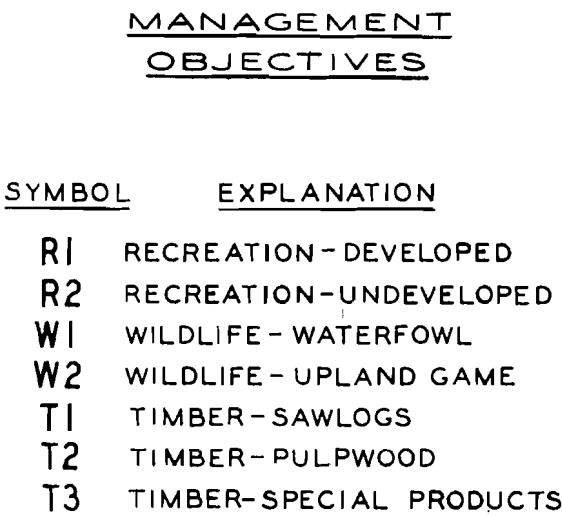


Figure 3. Key to symbols used to show management objectives on the forestry overlay of the base map for base map for the Upper Mississippi River master plan for resource protection and use.

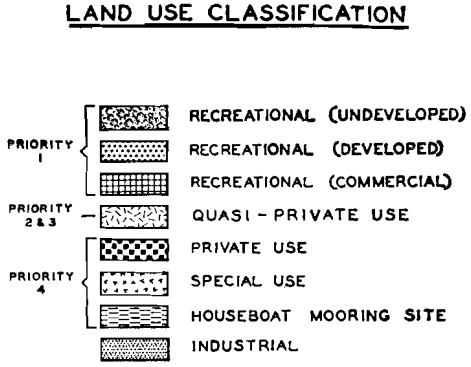


Figure 4. Key to symbols and priorities used to show zoned uses of land and water on the land-use overlay of the base map for the Upper Mississippi River master plan for resource protection and use.

categories are somewhat self-explanatory. For example, recreation-undeveloped means the area can be used for recreation, but without facilities. Recreation-developed allows for development of facilities. Commercial-recreation provides space for recreation concessions. Quasi-private areas are for group camping, etc. Private use authorization for controlled use of particular activities. Houseboat mooring areas are for long-term houseboat mooring. Industrial areas are for industrial developments, either existing or planned.

Admittedly, as each acre of land is zoned for a specific use, wood duck habitat may not be paramount in determining the use of a particular area. But the zoned use and the previously outlined forest management objectives are adjusted to provide compatibility between use and management.

Essentially, the inventory of forest resources, assignment of management objectives, and zoning for land uses are the heart of this master plan. While the development of the plan and administration of Corps lands are solely Corps responsibilities, full practical application of the plan can only be accomplished by coordination with other federal and non-federal agencies. In early stages of planning land use zoning, the Bureau, affected states, counties and other interested agencies are consulted and given an opportunity to express their views on the proposed zoned use of each acre of land. In forest management coordination is effected primarily with the Bureau, since the Corps retains administrative responsibility for all forest resources, even those under the authority of the General Plan mentioned earlier. No forestry management objective is assigned to forest cover on Bureau-owned lands. Only vegetative cover density is indicated on Bureau lands.

INFLUENCE ON WOOD DUCK HABITAT

As mentioned several times before, the wood duck or wood duck habitat were not the prime factors in developing zoned land use or forest-management objectives. But the woodie is a major wildlife species of the Upper Mississippi River. Therefore, its welfare received more than routine attention.

What does this master plan mean to the preservation and perpetuation of the wood duck on the Upper Mississippi River? The greatest value, now and in future years, is the coordinated agreement on the use and administration of lands. This should provide a firm line of defense against any proposed non-compatible use or administrative change detrimental to prime wood duck habitat. But perhaps a more immediate benefit will be in providing the action agencies with factual data needed to preserve or improve habitat. The Corps can only be an indirect action agency in habitat manipulation, but coordination with other agencies under this type of planning can produce extensive results. We believe that master planning will (1) provide a firm base for evaluating the total ecological complex, (2) help define quality and quantity of existing wood duck habitat, and (3) give knowledge of anticipated land use and provide guidance for *man made* changes to improve habitat.

This planning and zoning is comprehensive and valuable. But only when all agencies fully accept and implement the concepts and plans will habitat be improved and controlled. The Corps in many cases is not a direct action agency in habitat development. But cooperation can be extended within the scope of existing regulations, especially if needed cooperation falls within the approved master plan.

Aside from master planning of Corps lands, another facet of Corps activity, flood-plain information studies, has some bearing on wood duck habitat. The authority for such studies is granted in Section 206 of Public Law 86-645 (Flood Control Act of 1960). Under this authority the Corps compiles and disseminates information on floods and flood damages upon the request of responsible local governmental agencies.

Studies provide engineering data for use by local or state agencies in establishing flood-plain regulations. Enactment and enforcement of these regulations lie entirely with local governmental agencies. To date, in the Rock Island District, two such studies have been completed, three are being prepared, three are approved for study, and one application is being prepared. It is evident that these studies could have an effect on wood duck habitat through the flood-plain regulations that are suggested. But the greatest influence on existing wood duck habitat will be exerted by the flood-plain regulations that are enacted and enforced.

DISCUSSION
SESSION I

CHAIRMAN BELLROSE: The program covering Session I, existing and anticipated status of natural wood duck habitat, is now open for discussion.

H. G. SMITH (*Soil Conservation Service, Field Biologist in Ohio*): There are a great many ponds being installed in Ohio and throughout the nation. Landowners all over the wood duck's range are adding ponds as part of the soil and water conservation program. In Ohio, since 1942, we have assisted landowners in installing about 23,000 ponds. Many of these ponds provide more habitat for wood ducks and other waterfowl.

The Southeast Sportsmen's Club in Franklin County, Ohio, near Columbus, has had a project of putting up wood duck boxes on many ponds on surrounding farms. They also have a natural 13-acre lake where they have put up many boxes. There has been some fabulous use of the approximately 100 boxes in this area. In fact, they are getting about 65 percent use of the wood duck boxes that are erected on their lake. On farm ponds the percentage of use was about 50 percent.

"Peak" production of wood ducks is just like "peak" production of corn in Mississippi where one farm boy raised 300 bushels per acre. On one farm pond, a third of an acre in size, all of three wood duck boxes were used. A total of 60-65 eggs were laid, and hatched. Now if you project that on an acre basis, it would figure out to nearly 200 wood ducks per acre. Well, this is peak production, like that 300 bushel an acre corn yield down in Mississippi. But, it shows that there is an upper level of production that we can try to reach. The average for the entire project was 20 ducks hatched per acre of water. Twenty-three acres of water in 18 ponds (40) acres and a large (13 acres) comprised the project. These farm ponds are useful habitat for producing a lot of wood ducks in a limited area, specially when they're near a woodland.

CHAIRMAN BELLROSE: Thank you very much sir. Any other comments?

R. A. HUNT (*Wisconsin Conservation Department*): I'd like to ask Don Hankla if he could distinguish between the impact of land-use changes on breeding habitat in the South and on winter range? I'm not familiar with the amount of each type of habitat and if this impact is on both types or just one.

D. J. HANKLA (*Bureau of Sport Fisheries and Wildlife*): I really don't have any figures on that point. The impact is on both wintering and rearing habitat, but probably more on rearing habitat.

CHAIRMAN BELLROSE: Based on my experience in flying over the Mississippi Delta at low altitude during the last ten years, I have to agree with Don that there's a tremendous destruction of wood duck habitat going on in the South. Soybean fields have replaced bottomland forests in an increasing number of cases. The financial return on soybeans has encouraged farmers to drain and clear land. On some parts of the Mississipi Delta you'll see some fine bottomland ponds and lakes surrounded by just a very few trees. Agricultural land extends to the very edge of the water. Under these conditions, there must be a shortage of natural nesting sites for wood ducks. Perhaps wood duck houses should be added in such places to alleviate some of the damage that is being done by continual destruction of bottomland woods.

Just recently the Obion River in Tennessee was ditched and drained. This was a beautiful spot for wood ducks and mallards. Now it has lost over 90 percent of its value for breeding wood ducks. So, certainly in the South we can't be very happy about the future of the habitat for wood ducks.

Your next Chairman is Dr. John P. Rogers of the Gaylord Memorial Laboratory, which is located near Puxico, Missouri. Dr. Rogers is well acquainted with the wood duck in Massachusetts, where he studied for several years before attending the University of Missouri. While at the University of Missouri, he studied the lesser scaup in the Great Plains for a number of years. He is now back in wood duck habitat once again. Chairman Rogers.

SESSION II

Wednesday, December 8

Chairman: J. P. ROGERS
Gaylord Memorial Laboratory, Puxico, Missouri

INVENTORYING WOOD DUCK HABITAT—EXPERIENCES AND NEEDS

PROBLEMS IN FLYWAY-WIDE APPRAISAL OF WOOD DUCK HABITAT

A. S. HAWKINS AND C. E. ADDY
Bureau of Sport Fisheries and Wildlife, Minneapolis, Minnesota; and Laurel, Maryland

Appraising wood duck habitat for an entire flyway has many pitfalls, some of which are discussed in this paper. These complications were impressed on us some time ago when we attempted to determine the amount of production habitat in the Atlantic and Mississippi Flyways. For this purpose, reports were studied from three surveys of nationwide scope: the wetland survey of the United States, the national inventory of soil and water conservation needs, and the survey of timber trends in the nation. The final compilation in each case was based on detailed reports by states and counties. Those pertaining to the two flyways were reviewed. Much of the available information is condensed in *Outdoor Recreation Resources Review Commission* (ORRRC) *Report No. 7* (U. S. Dept. Interior, 1962) and the book *Waterfowl Tomorrow* (U. S. Dept. Interior, 1964). Even with the help of these excellent sources of information, we were unable to determine the amount or status of wood duck habitat in the two flyways, except within very broad limits.

PRESENT KNOWLEDGE OF EXTENT OF HABITAT

The amount of wood duck habitat is summarized in *Waterfowl Tomorrow*. Deficiencies in available information are indicated by statements such as the following (p. 93): "The Mississippi River with its tributaries is breeding range for wood ducks. Wetland surveys show from 1,250,000 to 1,750,000 acres of overflow bottomland

hardwoods, swamps, streams, ponds, and small lakes—ideal nesting, feeding, and rearing areas for wood ducks. *Thousands of miles of uninventoried small streams* add niches suitable for breeding woodies." (Italics are ours.)

Another chapter in *Waterfowl Tomorrow* contains this statement (p. 100): ". . . 20 million acres of seasonally flooded woodland, 14 million acres of wooded swamp, and 1 million acres of flooded brushland from Virginia to eastern Texas had value for webfoot Beau Brummel. Thirty-five million acres or habitat is a lot. Already, however, much has been eliminated through drainage and leveeing along rivers and streams. Nest trees may remain, but water for rearing, feeding, and nesting usually is eliminated or reduced and quality impaired."

These two quotations suggest that, while some figures are available on the amount of wood duck habitat in the two eastern flyways, they are incomplete, constantly changing, and in some cases irrevelant. For example, nest sites may be available but lack supporting brood habitat nearby.

Wetlands of the United States (Shaw and Fredine, 1956) contains the best information available on the acreage of each wetland habitat type. However, in some parts of the two flyways, wetlands under 40 acres in size were ignored. Thousands of miles of streams also were excluded. Thus, some of the best wood duck production habitat was omitted from this survey. The classification system used has certain limitations, too. For example, seasonally flooded areas (Type 1) in the pothole country are quite different from the same type in the South and have an entirely different value to wood ducks. A finer breakdown of shrub and tree swamps (Types 6 and 7) would provide a more accurate figure on actual wood duck habitat.

The national inventory of soil and water conservation needs, conducted by the Department of Agriculture, summarizes the data by soil capability units. Some of these units contain poorly drained soils which may support wood duck habitat. However, there is no way to sort out poorly drained areas which provide duck habitat from those which do not.

Wood ducks, more than any other species, are closely associated with timber. Hence, it is appropriate to consult the various timber resources surveys for possible help in delineating wood duck habitat. Included in this survey, which is conducted at 10-year intervals as prescribed in the McSweeney-McNary Forest Research Act of 1928, are categories identified as "lowland brush" and "non forest" (including water). But it is impossible to select from these reports figures which can be classed without doubt as wood duck habitat.

Coming closer to what is needed for a complete appraisal of wood duck habitat is the *Illinois Surface Water Inventory* (Lopinot, 1964). This report lists the surface water areas in such detail that they can be regrouped in various useful ways, but unfortunately the wetlands were not classified by type. Other states, including New Hampshire, New York, Wisconsin, and Indiana, have conducted similar detailed surveys or have published reports on their lakes and streams.

Information presented in *ORRRC Report No. 7* gives a graphic presentation of the distribution of water bodies and streams, but is too general for making detailed evaluations of specific habitat needs.

Using these several sources of information, separately or collectively, permitted a wide range of estimates concerning the amount of wood duck production habitat in the two flyways. From the information developed for the Atlantic Flyway we estimated there are close to 4 million acres of significant breeding habitat in the Flyway, but probably not more than a tenth of the 4 million acres could be considered as high-value production habitat. These 4 million acres represent the principal breeding habitat. The other 25 million or more acres of low and negligible-value habitat may or may not produce wood ducks.

Information summarized for the Mississippi Flyway was equally difficult to interpret. Depending on the method used, the Flyway's production habitat varied from 3.2 to 7.5 million acres. Actually, an even greater acreage than the high figure may be involved to some extent in production when the contribution made by large lakes and streams is included. On the other hand, even the low figure may be too high if quality habitat alone is considered. The conclusion was that at the present time we are unable to properly evaluate wood duck production habitat because it has two dimensions. Quantity and quality yardsticks to measure the performance of most kinds of habitat are lacking; hence our dilemma.

HABITAT INVENTORY PROBLEMS

These statements are reflections of the obvious, namely that wood duck habitat is difficult to define and delineate. Wood ducks commonly nest in upland timber, as much as a mile from the nearest water, as well as in forested bottomlands. They even nest quite successfully in cities and may choose nesting boxes provided for them where natural cavities are unavailable. As many as 10 nests per acre have been recorded within the city limits of Burlington, Iowa, where artificial nesting boxes have been erected.

After the nesting season the birds may scatter widely during the day through many acres of swampland or streamside habitat and

then concentrate in high densities on feeding grounds or at their night roosts. Sometimes they feed in grainfields almost as freely as mallards do.

Added to the problem of habitat delineation is the ephemeral nature of the seasonal flooded wetlands (Type 1) which form much of the wood duck habitat. By definition, Type 1 wetland is "soil covered with water or waterlogged during variable seasonal periods; usually well drained during much of the growing season. Along river courses, flooding ordinarily occurs in late fall, winter, or spring." In 1954 this type occupied nearly 20 million acres in the two eastern flyways (Shaw and Fredine, 1956).

This prime habitat is extremely vulnerable to encroachment by agriculture and is being reduced permanently at an alarming rate, but the amount lost since 1954 is unknown. Wood ducks use seasonally flooded wetlands whenever and wherever they are available for production,migration, and wintering. But qualitative yardsticks are lacking to permit a numerical expression of what the loss of a given acreage means to the wood duck population.

Likewise, the gross inventory figure for shrub swamps (Type 6) and wooded swamps (Type 7) are of limited value because they are not supported by performance figures which show the extent to which these types are used by wood ducks in various parts of their range. These two types together occupied about 20.5 million acres in the Atlantic and Mississippi Flyways during the early 1950's, according to the national wetland survey. Forestry practices in the vicinity of these swampland types modify their value to wood ducks. This is another reason why gross acreage figures which ignore habitat quality may be misleading.

MAN'S INFLUENCE ON HABITAT

Man's insistence in modifying the landscape is affecting wood duck habitat and our ability to determine its status. Programs of many agencies, both local and national, affect wood duck habitat. The acquisition and development programs of the Bureau of Sport Fisheries and Wildlife and State Fish and Game Departments are aimed at preserving and improving habitats for waterfowl, including wood ducks. The efforts of these agencies, however, are small compared to the scope of land and water management programs under the direction of the Department of Agriculture and the Corps of Engineers. Projects carried out by these two agencies often directly affect waterfowl and waterfowl habitat in a major way, sometimes beneficially, but more often detrimentally. Habitat losses associated with these activi-

ties are in addition to those occurring with increasing highway, industrial, and home construction.

Of programs of the Department of Agriculture, the Small Watershed Program (Public Law 566) is of tremendous scope and will have far-reaching effects on wood duck habitat. Within the two eastern flyways there are thousands of small watersheds which could and very likely will come under this program. As of November 1, 1965, there were 1,475 small watershed applications encompassing nearly 86 million acres. Of these, 711 already have been approved for planning assistance, and 454 have been approved for construction in the two flyways.

To date the effect of the Small Watershed Program on wood duck habitat has varied considerably. Generally speaking most projects in the Northeast appear to have had little or no detrimental effects. In fact, a number of projects have included features which have improved habitat conditions.

In the northern end of the Mississippi Flyway, both flood control projects of the Corps and watershed projects employ channelization and drainage. These practices usually destroy valuable wood duck habitat. On the other hand, some impoundment projects probably improve conditions for wood ducks. Over-all, we believe habitat losses due to these programs exceed gains, but to what extent is unknown.

In the southern end of the two Flyways, however, the situation is decidedly on the minus side of the ledger. Here the extensive swamps and bottomlands, which constitute the bulk of the wood duck breeding, migration, and wintering habitats of the Southeast, are particularly vulnerable and are being lost.

PERIODIC HABITAT INVENTORY NEEDED

Knowing that wood ducks utilize various habitat types totaling many million acres may give us a false sense of security. We must consider the fact that major habitat losses are occurring and could continue to occur in the future as various agricultural and water development programs proceed. It behooves us, therefore, to obtain the information needed to monitor, on a continuing basis, the status of habitats and wood duck populations. But how can this be done in light of the many problems discussed above?

A starting point in such an analysis is to recognize that the present amount of habitat is at least sufficient for the present wood duck population level. How many wood ducks are involved? According to estimates of the Migratory Bird Populations Station (Administrative Report No. 86), the pre-hunting season population of wood ducks in the Atlantic and Mississippi Flyways between 1962 and 1964 aver-

aged about 2.5 million. During these years hunters of these flyways, with a daily bag limit of two, harvested an average of 393,000 woodies per year. Age ratio for these years indicated good production.

How much habitat is required by 2.5 million wood ducks? We have already pointed out why this question cannot be answered, but have stated that Types 1, 6, and 7 wetlands receive the greatest amount of wood duck use. Perhaps these three types can be used most conveniently as a base from which to measure trends in the status of wood duck habitat. Ten years ago this habitat base totaled about 40 million acres in the stateside portions of the Atlantic and Mississippi Flyways. Additional habitat was available in eastern Canada, but the amount then or now is unknown. Neither do we know how much change has occurred south of the international border since the mid-fifties, but we suspect the total habitat has been reduced considerably.

Whether or not further expansion of wood duck numbers is limited by the amount of habitat available is unknown. There may be a surplus of habitat serving the birds for one function, such as nesting, but a developing shortage of habitat for another purpose such as brood rearing. Sooner or later additional inroads on production, migration, or wintering habitat could determine the number of birds which a flyway can accommodate. This could happen without anyone knowing it, unless a system is developed for (1) measuring trends in wood duck habitat and (2) establishing standards for evaluating the effects of these changes on the birds' welfare.

A full-fledged inventory of wood duck habitat is difficult, expensive, and even prohibitive on budgets provided for waterfowl investigations. But surveys already being conducted periodically to establish soil and water conservation needs and timber trends in the United States may provide an opportunity for inventorying wood duck habitat without much additional cost. To accomplish this, however, would require that the Department of Agriculture collect and record the data so that Types 1, 6, and 7 could be identified and separated from other land and forest types.

In addition to the complete periodic inventories, a uniform system of cataloging gains and losses of wood duck habitat should be developed as a project within both the Atlantic and Mississippi Flyways. A card system adapted to machine processing is recommended. Each habitat unit gained or lost should be rated according to qualitative yardsticks which need to be developed.

The principal reason why habitat types have seldom been rated on wood duck use is the difficulty in censusing the birds. The magnitude of this visibility problem is illustrated by midwinter population data. In recent years, census takers have tallied an average of 50,000

wood ducks in the two flyways. On the basis of a post-hunting season population of 2 million, only about one wood duck in 40 is seen. Hunters bagged almost eight times as many as were seen during the inventory. In fact the visibility rate is so low that the Bureau's Regional Office in Atlanta included the following statement in its January, 1964 Midwinter Survey Report: "You will note wood ducks have not been included in our summary of waterfowl populations for this region. The reason for this is that wood ducks observed in duck surveys never in any way reflect the true numbers present." This visibility problem makes it extremely difficult to assess duck use in different habitat types. Various approaches to surmount this obstacle will be considered at this symposium, and we are hopeful that a solution to this important problem will be found.

SUMMARY

We reviewed some of the problems associated with a flyway-wide appraisal of wood duck habitat. We conclude that existing data are inadequate for determining with much precision the quantitative dimensions of the production, migration, and wintering habitat of these birds. We believe this lack of data is likely to continue unless an approach is developed for monitoring the status of wood duck habitat through the periodic national soil and water or timber inventories. We are starting with a base of various habitat types totaling several million acres.

At present this habitat accommodates a fall flight of at least 2.5 million wood ducks. Land and water developments are rapidly reducing the prime habitat. Unless we can document the quantity and significance of the habitat losses, we are poorly prepared to advance proper stewardship of this important resource.

LITERATURE CITED

Lopinot, A. C.
1964. Illinois surface water inventory. Spec. Fisheries Rept. No. 1, Ill. Dept. of Conserv., Springfield.

Shaw, S. P., and C. G. Fredine
1956. Wetlands of the United States: their extent and their value to waterfowl and other wildlife. U. S. Fish and Wildl. Serv., Circ. No. 39. 67 p.

U. S. Department of Agriculture
1965. Timber trends in the United States. U. S. Forest Serv., Forest Resource Rept. No. 17. 235 p.

U. S. Department of the Interior
1962. Sport fishing—today and tomorrow. U. S. Govt. Printing Offict, Outdoor Recreation Resources Review Comm. Study Rept. No. 7. 127 p.

1964. Waterfowl tomorrow. U. S. Bureau of Sport Fisheries and Wildl., U. S. Govt. Printing Office. 770 p.

A PLAN FOR INVENTORYING AND DEVELOPING WETLAND HABITAT ON PUBLIC LANDS

J. MATHISEN

U. S. Department of Agriculture, Chippewa National Forest, Cass Lake, Minnesota

The purpose of this paper is to describe an approach to waterfowl habitat management on the Chippewa National Forest in north central Minnesota. The two basic ingredients are (1) an intensive inventory and evaluation of wetland habitat on the Forest, and (2) a plan of action for the development of the wetlands, based on the inventory data.

The Forest occupies a land area of about 1½ million acres, with about 642,000 acres under national forest control and management. The remaining lands are primarily under state, county and private ownership. The material described in this paper refers only to national forest lands.

The Chippewa Forest occupies an important position in the Mississippi Flyway. The Forest is characterized by a great variety and abundance of lakes and wetlands and is immediately adjacent to the prairie pothole region. The Multiple Use Act of 1960 has given increased emphasis to management of wildlife habitat on the national forests. It is clear that waterfowl habitat should be given high priority consideration on the Chippewa.

Basic information was needed on wetlands in the Chippewa Forest to identify opportunities for habitat development, to plan a habitat-improvement program, and to estimate benefits associated with the work. To supply information on these needs, assistance of many agencies and individuals was obtained in planning and organizing the efforts reported on here. The Bureau of Sport Fisheries and Wildlife, the Wildlife Management Institute, and the Minnesota Department of Conservation worked cooperatively with the U. S. Forest Service in all phases of the project.

THE INVENTORY

Inventory is a key word in resource management. Projects, plans, and long-range program direction are best accomplished if based on an inventory reflecting existing and potential resource values. Inventory is an essential tool for multiple use, being a requisite for effective integration of resource management.

Wetland inventories of various intensities and magnitude have been accomplished throughout the country by state and federal agencies. Most of these have had the primary objective of showing losses of wetlands through drainage (Jahn and Kabat, 1955) and locating

sites and areas for wetland preservation and acquisition (Rose and Morgan, 1964; Mann, 1964).

The wetlands under consideration here are already publicly owned, and they will be managed for the greatest public benefit. Thus, a unique characteristic of this inventory is immediately evident. Preservation and acquisition are not paramount. Establishing the development potential is the key objective.

Basic Wetland Types

The wetland classification system of the U. S. Fish and Wildlife Service was utilized (Shaw and Fredine, 1956). This system includes eight types in the fresh-water marsh category. Seven of these were considered on the Chippewa. Type 1 wetlands (seasonally flooded basins) were not inventoried due to the difficulty of locating them on aerial photos in a wooded area. In addition to the basic wetlands, lakes and streams were included. The separation of Type 5 wetlands (open water) from lakes was arbitrarily set at 10 acres. An open water area 11 acres or more in size was classed as a lake.

Lakes are important to waterfowl on the Chippewa, and they presented a special problem. It would not be logical to assign the total acreage of a lake as waterfowl production habitat. That portion of a lake considered to be important to a breeding duck was designated as a one-eighth mile strip along the shoreline. Thus, each mile of shoreline will provide 80 acres of duck production habitat.

Methods and Procedures

Working tools consisted of 1959 aerial photos showing government ownership and timber types, the timber-management inventory which outlined and measured the shrub swamps and timbered swamps, and the National Forest Recreation Survey, which provided lake and stream inventory data. The basic inventory units were townships and Ranger Districts.

Each photo was examined and all wetlands, 2 acres or more in size, on national forest lands were classified, measured and recorded. In cases where a definite type could not be determined by photo interpretation, the wetland was field-checked. A general appraisal of typing accuracy was also accomplished in the field. A permanent acetate overlay was made of each photo showing wetland number, size and type. Wetlands were numbered consecutively on each Ranger District.

Potential impoundment sites, beaver dams and other areas that showed particular promise for development were recorded at the time of photo examination. Tracts of non-government land considered

important for management were recorded for possible acquisition.

Breeding pair counts were also taken during the field-checking phase of the inventory. Data recorded for each observation included wetland type, size and location, and waterfowl occupying the wetland. The data collected showed (1) intensity of use on various habitat types, (2) general magnitude of the breeding waterfowl population and (3) species composition of waterfowl utilizing the Forest. Mathisen (1966) reported in detail on this aspect of the inventory. Knowledge of population characteristics is essential for a development plan, since habitat requirements vary with the species.

Results

The inventory showed there are 154,141 acres of wetland on the Forest, or 24.0 percent of the land area. The composition of wetland types and other statistics are presented in Table 1. Lake and stream data are presented in Table 2.

In order to place the data in a more functional form, the wetlands were divided into two categories of production habitat: primary and secondary.

Primary habitat are those wetlands normally containing surface water, and are productive in their present condition. This includes Type 3, 4, and 5 wetlands, the peripheral zone of lakes, and streams.

Secondary habitat are those wetlands containing little or no surface water. This includes Types 2, 6 and 8. A summary of acreages in this classification is presented in Table 3. The remaining acres of Type 7 (wooded swamp) are of minor significance, except that much of the temporary run-off waters occur in this type and it is important habitat for mallards and wood ducks in certain years.

Approximately 55 percent of the 121,579 acres of wetlands are essentially unproductive of waterfowl due to lack of surface water. About 42 percent, mostly lakeshore, is suitable as brood-rearing habitat in most years when emergent vegetation is present. Rapid development of shoreline for recreation purposes, increased boating activities, and general disturbance are affecting the suitability of this habitat for duck production.

Since the basic inventory data were available on a township basis, the Forest was zoned to indicate where the greatest development potential is located. Secondary production habitat is the primary target of habitat improvement. The overlays giving wetland locations and types show precisely where development sites are located. Development activities can be intelligently planned by the land manager using the inventory data as a tool.

TABLE 1. COMPOSITION OF WETLANDS ON THE CHIPPEWA NATIONAL FOREST, USING CLASSIFICATION SYSTEM OF SHAW AND FREDINE (1956).

Ranger District	Type 2 Sedge Meadow		Type 3 Shallow Marsh		Type 4 Deep Marsh		Type 5 Open Water	
	No.	Acres	No.	Acres	No.	Acres	No.	Acres
Bena	330	8597	40	517	7	55	8	38
Blackduck	136	1310	17	115	17	121	24	117
Cass Lake	201	2315	39	288	11	84	10	43
Cut Foot Sioux	121	2439	61	1308	19	200	21	95
Dora Lake	96	1597	15	168	18	188	28	138
Marcell	219	1855	40	249	55	461	80	316
Remer	227	2696	62	558	20	1361	27	111
Walker	344	3191	93	839	79	556	77	351
Total	1,675	23,982	373	4,042	226	3,026	275	1,209
Percent		32.2		5.4		4.0		1.6
Average Size		14.3		10.8		13.4		4.4

Ranger District	Type 6 Shrub Swamp		Type 8 Bog		Total[8]		Type 7 Wooded Swamp
	No.	Acres	No.	Acres	No.	Acres	Acres
Bena	305	5,340	18	377	714	15,014	10,339
Blackduck	352	4,188	40	753	586	6,604	10,216
Cass Lake	329	3,028	30	244	621	6,002	3,921
Cut Foot Sioux	300	3,240	15	187	537	7,468	13,362
Dora Lake	437	7,000	14	241	608	9,314	14,453
Marcell	374	4,488	78	833	846	8,202	11,839
Remer	688	8,874	64	1,313	1,088	14,913	13,556
Walker	261	1,775	48	303	902	7,015	1,992
Total	3,046	38,023	307	4,251	5,902	74,533	79,608
Percent		51.0		5.8		100.0	
Average Size		12.5		13.8		12.6	

[8] Wooded swamp not included.

The inventory provided essential information on wetlands and waterfowl. The next step was to apply the data to a development plan.

THE DEVELOPMENT PLAN

The development plan is a direct result of the inventory and consists of seven basic parts:

1. The Inventory. A brief description of the methods employed in gathering data.

TABLE 2. LAKE AND STREAM DATA AND COMPUTED WATERFOWL PRODUCTION HABITAT, CHIPPEWA NATIONAL FOREST

Ranger District	Bena	Black-duck	Cass Lake	Cut Foot	Dora Lake	Marcell	Remer	Walker	Tota
Number Lakes	28	122	87	122	109	377	121	270	121
Acreage of Lakes	55,238	11,542	67,871	42,947	8,566	34,606	15,678	96,165	332,51
N. F. Shoreline Miles	38	38	79	107	24	158	53	73	57
Number Streams	10	18	9	33	22	35	32	8	15
N. F. Stream Miles	18	24	16	38	60	26	51	8	24
Production Habitat-Lakes*	3,040	3,040	6,320	8,560	1,920	12,640	4,240	5,840	45,60
Production Habitat-Streams**	107	144	132	228	360	155	306	48	1,44

* 1/8 mile strip, regardless of type of shoreline; values are listed in acres.
** Average stream width estimated at 50 ft.; values are listed in acres.

TABLE 3. THE EXTENT OF PRIMARY AND SECONDARY WATERFOWL PRODUCTION HABITAT ON THE CHIPPEWA NATIONAL FOREST. ALL UNITS GIVEN IN ACRES. PRIMARY PRODUCTION HABITAT.

Shallow Marsh (3)	Deep Marsh (4)	Open Water (5)	Lake Shore	Streams	Total
4,042	3,026	1,209	45,600	1,446	55,323

SECONDARY PRODUCTION HABITAT

Sedge Meadow (2)	Shrub Swamp (6)	Bog (8)	Total
23,982	38,023	4,251	66,256 acres

( ) Refers to wetland type numerical designation.

2. The Wetland Resource. A summary of the inventory data and statistics.
3. The Waterfowl Resource. An analysis of the population as it presently exists.
4. Improving Wetland Habitat. The approaches and techniques available for wetland development.
5. Development Potential. Criteria, acres available for each type of development and cost estimates.
6. Calculated Response. Potential breeding pairs which the additional habitat will accommodate.
7. Summary. Justification and benefits in terms of estimated economic returns and related resource values.

Improving Wetland Habitat

Our first step was to look at the various techniques available for wetland habitat improvement on the Chippewa Forest. Based on our own experience and the experience of others, we assembled the best cost data available.

The major objective is to convert secondary habitat to primary habitat by making surface water available to waterfowl. This is accomplished by the construction of low-head dams and removing dense stands of emergent vegetation by blasting and burning. The blasting technique, as described by Mathisen, Radtke and Byelich (1964), is especially appropriate on the Forest, with about 24,000 acres suitable for this type of development.

Nesting boxes for goldeneyes and wood ducks were considered since

both of these species are important breeders on the Chippewa. The response of goldeneyes to nesting boxes is well documented in this area by the studies of Johnson (1962).

Nesting islands and platforms, although somewhat experimental in nature, show a great deal of promise. The ring-necked duck is an important breeder on the Forest, and sedge islands are favored nesting sites (Mendall, 1958:103).

Development Criteria

To properly estimate wetland development potential it was first necessary to establish standards or criteria for each type of improvement, based on the best available information.

The numbers and acres of impoundments were based on known potential sites. The average cost per acre for construction is about $55, except for large areas where per acre costs are usually reduced.

Blasting could potentially be used on all Type 2 (sedge meadow) acreage, less that which could be flooded by impoundments. In addition, 20 percent of the Type 6 (shrub swamp) acreage was considered suitable for the blasting technique. One 15 x 35 foot hole per acre, at a cost of $16, was considered sufficient.

The potential for nesting box development was determined by assuming every two acres of Type 4 and 5 wetlands (including acres produced by impoundments) would accommodate one box, and each mile of lake and stream shoreline would accommodate five boxes. Cost per box is $10.00.

Approximately 50 percent of the Type 6 (shrub swamp) acreage was considered suitable for burning, at $15 per acre.

There was an estimated potential of 1,000 floating nesting islands at $10 each, and 500 experimental nesting platforms at $25 each.

Overhead cost was estimated at 20 percent of the project cost.

Development Potential

Applying the above cost estimates to the inventory data resulted in an estimate of wetland development potential on the Forest and on individual Ranger Districts. The estimate shows what is required in terms of dollars to improve duck production on the acres available for improvement.

There are 50,000 acres of wetland on the Chippewa Forest that can be improved with known techniques. This is roughly 76 percent of the 66,256 acres of secondary habitat presently producing little or nothing in the way of aquatic wildlife. The over-all development cost of such a program is $27 per acre, or a total of $1.3 million.

We have brought together the inventory and development phases of the problem. Now the big question remaining—is it worth it?

Calculated Response of Waterfowl

If the improvements were provided as outlined, what would be the response of waterfowl? How many additional ducks would the Chippewa Forest accommodate as a result of habitat improvements? This can be estimated by applying the average density of breeding pairs observed on existing wetlands and development sites to the additional acres and units provided by management. The expected intensity of use resulting from practices applied directly to wetlands is shown in Table 4.

TABLE 4. EXPECTED YEARLY WATERFOWL BENEFITS FROM WETLAND DEVELOPMENTS ON THE CHIPPEWA NATIONAL FOREST, MINNESOTA.

Type of Development	Expected Annual Duck Use	Acres To Be Improved	No. Breeding Pairs of Ducks At Different Occupancy Levels		
			50%	70%	100%
Blasting	1 pair/pothole	23,700	11,800	16,600	23,700
Impoundment	47 prs./100 acres	7,500	1,700	2,500	3,500
Burning	47 prs./100 acres	18,800	4,400	6,200	8,800
TOTAL		50,000	17,900	25,300	36,000
TOTAL DUCKLING YIELD*			53,700	76,000	108,000

* Based on 50 percent of the pairs producing young and an average brood of 6 at flight stage in fall.

The proposed habitat improvements could accommodate additional breeding pairs of waterfowl at various levels of occupancy. The rate of occupancy will vary with over-all status of Flyway waterfowl populations, water conditions within the Forest and on the nearby prairies, and other factors. About 50 percent of the wetlands containing surface water were occupied in 1965. Duckling yield is based on 50 percent nesting success and an average brood of six at flight stage in early fall.

In addition to the above response, nesting success and breeding pair density will be increased by means of nesting boxes, islands and platforms. The magnitude of this response is difficult to predict since an increase in nesting success is involved. The estimated returns from this type habitat improvement are shown in Table 5.

In evaluating and justifying this type of development program it is interesting to look at some dollar figures. The present wetland acquisition program of the Department of Interior is designed to pre-

TABLE 5. EXPECTED YEARLY WATERFOWL BENEFITS FROM HABITAT IMPROVEMENTS ON THE CHIPPEWA NATIONAL FOREST, MINNESOTA.

Type of Development	Expected Occupancy By Duck Pairs	Units To Be Added	No. Breeding Pairs Accommodated
Am. goldeneye houses	70%	5,000	3,500
Wood duck houses	25%	5,000	1,200
Nesting islands	50%	1,500	750
TOTAL			5,450
TOTAL DUCKLING YIELD*			16,350

* Based on 50 percent of the pairs producing young and an average brood of 6 at flight stage in fall.

serve existing habitat and is costing an average of $55 per acre in Minnesota. The cost of $27 an acre for development of government-owned lands is therefore easily justified, especially since development is creating habitat, while acquisition is simply preserving that which already exists.

Acquisition and development of wetlands under other Federal programs are requiring an investment of about $100 per acre. This value applied to the wetlands under consideration here would amount to $5,000,000.

What is the annual value of the ducks produced? Although the dollar value of a duck is difficult to determine in terms of what a hunter is willing to pay, an estimate can be applied on the basis of the average cost of a duck at a shooting preserve. This might be considered "market value." The average cost of a shooting preserve duck is $5 (Benson and Perry, 1965). This means the potential annual value of waterfowl resulting from habitat improvement would be between $358,500 and $631,500.

Other Values

Although primary emphasis is on waterfowl, there are many other benefits associated with wetland development that should be considered. The value of wild rice as a cash crop, for instance, may well exceed $30,000 annually on parts of the impoundments. Increased fish production (especially northern pike), fur animal harvest, flood control and fire control are all benefits that are difficult to express in monetary terms. Then there are the intangible benefits associated with wildlife of all kinds, and the aesthetics that defy measurement.

SUMMARY

A graphic summary of this paper is presented in Figure 1. The orderly progression of interrelated information is shown as a series of

Figure 1. Steps involved in the comprehensive planning of a habitat management program.

building blocks. The foundation is inventory with the building blocks of techniques, criteria, development potential and justification culminating in the action required to accomplish the objective.

The Chippewa National Forest could well become a model or demonstration of wetland habitat development on public lands if the action phase is initiated. Such a program is supported by the Multiple Use Act of 1960, and is within established policy and over-all mission of the U. S. Forest Service.

LITERATURE CITED

Benson D., and R. F. Perry
1965. An acre of marsh is worth . . . The Conservationist (New York). June-July: 30-33.
Jahn, L. R., and C. Kabat
1955. A survey of Wisconsin's remaining wetlands, with comments on their preservation. Paper presented at 17th Midwest Wild. Conf. 12 p. (mimeo.)
Johnson, L.
1962. A study of the go'deneye and other forest nesting species. *In* Minn. Dept. of Conserv. P-R Quart. Progress Rept. 22(2): 197-233.
Mann, G. E.
1964. Improved techniques for aerial wetland surveys. J. Wildl. Mgmt. 28(3): 576-580.
Mathisen, J. E.
1966. The breeding population of waterfowl on the Chippewa National Forest. The Loon. 38(1).
Mathisen, J. E., R. E. Radtke and J. Byelich
1964. The use of ammonium nitrate for marsh blasting. Trans. N. Amer. Wildl. and Nat. Resources Conf. 29: 143-150.
Mendall, H. L.
1958. The ring-necked duck in the northeast. Univ. of Maine Bull. 60(16): 1-317.
Rose, B. J., and H. R. Morgan
1964. A priority rating system for Canadian wetlands preservation. Trans. N. Amer. Wildl. and Nat. Resources Conf. 29: 143-150.
Shaw, S. P., and C. G. Fredine
1956. Wetlands of the United States: their extent and value to waterfowl and other wildlife. U. S. Fish and Wildl. Serv., Circ. No. 39. 67 p.

DISCUSSION
SESSION II

CHAIRMAN ROGERS: We now have a few minutes that can be devoted to questions on material presented in this session

L. R. JAHN (*Wildlife Management Institute*): I have two questions concerning broad inventories of wood duck habitat. Was the forest inventory, which is con-

ducted at periodic intervals, considered in detail as a source of information on wood duck habitat? Were specific suggestions developed on how to incorporate particular definitions and classifications of wood duck habitat into that inventory? These are important points of detail required to develop practical approaches that I hope we're going to end up with.

A. S. HAWKINS: We hope answers to these important questions will be promoted by this meeting. We made only general recommendations for certain types of habitat in our report.

R. A. HUNT (*Wisconsin Conservation Department*): Art Hawkins, do you know of any studies where a determination has been made of the cavities per mile of stream or per acre of lowland habitat? Just acres of bottomland habitat do not indicate capacities to accommodate wood ducks now or in the future.

A. S. HAWKINS: I'm going to farm that question out to Frank Bellrose. I know that Illinois has made studies of this type.

F. C. BELLROSE: We have made canvasses through upland and bottomland woods. The unfortunate problem is that the bottomland in Illinois is not typical of the bottomland in the Mississippi Delta. In Illinois we found one cavity per 5 acres of black oak woodlot and about one cavity for 64 acres of bottomland forest. This survey of upland woods was made annually over a seven-year period. We always came up with about the same number of cavities, even though old cavities were lost through wind throw and other destructive agencies. New cavities also appeared; therefore, over a period of time the number of acres per cavity remained about the same.

CHAIRMAN ROGERS: We have a study on wood ducks in the Mingo Swamp in Missouri. The student on this investigation is Wayne Weier, who is in the audience. Wayne, could you give some brief comments on the types of information you have been collecting?

W. WEIER (*University of Missouri*): Several transects were laid out in bottomland and upland timber to determine the species composition and characteristics of the forests. I climbed the trees to examine cavities, to determine the capabilities of trees to develop cavities, and to determine cavity density. Basically cavity density is related to type of timber. In the bottomland forest there was one suitable cavity per 35 acres. Cavity density in hardwood timber was pretty close to that reported in Illinois. There was one suitable cavity for 4.6 acres in my study. I also studied a small section of the Illinois maple type timber. Here cavity density ran about one per 8 acres. These are quantitative data that could perhaps be used in connection with larger habitat inventories all across the United States. However, I think more studies of this type are needed to establish cavity densities for different types of timber.

R. E. RADTKE (*U. S. Forest Service*): I'd like to bring up a couple of quick general comments. And I'd like to restrict my remarks to the northern forests in Minnesota, Wisconsin, and Michigan, because I don't have data right here for southern forests. In general, timber-type information is available for individual forest lands which does not show up in overall forest inventories. One thing we shouldn't do is generalize on trends in wood duck habitat based on the trend of commercial forest land, such as the amount in private ownership versus the amount in public ownership. When we get right down to actual wood duck habitat, we're talking primarily about the lowland-hardwood type. Most of the private commercial forest land is not of that type. Of swamp-conifer types, the larger share is in public ownership, such as counties, states, and the Forest Service. The same situation holds for lowland brush.

In Minnesota for example, a large part of their acquisition is based on swampland and tax delinquent land considered under the Swamp Act. But considering all Forest Service lands in the Lake States, there's approximately 80,000 acres of lowland-hardwood and 330,000 acres of swamp conifers. The trend, which I think is the important thing, is an increase in these particular timber types. On the Chippewa National Forest, for example, between the last detailed forest inventory, and some 14 years ago, there is an approximate 26 percent increase in lowland hardwoods. Now there's going to be reasons,

sampling procedures, etc., which account for this 26 percent. But I think it shows that there has been a general gain in lowland hardwoods. The main reason for this is that these types are not economical to harvest presently. The same reason applies to private lands. I think at least in the unforseeable future, both lowland hardwood types and swamp conifers will increase in area.

W. E. GREEN (*Bureau of Sport Fisheries and Wildlife*): Mr. Mathisen, if I understood you correctly, you mentioned that you were putting out one wood duck nesting box per two acres of wetland or marsh, and five boxes per shoreline mile of lake. What was the basis for this statement?

J. E. MATHISEN: We didn't have any real good information at hand, so we contacted Larry Jahn and Frank Bellrose. Our original ideas were pretty close to what these two gentlemen came up with, so we used them.

W. E. GREEN: I'd like to make one comment on how you go about inventorying the amount of wood duck habitat. We tend to think of the lowland-hardwood type as being principal nesting habitat for the wood duck. But I think available data show that it isn't high quality wood duck nesting habitat. Rather, the open hardwood adjacent to bottomlands may, in the long run, be more important than the lowland timber.

F. C. BELLROSE: I suppose that when you make that statement, you are referring to the upland hardwood as being more valuable from the standpoint of nesting habitat?

W. E. GREEN: That's correct.

F. C. BELLROSE: But you won't overlook the fact that bottomland habitat is probably much more valuable than the upland habitat for broods?

W. E. GREEN: I agree.

SESSION III

Wednesday, December 8

Chairman: R. J. JESSEN
Minnesota Department of Conservation

HABITAT MANAGEMENT FOR WOOD DUCKS—KNOWLEDGE AND VOIDS

SILVICAL CHARACTERISTICS OF TREE SPECIES AND DECAY PROCESSES AS RELATED TO CAVITY PRODUCTION

H. L. HANSEN
School of Forestry, University of Minnesota, St. Paul

NATURE AND OCCURRENCE OF WOOD DUCK NESTS

Any consideration of silvical characteristics and decay-forming processes which might conceivably affect wood duck nest-cavity production must first consider what knowledge is available on nest cavities and what tree species are now utilized by nesting wood ducks.

A survey of some of the more comprehensive published reports on this subject by Bellrose *et al.* (1964), Gigstead (1938), and Hawkins and Bellrose (1941) reveals that few nests have entrance holes smaller than about 4 by 4 inches, and that the minimum interior cavity size is about 5 by 5 inches. Average hole sizes are more nearly 6 by 8 inches, and nests average about 10 inches in diameter. Apparently the depth of the nest used is extremely variable, and the entrance hole can be almost any height above the ground. Occupied nests have been reported close to water, as well as at distances more than a mile away.

From published records of tree species having wood duck nests, a list has been arranged giving in approximate decreasing order of frequency the tree species involved (Table 1).

Silvical characteristics having possible significance in development of nesting cavities include (1) tree size, longevity, and distribution, (2) vegetative regeneration by sprouts, and (3) decay in standing trees.

TABLE 1. TREES REPORTED IN PUBLISHED SOURCES AS HAVING WOOD DUCK NEST CAVITIES, LISTED IN ORDER OF DECREASING FREQUENCY

A. Primarily on Flood Plains
Baldcypress
Sycamore
Silver maple
Black ash
Sour gum
Black willow
Bottomland hardwoods (oaks - gums - cypress)
B. Primarily on uplands
Black oak group (includes black and red oaks)
Black oak
White oak
Black jack oak
Bur oak
Apple
Basswood
Pine (no species specified)
Aspen
White pine
Oak-hickory type
C. Ubiquitous
American elm
Sweet gum
Red maple

TREE SIZE, LONGEVITY, AND DISTRIBUTION

Considering the average dimensions of nesting cavities, as previously described, it seems that any tree species which under average conditions has a mature size of less than 14 to 16 inches in diameter at breast height is too small to yield an adequate cavity. On the basis of information compiled by the U.S. Forest Service (U.S. Dept. Agr., 1965), such species as aspen, balsam fir, bitternut hickory, ironwood, and others are considered too small to manage for cavity production, except under very favorable growing conditions.

In addition to providing suitable cavities, a tree should also have long life expectancy. Such species as aspen and balsam fir are commonly subject to wind breakage and mortality when they reach 60 to 80 years of age. Ironwood seldom grows larger than 6 to 8 inches in diameter. Although bitternut hickory may sometimes reach 15 or 20 inches in diameter, it is usually smaller over much of its range.

Species occurring on flood plains, bottomlands, at water edges, and in swamps deserve special attention. Many of these trees, such as baldcypress, sycamore, silver maple, black ash, and black willow, are known to accommodate nesting wood ducks (Table 1).

Boreal species, such as white spruce, black spruce, and tamarack, and montane or alpine species, such as alpine fir, bristlecone pine, mountain hemlock, and many others, are not in habitats frequented by

wood ducks. None of these species has characteristics favoring development of suitable nesting cavities. Low or no wood duck use of regions supporting these conifers may be a consequence of this lack of nesting sites.

VEGETATIVE REGENERATION BY SPROUTS

A review of the literature on tree rot reveals that a major avenue of infection by the rotting fungi is from an old stump into sprouts which have grown from it. Most hardwood trees sprout from cut stumps. Therefore, they are more commonly subject to heart rot decay than are conifers and consequently produce more wood duck cavities.

While most hardwoods can produce sprouts, there is considerable variation in their sprouting vigor and in the age to which they can continue to sprout. Basswood is one of the most vigorous of all species in this respect. Westveld (1929) reported that a stand of mixed hardwoods, including basswood of sprout origin, had 32 percent of the stems with rot at their base and that 70 percent of the trees over 10 inches in diameter were defective.

Among the oaks, a decline in sprouting vigor with age of the parent tree occurs earlier in white oaks than in red oaks (Kittredge and Chittenden, 1929). Sprouts from old stumps are more subject to decay that those from smaller and younger stumps. This probably explains the greater number of cavities reported used by wood ducks in red and black oaks than in white oaks. Another factor affecting this comparison is the greater resistance of white oaks to decay, as documented amply by experience with wood products and in the laboratory (Scheffer *et al.*, 1949).

A considerable amount of information is available to show how to reduce rot in stems originating from sprouts (for examples see Putnam, 1951; Roth and Sleeth, 1939). Conversely, this same information can be used to learn how to increase early rotting. This knowledge is now important in silvicultural management for wood production purposes, and may in the future be important in encouraging cavity formation for wood ducks.

Such measures as leaving high stumps in sprouting hardwood species and pruning occasional large branches on some of the less valuable trees might be helpful in introducing decay in some individual trees. In addition, low-quality trees with existing rot or damaged trunks could be left beyond their normal economic rotation if future nesting cavities are to be encouraged.

DECAY IN STANDING TREES

A thorough review of the literature dealing with decay processes in forest trees is, of course, beyond the scope of this report. Some atten-

tion has been given, however, to several aspects of this process which have more direct bearing on the feasibility of utilizing these natural processes to create wood duck nest cavities.

A typical wood duck nest is a hollow in the center of a tree with a bottom to hold the eggs, a covered top, and an entrance hole. Hollows of this sort are a product of decay. Decay occurs in the center of trees because the dead heartwood in most cases is easily rotted by a number of fungi. These fungi do not rot live bark or the outer rim of sapwood in the tree trunk, so they must gain access to the heartwood through a break of some sort. Basal fire scars, cut stumps, and dead or broken branches provide most entrance channels. But the importance of lightning scars, tree splits due to frost, wind breakage, branch breakage from sleet or snow, natural root grafts with infected trees, and stem cankers has not been fully evaluated as channels of infection.

It is probable that animals are also important in the cavity forming process. Sapsuckers and woodpeckers drill holes that may become infection centers or which may expand already decayed areas. Allen (1943) reports repeated gnawing by fox squirrels of the scar tissue surrounding cavity entrances they use for nests. This process may expand these holes to a size useful to wood ducks. He also reports that squirrels, woodpeckers, and flickers all expand cavities by removing the dead punky wood resulting as decay progresses.

Much information has been reported on the incidence of heart rot in forest stands and on the avenues of entrance of rot fungi. Roth and Sleeth (1939) made detailed studies of butt rot in sprout oak stands which had not been burned and in which the effect of basal fire scars was, therefore, eliminated. Hepting and Hedgecock (1937) reported on decay in oak, yellow poplar, and basswood in the Appalachians. Burns (1955) studied the relationship between fire scars and decay in Missouri oaks.

Because decay is importantly related to the occurrence of heartwood and the entrance of decay fungi from the stump, a knowledge of the pattern of heartwood formation is important. Heartwood usually appears in oak sprouts at ages 8 to 15 years. Initial development is at a point from 1 to 3 feet above the union of the sprout and its parent stump. The heartwood then extends upward to where the stem is 12 to 15 years old and from 1.5 to 2 inches in diameter (Roth and Sleeth, 1939). Sprout age, growth vigor, and distance from the active living cambium all influence the inception of heartwood formation.

Some idea of the rate of spread of heartwood rots is given in data on extent of decay in a 25 to 55-year old stand studied by Roth and Sleeth (1939). They found that decay extended about 42 inches above the ground in the 744 sprouts examined.

Unfortunately, information on the decay-forming process initiated in branch wounds is not as readily available. Considering the slow rate of spread of butt rots entering from basal scars or stumps, it would seem impractical to depend on them as a means of inducing cavity formation for wood duck nests. Such cavities would be more easily created from branch scars and would have floors at various heights as rotting progressed down the heartwood.

CONCLUSIONS

Wood duck nesting cavities in trees are products of heartwood decay Avenues of infection by fungi include fire scars, stumps, branch scars, splits in tree trunks, and other less important channels. Hardwood trees of sprout origin are more frequently decayed than trees of seed origin. As a result, conifers seldom produce appropriate cavities for wood ducks.

There is considerable variation among hardwood trees in sprouting vigor, age to which sprouting will continue from the parent tree stump, and other sprouting characteristics. Decay cannot occur until heartwood is formed and until fungi reach the heartwood without having to penetrate living or dead bark, or sapwood tissues. Information on various oak species and on decay from basal origin indicates that cavity formation under natural conditions is a very slow process. But more information is needed to properly assess the role of decay originating from such sources as branch scars, woodpecker drillings, and squirrel gnawings in forming nesting cavities for wood ducks.

LITERATURE CITED

Allen, D. L.
1943. Michigan fox squirrel management. Mich. Dept. Conserv., Game Div. Publ. 100. 404 p.
Bellrose, F. C., K. L. Johnson, and T. U. Meyers.
1964. Relative value of natural cavities and nesting houses for wood ducks. J. Wildl. Mgmt. 28(4): 661-676.
Burns, P. Y.
1955. Fire scars and decay in Missouri oaks. Mo. Agr. Expt. Sta. Bull. 642. 8 pp.
Gigstead, G.
1938. Wood ducks in the Illinois River bottoms, Trans. N. Amer. Wildl. Conf. 3: 603-609.
Hawkins, A. S. and F. C. Bellrose
1941. Wood duck habitat management in Illinois. Trans. N. Amer. Wildl. Conf. 5: 392-395.
Hepting, G. H. and G. G. Hedgcock
1937. Decay in merchantable oak, yellow poplar, and basswood in the Appalachian Region. U. S. Dept. Agr., Tech. Bull. 570. 30 p.
Kittredge, J. and A. K. Chittenden
1929. Oak forests of northern Michigan. Mich. Agr. Expt. Sta., Spec. Bull. 190. 47 p.
Putnam, J. A.
1951. Management of bottomland hardwoods. U. S. Forest Serv., Southern Forest Expt. Sta., Occasional Paper 116. 60 p.
Roth, E. R. and B. Sleeth
1939. Butt rot in unburned sprout oak stands. U. S. Dept. Agr. Tech. Bull. 684. 43 p.
Scheffer, T. C., G. H. Englerth, and C. G. Duncan
1949. Decay resistance of seven native oaks. J. Agr. Res. 78: 129-152.
U. S. Forest Service
1965. Silvics of forest trees of the United States. U. S. Dept. Agr. Handbook No. 271. 762 p.
Westveld, R. H.
1929. Seedlings and sprouts have different value. Mich. State Coll. Quart. Bull. 12: 7-9.

PROVIDING BROOD HABITAT FOR WOOD DUCKS

C. G. WEBSTER[1] AND F. B. MCGILVREY
Bureau of Sport Fisheries and Wildlife, Washington, D. C. and Laurel, Maryland

Duck production, from a practical point of view, adds new birds on the wing to the population. Successful development of newly hatched ducklings to the flying stage requires suitable habitat.

Wood duck brood habitat may be provided via two basic methods: (1) the maintenance of existing habitat and (2) the creation of new habitat. In addition, some existing habitats can be vastly improved. Regardless of how it is done, the forester, wildlife manager, and interested layman require criteria for (1) recognizing good quality habitat that should be saved, and (2) knowing what to "shoot" for in creating new or improving existing habitat. In either situation, the criteria remain the same, because they would be based on the needs of the mother wood duck and her young.

The habitat must meet both physiological and psychological needs of hen and young. Physiological requirements include food, loafing sites, and cover for screening from adverse weather, predators and other disturbing elements. Psychological needs involve a sense of security and general well being. Unless these needs are met, broods will seek more attractive areas elsewhere, or perish. Little is accomplished by hatching ducklings if all essential elements of brood habitat are not provided throughout the rearing season.

Our knowledge of what constitutes good wood duck habitat is limited, largely because most production studies have concentrated on nesting requirements and have given little attention to the needs of ducklings. In most of the publications we reviewed, the suitability of a given habitat was established through implication alone. The habitat was described, but its actual use by broods was not discussed.

Suitable wood duck brood habitat, in general terms, seems to consist of a patchy pattern of emergent cover interlaced with a network of open water passageways. The former can consist of downed timber, herbaceous or woody plants, or combinations thereof. Identifying optimum size, ratio, and pattern of cover and open water is still largely a matter of judgment based on general observations and experience. It is quite evident, though, that an extensive web of small, open water channels provides optimum conditions for broods to move about freely and feed. Invertebrates are readily available, and duckweeds, which are a prime vegetable food for young wood ducks, grow best in such wind-free sites. Larger expanses of open water appear to be of

[1]Now Manager of Wildlife Management, Remington Farms, Chestertown, Md.

little value to young birds. Flyers, however, favor openings of adequate size to take off and land.

The seasonal availability of plants and plant residues that provide cover, food, and loafing sites is more easily evaluated. One deficiency of brood habitat often overlooked is the early season scarcity of cover and food vitally needed by early hatched ducklings. Emergent aquatics leaf out later than terrestrial plants because water and submerged soils warm more slowly in spring than upland soils. Therefore, most emergent plants are still bare when first needed by ducklings, and plant remains, either living or dead, must be counted on to ameliorate this deficiency of leaf cover. Tangles of downed timber generally provide year-round cover, loafing sites, and a supply of insects and other invertebrates that fulfill the high protein requirements of young ducklings. Optimum habitat conditions probably would be provided by a combination of downed timber and the better-suited emergent plants, both woody and herbaceous.

The ideal life form of a cover plant appears to be a dense, spreading, low growth. The height of the plant depends on local water level fluctuations. Such a plant provides protective cover near the water, while permitting easy movement of broods. Also, it harbors invertebrates upon which the ducklings feed.

Cover plants that have been cited most frequently may be divided into three groups based on general life-form (Bellrose, 1953; Decker, 1959; Hardister *et al.*, 1962; Hawkins and Bellrose, 1940; Klein, 1955; Miller, 1952; Stewart, 1962; and pers. comm. with others).

1. Shrubs. Buttonbush (*Cephalanthus occidentalis*) appears to head the list of all cover plants. It most nearly exemplifies our present concept of the optimum life form and is well distributed over much of the wood duck's eastern range. Other species include swamp rose (*Rosa palustris*), alder (*Alnus* spp.), swamp privet (*Forestiera acuminata*), spiraea (*Spiraea* spp.), winterberry (*Ilex verticillata*), sweet pepperbush (*Clethra alnifolia*), and sweetbells (*Leucothoe racemosa*). Willow (*Salix* spp.) provides satisfactory cover when low and spreading.
2. Broad-leaved herbs. Spatterdock (*Nuphar* spp.) and lotus (*Nelumbo lutea*) lead this life-form list because they provide excellent cover and are well distributed. Unfortunately, like others in this group, they are not available to early hatched broods. Other plants include pickerelweed (*Pontederia cordata*), arrow-arum (*Peltandra virginica*), and arrowhead (*Sagittaria* spp.).

3. Medium to narrow-leaved herbs. We consider soft rush (*Juncus effusus*) the most important species in this group. Other plants include the various water smartweeds (*Polygonum* spp.), river bulrush (*Scirpus fluviatilis*), cattail (*Typha* spp.), and various grasses and sedges. Especially important are those that form clumps which last until spring and provide some early-season cover, such as switchgrass (*Panicum virgatum*), redtop panicum (*P. agrostoides*), bottlebrush sedge (*Carex comosa*) and tussock sedge (*C. stricta*).

At the Patuxent Wildlife Research Center near Laurel, Maryland, wide differences in habitat types in impoundments provide opportunities for studying the selection and utilization of cover types by wood duck hens and their broods. Results of these studies illustrate some of the more obvious habitat needs.

During the spring and early summer, censuses of the impoundments are made about five mornings weekly to determine brood use. Hens using nest boxes are caught and marked with colored plastic tape placed around their necks. Movements of these marked hens and their broods can then be traced. Table 1 presents the brood use of impoundments in 1964 and 1965.

Two things should be noted immediately: (1) very few units received the majority of the brood use, and (2) several nesting units were not used by broods. The key to heavy use of certain impoundments is an abundance of brood cover in early spring. Peak of hatch-

TABLE 1. WOOD DUCK BOX AND BROOD USE OF IMPOUNDMENTS, PATUXENT WILDLIFE RESEARCH CENTER, 1964–65.

Unit	Acres	1964			1965		
		Broods Hatched	Broods Reared	Ducks Reared Per Acre*	Broods Hatched	Broods Reared	Ducks Reared Per Acre*
Duval 1	13.8	2	17	6.15	3	19	7.16
Knowles 3	14.7	4	13	4.60	2	7	1.41
Knowles 1	41.6	5	18	2.25	9	18	2.25
Knowles 2	19.8	6	4	1.05	4	4	1.05
I. Marsh 1	6.4	3	2	0.64	2	0	—
Duval 2	8.7	0	3	0.18	2	1	0.06
Cash Lake	53.0	5	3	0.04	3	6	0.08
Lake Redington	38.0	2	1	0.01	3	5	0.07
Hance 1	6.2	4	0	—	1	0	—
Mabbott Pond	5.0	2	0	—	1	0	—
Snowden	7.8	2	0	—	1	0	—
Harding Spring	2.4	1	0	—	1	0	—
Goose Pond	3.3	1	0	—	2	0	—
I. Marsh 2	6.7	0	0	—	2	0	—
TOTAL	227.4	37	61		36	60	—

* Estimated 5.2 ducklings per brood reared to flight age.

ing at Patuxent occurs from the end of April until the end of May (Uhler and McGilvrey, 1964a and 1965). During much of this period seasonal plant growth has not proceeded far enough to provide essential brood cover. The cover available in heavily used impoundments consists of an abundance of dead and downed timber and various swamp shrubs.

The large numbers of downed trees also provide an abundance of loafing sites. Beard (1964) reported that loafing sites may often be a limiting factor in brood use. Large tangles of debris also harbor quantities of insects that are probably the most important component in the diet of young ducklings. The exceptionally high brood use of Duval Unit 1 may be due to the abundance of duck meal (*Wolffia papulifera*) that covers about one-half the surface of the impoundment.

The heavily used impoundments (Duval Unit 1 and Knowles Units 1 and 3) were developed by constructing dikes and impounding areas of low-quality timber and swamp shrubs. Over the years, the standing timber gradually died and fell, forming tangles of debris that now constitute the most heavily used habitat.

Some of the cleared units (Knowles Unit 2 and one-half of Knowles Unit 1) developed growths of swamp shrubs and soft rush that constituted fair brood habitat, but they were inferior to areas left uncleared. Soft rush is valuable because the previous season's growth does not break down during the winter, new growth comes early in spring, and the plant grows in tussock form, allowing easy movement of broods. The elevated leaves of spatterdock (*Nuphar luteum*) provide fair cover and an abundance of insect food in late spring.

The units in Table 1 that list nest box use but little or no brood use are either of the open water type or, if vegetated, their dominant plants come in too late to provide cover, except for late hatched broods. Color marking nesting hens has shown that broods hatched in these units are quickly led to impoundments with an abundance of brood cover.

Duval Unit 1 appears to provide optimum habitat for wood duck broods with up to 7 ducks per acre reared to flight age (Table 1). Therefore, a more complete description of the unit seems in order. Based on transect studies, water in this unit was found to average 17 inches in depth, with a maximum of 37 inches. Water is held at full pool level the year round.

There is a rather sharp dropoff in topography, with the higher 40 percent of the unit supporting live or partially live trees, shrubs and emergent aquatics. The lower 60 percent of the unit consists of dead and downed timber with open water or floating vegetation. The

shallow part averages 7 inches in depth and the deep portion 23 inches. Duckmeal, slender pondweed (*Potamogeton pusillus*), and watershield (*Brasenia schreberi*) are the only common plant species in the deeper portion of the unit. In the shallow part, marsh plants include sweet pepperbush, sweetbells, winterberry, sedges (*Carex* spp.), rice cutgrass (*Leersia oryzoides*) three-way sedge (*Dulichium arundinaceum*), soft rush, and water purslane (*Ludvigia palustris*). Water samples have revealed a pH ranging from 5 to 8, total alkalinity from 12 to 50 ppm, and total nitrates up to 1.4 ppm. Much of the water draining into this unit is from heavily limed and fertilized fields. This runoff contributes to the fertility of the unit and makes it higher than normally expected for such an acid site (Uhler and McGilvrey, 1964b).

Over most of the wood duck's breeding range similar impoundments of 10 to 20 acres could be constructed. Many state and federal management areas could materially increase their wood duck production at relatively little expense by impounding low-quality swamps.

SUMMARY

1. Optimum wood duck brood cover consists of a mixture of (a) downed timber for dependable early cover and sites for feeding and loafing, and (b) early leafing shrubs and herbs, some of which provide optimum edge conditions and all of which permit free movement of ducks.
2. Shrubs and/or clumped grasses and sedges, without downed timber, are secondary cover. Emergent herbs, of the type that provide no early spring cover, are even less desirable, especially in pure stands.
3. Optimum brood habitat consists of at least 75 percent optimum emergent cover with just enough open water for broods to move about and feed and for adults to take off and land.

LITERATURE CITED

Beard, E B.
1964. Duck brood behavior at the Seney National Wildlife Refuge. J. Wildl. Mgmt. 28(3): 492-521.
Bellrose, F. C.
1953. Housing for wood ducks. Ill. Nat. Hist. Survey, Circ. No. 45. 47 p.
Decker, E.
1959. A 4-year study of wood ducks on a Pennsylvania marsh. J. Wildl. Mgmt. 23(3): 310-315.
Hardister, J. P., Jr., F. E. Hester, and T. L. Quay
1962. Movements of juvenile wood ducks as measured by webtagging. Proc. 16th Annual Conf. Southeastern Assoc. Game and Fish Comm. (in press).
Hawkins, A. S., and F. C. Bellrose
1940. Wood duck habitat management in Illinois. Trans. N. Amer. Wildl. Conf. 5: 392-395.
Klein, H. G.
1955. Wood duck production and use of nest boxes on some marshes in New York. N. Y. Fish and Game Jour. 2(1): 68-83.

Miller, W. R.
1952. Aspects of wood duck nesting box management. Proc. 8th Northeast Fish and Wildl. Conf. 6 p. (mimeo.)
Stewart, R. E.
1962. Waterfowl populations in the upper Chesapeake region. U. S. Fish and Wildl. Serv., Spec. Sci. Rept.—Wildl. No. 65. 208 p.
Uhler, F. M., and F. B. McGilvrey
1964a. Improvement of artificial nesting structures for waterfowl. U. S. Bur. Sport Fisheries and Wildl., Annual Progress Rept. 14 p. (mimeo.)
———, and ———
1964b. Waterfowl management through water-level control. U. S. Bur. Sport Fisheries and Wildl., Biennal Progress Rept. 47 p. (mimeo.)
——— and ———
1965. Improvement of artificial nesting structures for waterfowl. U. S. Bur. Sport Fisheries and Wildl., Annual Progress Rept. 12 p. (mimeo.)

MANAGEMENT OF MAST CROPS FOR WOOD DUCKS[1]

G. K. BRAKHAGE
Missouri Department of Conservation, Columbia

The value of acorns as food for wood ducks, *Aix sponsa*, is widely recognized (Mabbott, 1920; Martin and Uhler, 1939; Stollberg, 1950; Korschgen, 1955; Coulter, 1957). Mast from pin oak (*Quercus palustris*), water oak (*Q. nigra*), willow oak (*Q. phellos*), and nuttall oak (*Q. nuttallii*), is commonly eaten by wood ducks. Because of their abundance and ecological distribution, these species provide most of the mast available to waterfowl. However, mast from any oak producing small acorns would probably be attractive to feeding wood ducks (Christisen, 1965).

Pin, water, willow, and nuttall oaks are bottomland species. They thrive on tight, poorly drained soils characteristic of overflow land commonly used by wood ducks as fall and winter habitat. All four species are often found growing in nearly pure, even-aged stands on relatively level land. Species distribution grades from north to south from pin oak through willow and nuttall oaks into water oak.

IMPROVEMENT OF MAST CROPS

What constitutes a good mast producing tree? Most authors agree that a dominant or co-dominant specimen in a large diameter class with vigorous growth and a large crown is likely to produce an abundant seed crop (Burns *et al.*, 1954; Christisen and Korschgen, 1955; Collins, 1961; Cypert, 1951; Downs, 1949; Harlow and Eikum, 1963; Moody, 1953; Petrides *et al.*, 1953). Individual trees are generally consistent in their level of productivity; those that produce abundantly one year are likely to produce abundantly in other years (Burns *et al.*, 1954; Collins, 1961; Cypert, 1951). But productivity

[1]This study was done with cooperation of Federal Aid in Fish and Wildlife Restoration funds under Missouri's project W-13-R-20.

is a heritable characteristic, and there may be considerable difference in size of seed crops between individual trees which are otherwise similar (Burns *et al.*, 1954; Cypert, 1951; Downs, 1949).

Mast failures can be triggered by many factors. Late spring frosts can kill flowers and young fruit, and aborted acorns may be the result of early insect damage (Downs, 1949). Minckler and Janes (1965) found that acorn production closely followed yearly and summer precipitation totals. Favorable moisture conditions resulted in abundant acorn crops. They believed that unusual rainfall at flowering and pollination time also influenced the size of acorn crops.

Downs (1949) suggested that oaks may need more than one growing season to build food reserves for a large acorn crop. He suggested this was one reason why mast crops were good on an average of once in three or four years. Minckler and Janes (1965) agreed that stored food supplies possibly were a factor in the size of acorn crops. They also concluded that the *variability* in mast crops among years was not affected by stand density, stand structure, or dormant season flooding.

Stand density influences *total* acorn production. Bottomland oaks, particularly pin and water oaks, often are found growing where intraspecific competition for light, soil nutrients, and moisture is keen. A dense, even-aged stand of bottomland oaks is characterized by a closed canopy composed of trees with narrow crowns. Lower limbs of pin oaks, for example, die soon after being shaded by their crown (Minckler, 1957). Small-crowned trees produce fewer acorns even though bole size may be impressive (Burns *et al.*, 1954; Christisen and Korschgen, 1955). Many authors have observed that stand densities which allow full crown development are favorable to abundant mast production (Collins, 1961; Cypert, 1951; Harlow and Eikum, 1963; McDermott and Minckler, 1961; Merz and Brakhage, 1964; Minckler, 1957; Minckler and Janes, 1965). Growth rates are also improved, but bole characteristics may suffer (Cypert, 1951). Clear 16-foot logs are obviously more attractive to forest products users than knotty 8-foot logs. Pruning, as recommended by Minckler and Krajicek (1964), may offer an inexpensive procedure to avoid undesirable characteristics of pin oaks grown in open stands.

Stand regeneration is enhanced by abundant seed crops. Light mast crops are more liable to weevil (*Curculio* spp.) damage and complete consumption by wildlife (Downs, 1949; Merz and Brakhage, 1964; Minckler and Janes, 1965). The relative importance of insect infestation is reduced when mast crops are bountiful. Research has shown that *Curculio* larvae infest a certain *number* of acorns each year. In years of poor production, the entire crop may be weevil-

damaged; when production is high, a greater number of acorns escape damage (Minckler and Janes, 1965).

Minckler and McDermott (1960) found that pin oak stands thinned to 40 square feet basal area per acre produced nearly as many acorns as stands of 60, 80, or more square feet basal area. Harlow and Eikum (1963) found that turkey oak (*Q. laevis*) stands of 150 trees per acre could be thinned 50 percent without reducing acorn production, if the best-producing trees were left.

Pin oaks normally start to bear fruit when 25 to 30 years old, but open-grown trees often produce seed at an earlier age. Minckler (1957) reported mast production from open-grown pin oaks 20 years old. I found acorns on 15-year-old open-grown pin oaks hand-planted in northwest Missouri.

The best silvicultural treatment of a bottomland forest for maximum mast production would be selective thining so each tree is allowed to become dominant or co-dominant. Trees selected for removal should be those with poor form, poor growth chracteristics, or poor history of mast production. Thinning should be done after a good mast crop to insure regeneration (Minckler and McDermott, 1960), and to allow evaluation of productivity of individual trees. Minckler (1953) found the canopy of a heavily thinned stand of pin oaks virtually closed in four years. Obviously the released trees responded quickly to their improved environment. The end result of such treatment should be an uneven-aged stand of fast-growing, large-crowned, short-boled trees ideally suited for mast production.

FLOODING MAST CROPS

Wood ducks will search for acorns in leaf litter on the forest floor, and even on limbs before the mast crop has fallen. But their favored feeding grounds are the shallowly flooded oak "flats" found in much of their fall and winter range.

Bottomland hardwoods can be flooded safely when the trees are dormant (Hall and Smith, 1955; McDermott and Minckler, 1961; Merz and Brakhage, 1964). Flooding during the growing season has a debilitating effect on trees and, if prolonged, will result in their death (Green, 1947; Kramer, 1951; McDermott, 1954; Parker, 1950; Yeager, 1949). In Kentucky, Hall and Smith (1955) recorded complete mortality among water oaks flooded 24 percent, pin oaks flooded 40 percent, and willow oaks flooded 42 percent of their growing season (April 1-October 1). At the Duck Creek Wildlife Area in southeastern Missouri, pin and willow oaks have been flooded annually since 1955 from October until as late as the first week in April with-

out discernible effects on mast production or tree mortality (Merz and Brakhage, 1964).

Annual winter flooding of bottomland hardwoods has a harmful effect on stand regeneration. Overtopping, particularly by muddy water, halts physiological processes, and seedlings succumb (McDermott, 1954). In addition, consumption of the readily available acorns by feeding ducks greatly reduces opportunity for stand regeneration. Annual flooding may have to be suspended occasionally for periods of one to three years to permit natural stand regeneration (McDermott and Minckler, 1961). Regeneration could be accomplished by hand-planting seedlings (Merz and Brakhage, 1964). Periodic winter flooding likely enhances mast production by improving soil moisture early in the summer (Minckler and McDermott, 1960).

Annual winter flooding results in a higher percentage of sound acorns because losses to insects are reduced. *Curculio* are the most important insects causing acorn damage (Breznor, 1960). The larvae overwinter underground and prolonged winter flooding reduces a local population. Migration of adult *Curculio* beetles from surrounding areas may, however, reduce the importance of localized larvae mortality (Minckler and McDermott, 1960).

Wood ducks are classified as puddle ducks which tip to find food in shallow water. Water depths 18 inches or less are ideal for mast-feeding birds. Through progressive flooding the attractiveness of a bottomland forest can be prolonged for feeding wood ducks. Part, perhaps half, of an area can be rapidly flooded early in October. The remainder could then be flooded slowly over a period of several weeks. Through this approach wood ducks are constantly presented with new feeding areas. This method of water management could be used to take maximum advantage of mast crops on undulating ground.

In heavily hunted locations, such as public use areas, it is wise to dewater shortly after the close of hunting seasons to stop duck usage. Spent shot accumulates on the undisturbed forest floor, and lead poisoning can become a serious problem. Lead poisoning is not a major problem when hunting disturbs birds and keeps them from feeding in such areas. Usually their foraging trips are short during the hunting season. But after the season closes, birds frequently feed, loaf, and roost in flooded timber and thereby increase their chances of ingesting spent shot.

AUGMENTING MAST CROPS

A general mast crop failure in a stand of mixed oaks is unlikely (Burns *et al.*, 1954). The bottomland species of interest to waterfowl managers often grow in nearly pure stands, however, and the possi-

bility of a complete mast failure does exist (Minckler, 1957). To avoid a serious food shortage at such times, managers have devised a technique for augmenting mast crops (Merz and Brakhage, 1964). Briefly, all non-mast-producing trees and understory species are mechanically removed. The resulting cleared areas are then cultivated annually and seeded to millets. The benefits are two-fold: (1) loss of a mast crop does not eliminate all the food resources from a managed bottomland forest, and (2) ecological conditions are much improved for remaining trees, so they are more likely to produce abundant mast crops.

The disadvantages are also two-fold: (1) regeneration of oaks is eliminated by both cultivation and winter flooding, and (2) millet planting must be done annually and involves yearly expenditures. Proper management can minimize the importance of both of these objections. Regeneration of oaks can be accomplished by periodic hand-planting of seedlings. Farming schedules can be adjusted to allow time for millet planting in late June and July, with equipment already on hand for other farming purposes.

SUMMARY

Mast crops can be managed for wood ducks by (1) developing a fast-growing stand of trees by selective thinning to allow each tree to have dominant or co-dominant status, (2) flooding during the dormant season only to depths of 18 inches or less, and (3) interseeding thin stands of trees with millet to provide food for wood ducks in years of mast failure.

LITERATURE CITED

Breznor, J.
1960. Biology, ecology, and taxonomy of insects infecting acorns. Mo. Agr. Expt. Sta. Research Bull. No. 726. 40 p.
Burns, P. Y., D. M. Christisen, and J. M. Nichols
1954. Acorn production in the Missouri Ozarks. Mo. Agr. Expt. Sta. Bull. No. 611. 8 p.
Christisen, D. M.
1965. Nuts for wildlife. Mo. Conservationist 26(11): 10-12.
———, and L. J. Korschgen
1955. Acorn yields and wildlife usage in Missouri. Trans. N. Amer. Wildl. Conf. 20: 337-356.
Collins, J. O.
1961. Ten year acorn mast production study. La. Wildl. and Fish. Comm., P-R Projects 24-R and 29-R. 33 p. (mimeo.)
Coulter, M. W.
1957. Food of wood ducks in Maine. J. Wildl. Mgmt. 21(2): 235-236.
Cypert, E.
1951. Suggestions for the management of oak forests for mast production. Southeastern Assoc. Game and Fish Comm. Conf., Edgewater Park, Miss. 8 p. (mimeo.)
Downs, A. A.
1949. Trees and food from acorns. p. 571-573. *In* Trees: Yearbook of Agriculture, U. S. Dept. Agr. 944 p.
Green, W. E.
1947. Effect of water impoundment on tree mortality and growth. J. Forestry 45(2): 118-120.
Hall, T. F., and G. E. Smith
1955. Effects of flooding on woody plants, West Sandy Dewatering Project, Kentucky Reservoir. J. Forestry 53(4): 281-285.

Harlow, R. F., and R. L. Eikum
1963. The effect of stand density on the acorn production of turkey oaks. Proc. Southeastern Assoc. Game and Fish Comm., 17: 126-133.
Korschgen, L. J.
1955. Fall foods of waterfowl in Missouri. Mo. Conserv. Comm., P-R Rept., Series No. 14. 41 p. (mimeo.)
Kramer, P. J.
1951. Causes of injury to plants resulting from flooding of the soil. Plant Physiol. 26(4): 722-736.
Mabbott, D. D.
1920. Food habits of seven species of American shoal-water ducks. U. S. Dept. Agr. Bull. No. 862. 67 p.
Martin, A. C., and F. M. Uhler
1939. Food of game ducks in the United States and Canada. U. S. Dept. Agr., Tech. Bull. No. 634. 156 p.
McDermott, R. E.
1954. Effects of saturated soil on seedling growth of some bottomland hardwood species. Ecol. 35(1): 36-41.
———, and L. S. Minckler
1961. Shooting area management of pin oak. Trans. N. Amer. Wildl. and Nat. Resources Conf. 26: 111-120.
Merz, R. W., and G. K. Brakhage
1964. The management of pin oak in a duck shooting area. J. Wildl. Mgmt. 28(2): 233-239.
Minckler, L. S.
1953. How thinning influences growth of pin oak. Centr. States Forest Expt. Sta., Tech. Paper 139. 8 p.
———
1957. Silvical characteristics of pin oak. Centr. States Forest Expt. Sta., Misc. Release 20. 10 p.
———, and D. Janes
1965. Pin oak acorn production on normal and flooded areas. Mo. Agr. Expt. Sta.. Research Bull. 898 (in press).
———, and J. E. Krajicek
1964. Pruning pin oak: results and cost. J. Forestry 62(1): 19-22.
———, and R. E. McDermott
1960. Pin oak acorn production and regeneration as affected by stand density, structure, and flooding. Mo. Agr. Expt. Sta., Research Bull. 750. 24 p.
Moody, R. D.
1953. Mast production of certain oak species in Louisiana. La. Wildl. and Fish. Comm., P-R Rept. 24-R. 25p. (mimeo.)
Parker, J.
1950. The effects of flooding on the transpiration and survival of some southeastern forest tree species. Plant Physiol. 25(3): 453-460.
Petrides, G. A., P. Parmalee, and J. E. Wood
1953. Acorn production in east Texas. J. Wildl. Mgmt. 17(3): 380-382.
Stollberg, B. P.
1950. Food habits of shoal-water ducks on Horicon Marsh, Wisconsin. J. Wildl. Mgmt. 14(2): 214-217.
Yeager, L. E.
1949. Effects of permanent flooding in a river-bottom timber area. Ill. Nat. Hist. Survey Bull. 25: 33-65.

MEETING MANAGEMENT OBJECTIVES FOR WOOD DUCKS ON MIDWEST NATIONAL WILDLIFE REFUGES

H. H. DILL

Regional Management Biologist, U. S. Bureau of Sport Fisheries and Wildlife, Minneapolis, Minnesota.

Management objectives for the wood duck on Midwest (Region 3) national wildlife refuges are:

1. To preserve breeding and rearing habitat.
2. To provide migrational habitat with adequate food and sanctuary to assure survival of the species.
3. To devise and apply management techniques for improving production, including forest management.
4. To band sufficient numbers to assess mortality rates, determine migration routes and identify distribution of hunting pressure.
5. To promote interest and enjoyment by the public of this beautiful and valuable bird.

The purpose of this report is to outline briefly major activities aimed at meeting these management objectives. For supplying information from individual national wildlife refuges I gratefully acknowledge the splendid cooperation of the following refuge managers: R. Personius, Horicon; J. Hakala, Seney; R. E. Toltzmann, Chautauqua; P. Ferguson, Union Slough; J. Salyer, Mark Twain; C. Pospichal, Rice Lake; R. Timmerman, Swan Lake; A. O. Manke, Ottawa and Cedar Point; L. A. Mehrhoff, Crab Orchard; J. Frye, Shiawassee; D. V. Gray, Upper Mississippi River.

HABITAT INVENTORY

Of 36 national wildlife refuges in the Midwest (Region 3) administered by a resident staff, 17 have annual populations of migrational and breeding wood ducks. All of these refuges have marsh and water areas considered suitable to some degree for brooding and rearing. These are located within one-half mile of hardwood timber. Based on 10 percent of the timber averaging 18 inches or more d.b.h. within one-half mile of water the assumption is made that 93,325 acres of timbered wood duck nesting habitat occurs on these 17 refuges (Table 1).

Significant populations of wood ducks are found in summer at the Horicon and Cedar Point National Wildlife Refuges. These are predominantly adults that have gathered to molt on two refuges, which together have only 70 acres of timber. Abundance of cattail and bulrush at both of these refuges suggests the importance of emergent cover for molting wood ducks.

TABLE 1. ESTIMATED WOOD DUCK BREEDING HABITAT AND POPULATION DATA FOR MIDWEST NATIONAL WILDLIFE REFUGES.[1]

National Wildlife Refuges	Timber Within 1/2 mile of Water (acres)	Estimated Wood Duck Populations		
		Breeding Pairs (1961-65)	(Avg. Annual) Molting	Peaks in Fall (1961-65)
Horicon, Wis.	20	14	3,500	None
Seney, Mich.	2,000	25	100	330
Chautauqua, Ill.	378	100	1,500	1,500*
Union Slough, Ia.	25**	25	200	1,362
Mark Twain, Ia., Ill., and Mo.	7,500	924	1,500	5,529
Rice Lake, Minn.	5,120	325	400	1,230
Swan Lake, Mo.	2,225	70	Unkn.	Unnk.
Ottawa, Ohio	200	100	500	2,250
Cedar Point, Ohio	50	50	2,000	2,000
Crab Orchard, Ill.	250	32	100	100
Shiawassee, Mich.	2,500	55	None	450
Upper Mississippi, Ill., Minn., Wis., Ia.	35,164	1,761	4,000	16,125
Mingo, Mo.	12,000	250	Unkn.	2,000
Tamarac, Minn.	25,493	1,131	Unkn.	5,500
Necedah, Wis.	400	50	400	1,300
TOTAL	93,325	4,912	14,200	—

[1] All values in this table were assembled from questionaires and reports of refuge managers.
* Three year average, 1963-65.
** Plus farm groves nearby.

An estimated average of 4,912 pairs of breeding wood ducks were reported for the 93,325 acres of hardwood timber nesting habitat. These census figures are influenced by (1) the well-recognized difficulty in inventorying breeding wood ducks and (2) assumptions employed in delineating the acres of breeding habitat. These gross population and habitat figures are the best available now. Investigations are needed to determine the number of suitable nesting cavities available in existing stands of timber. However, my impression is that availability of rearing and molting habitat, which ordinarily is not abundant in timbered areas in the Midwest, may limit the breeding population. Further evaluations are required to test this hypothesis.

TIMBER MANAGEMENT

During the earlier years of the refuge program in Region 3, a strict no-cut policy was advocated. The impetus given wood products during the war years caused some modification of this policy, which has extended to the present time. For example, at Tamarac, from 1940 through 1954, the average annual cut of all trees both dead and green, was 1,150 cords. From 1955 through 1964, a cut averaging 109 thousand board feet, plus 937 cords, was made.

Throughout the years close attention has been paid to preservation of the larger-diameter trees. These have been carefully preserved,

although little thought was devoted to regeneration of those species best producing cavities.

These consist of basswood, American elm, maple, ash and oak. Because wood ducks are relatively abundant at Tamarac, it is assumed that suitable cavities are also abundant. Subjectively, at least, Tamarac seems at present to afford good nesting habitat for wood ducks. The question is, what will happen to these trees in another 30 years? Will they continue to regenerate and produce cavities under the present management policy? Or will forest management be required to expedite growth of the desired cavity-producing species?

The answer to the last question seems obvious as the canopy is shading out reproduction. The problem of providing a thriving stand of trees that will sustain nesting cavities should be solved by the application of forest-management techniques. In Region 3, the Regional Forester has been assigned the task of developing these techniques.

In final analysis, the vast tracts of public and privately owned timber, which are associated with most of the wood duck habitat, are where we can expect the forest-management effort to produce the greatest achievments in wood duck management. Perhaps the chief role of refuge management for this species will be to develop and test techniques which can be passed along to other forest managers.

RESTORATION OF HABITAT

At the Tamarac National Wildlife Refuge we learned that wood ducks readily use small potholes built or reclaimed in hardwood timber. These ponds range from ¼- to ⅓-acre in size; most were excavated with a bulldozer or dragline at a cost ranging from $11.50 to $53.50 each (Burnard, 1964). Wood ducks frequently use them during the nesting period, but broods are seldom seen on these potholes. Probably broods are moved overland by females to larger lakes.

Ammonium nitrate has been used experimentally to blast small potholes in timbered habitat. As refuge personnel become more familiar with this technique, its use will probably expand.

ARTIFICIAL NESTING STRUCTURES

Hundreds of nest houses have been placed out on national wildlife refuges in Region 3 in the past 30 years. These were largely made from boards. Most of them were put out under the Civilian Conservation Corps (CCC), some by Boy Scouts, and others through various conservation organizations. Few of these boxes remain today, and their contribution to the welfare of the wood duck has never been assessed. In the light of present knowledge of predation by raccoons,

TABLE 2. WOOD DUCK NEST BOXES ON MIDWEST NATIONAL WILDLIFE REFUGES IN 1965.

Refuge	No. Boxes	When Erected	Percent Used By Wood Ducks	Predation Rate (Percent)	Remarks
Upper Mississippi, Ia., Minn., Wis., Ill.	209	1952–1964	10–15	10	Problem: Occupancy by colonial insects & other b
Mark Twain, Ia., Mo., Ill.	116	1965	0	0	Problem: Occupancy by squirrels.
Union Slough, Ia.	37	1960–1965	8	1	Problem: 62% used by other birds.
Rice Lake, Minn.	60	1940	0		Problem: Predation by coons & occupancy by inse
Shiawassee, Mich.	39	1957–1960	0		Have deteriorated; 11 remain in 1965.
Crab Orchard, Ill.	81	1962–1964	4	Unkn.	Problem: Occupancy by starlings.
Ottawa, Ohio	75	1955-1964	0		Problem: Predation by coons; occupancy by swall
Cedar Point, Ohio	25	1964–1965	20	0	
Swan Lake, Mo.	18	1957	0		Poorly designed.
Chautauqua, Ill.	140	1938-1960	33	Low	Some nest desertion caused by starlings & flickers.
Seney, Mich.	38	1954	15	15	Some boxes occupied by mergansers.
Mingo, Mo.	126	1958–1963	25	7	Predators: Black snake and raccoon.
Necedah. Wis.	18	1958	.6	High	Plans to add 50 fiberglass boxes in 1966.
TOTAL	982	—	—	—	

they actually may have been a detriment to the species. Table 2 summarizes the current nest house program on Midwest national wildlife refuges.

Some refuges at which wood duck houses are consistently used have large timbered areas in which additional houses could be placed. For example, the Upper Mississippi has only 209 houses on a timbered area of 35,164 acres. With an estimated breeding population of only 1,800 pairs it seems likely that production could be increased by erecting nest houses, if natural cavities are actually limiting nesting success and mortality of local birds is not excessive.

Refuge Manager D. V. Gray states (pers. comm., Nov., 1965): "Properly constructed or shielded houses can contribute in some degree to management of this species by providing reasonable assurance of a safe hatch for those birds utilizing them. However, even the shielded structures may be invaded to a limited extent by colonial insects and other species of birds, and an improperly protected structure invites invasion by mammalian predators or snakes. In addition to the beneficial aspects of properly built and placed boxes, they serve as a means of stimulating interest among conservation-minded groups or individuals. However, large numbers of the houses must be placed out to materially attract and increase wood duck populations, and considerable time and expense would be involved in constructing, placing, checking and cleaning the structures. Their use is recommended to the *extent of available time and means* either for cooperating groups or those refuges having wood duck populations."

The modest rate of occupancy (Table 2) of nest houses by wood ducks at Upper Mississippi may not necessarily be related to the abundance of nest sites in natural cavities. Bellrose (1964) states: "Low occupancy of nest houses by wood ducks (*Aix sponsa*) does not necessarily indicate an abundance of nest sites in natural cavities, but either a low breeding population or nest houses improperly constructed or placed. A low breeding population may be caused by high nest losses to predators, shortcomings of the breeding habitat, or shooting losses."

R. E. Toltzmann, refuge manager at Chautauqua, reports (pers. comm., Nov., 1965): "Approximately 1.2 wood ducks were produced in nest boxes for each acre of timber on the refuge. Nest success was 81 percent in nesting boxes in 1965. Natural cavities usually produce approximately 0.1 duck per acre of timber. Nest success in natural cavities in this area averages 35 percent."

The cost of building and placing out nesting houses in trees, plus the time required to climb the trees for checking and cleaning are the chief deterrents to expanding the nest-house program at refuges.

Also, many nesting houses placed in trees have a relatively short life expectancy.

These factors prompted me to design a fiberglass nesting house which is molded directly into a larger nesting structure designed for general use by other species of ducks and Canada geese. A prototype of the structures was displayed at the Wood Duck Symposium in Lansing, Michigan (Figure 1). This structure is placed securely on four legs over water. It is intended to be invulnerable to mammalian predators, chiefly the raccoon. Because fiberglass is translucent, light will freely penetrate the nesting house. This illumination should discourage starlings from using the structure.

Life expectancy of such a structure is indefinite. It is light in weight and may readily be moved. If successful, it could be used widely for Canada geese and ducks at both public and private water-

Figure 1. New Waterfowl Nesting Structure. H. H. Dill with a prototype of his dual-purpose nesting structure made of fiberglass. The 42-inch diameter shallow depression is 12″ deep at the center and has five holes in the bottom for drainage. It is designed to accommodate Canada geese and other waterfowl, especially mallards. The 12″ x 12″ nest house, 17″ deep and having a 4-inch diameter entrance, is designed for wood ducks. Some models being tested have a tunnel extending outward 10″ from the entrance. Four 8-foot legs support the structure over water.

fowl management areas. Because the wood duck nesting house can be made an intergral part of the structure, it follows that its use may expand to areas where a breeding potential exists for both Canada geese and wood ducks. This potential exists at national wildlife refuges, such as Necedah, Rice Lake, Tamarac and others.

BANDING EFFORTS

Table 3 summarizes banding since 1958 on Midwest national wildlife refuges. Kaczynski and Geis (1961) point up the importance of banding in relation to Management Objective No. 4. "Banding of an adequate sample of immature and adult wood ducks in late summer and early fall, before the opening of the hunting season, could provide data for estimating mortality rates, for measuring the importance of hunting as a mortality factor, and determining the effects on the kill."

Midwest refuge personnel have made an outstanding contribution to the banding program. An average of 6,642 wood ducks have been banded annually, totaling 42,058 for the period 1958-1965. In further-

TABLE 3. PRE-HUNTING SEASON WOOD DUCK BANDING EFFORTS ON MIDWEST NATIONAL WILDLIFE REFUGES.

Refuge and Place	Year Banding Commenced	No. Banded		Remarks
		Avg. Annually	Total Through Nov. 1965	
Upper Mississippi	1958	(2,520)	20,165	
Winona, Minn.	1958	547		
LaCrosse, Wis.	1958	542		
Lansing, Ia.	1958	254		
Prairie du Chien, Wis.	1958	449		
Cassville, Wis.	1958	640		
Savanna, Ill.	1958	304		
Mark Twain	1959	(902)	6,314	
Louisa, Ia.	1959	261		
Keithsburg, Ia.	1962	43		
Gardner, Ill.	1959	324		
Calhoun, Ill.	1963	679		
Mingo, Mo.	1965	375	375	
Horicon, Wis.	1958	355	2,845	
Seney, Mich.	1946	82	1,646	A few wood ducks were banded previously.
Chatauqua, Ill.	1959	358	2,511	A few wood ducks were banded previously.
Swan Lake, Mo.	1959	11	11	One year only.
Cedar Point, Ohio	1965	83	83	
Ottawa, Ohio	1963	58	174	
Crab Orchard, Ill.	1951	100	701	Bandings for 7 years, through 1963.
Shiawassee, Mich.	1961	151	756	
Union Slough, Ia.	1959	233	1,633	A few wood ducks were banded previously.
Rice Lake, Minn.	1958	135	1,082	
Tamarac, Minn.	1962	284	1,138	A few wood ducks were banded previously.
Necedah, Wis.	1959	374	2,624	
		6,642	42,058	

ance of the banding program at other refuges and with the states, two banding workshops have been held: one at Agassiz, Minnesota in 1964 and one (in Region 4) at Reelfoot, Tennessee in 1965. Trapping techniques, developed at refuges, were explained to the participants. This type of instruction has met enthusiastic reception and has resulted in vast improvement in the quality of wood duck banding.

Interpretation of banding data is not a major purpose of this paper. However, one local finding has potential practical implications. Wood ducks were banded prior to the hunting season in 1963-64 at the Mark Twain National Wildlife Refuge. Of 3,357 woodies banded within closed areas, 6 percent (210) were recovered the first hunting season. Of 1,095 woodies banded in public hunting areas, 13.6 percent (150) were recovered the first year. These data suggest that sedentary habits of the birds locally contributed to their recovery rates. The local refuge apparently provided effective sanctuary during the waterfowl hunting season. After leaving the refuge, the wood ducks dispersed widely. First-year band recoveries occurred in every state of the Mississippi Flyway.

ROOST COUNTS

Hein (1961) has described in detail wood duck roosting flights at Paint Creek, Allamakeé County Iowa. Paint Creek is one of 20 roosts which are regularly visited by personnel from the Upper Mississippi Refuge. Roost counts afford a valuable index to populations of wood ducks from the surrounding countryside. At Paint Creek, Hein established that August roosting flights comprised immature ducks; no adults were observed until early September. A mid-September pre-migration peak was reached. No exchange of ducks occurred between Paint Creek and other nearby roosts. Table 4 illustrates the application of the technique at other Midwest refuges (in Region 3).

TABLE 4. ROOST COUNTS OF WOOD DUCKS ON MIDWEST NATIONAL WILDLIFE REFUGES.

Refuge	No. Roosts Located	No. Years Counted	No. Ducks Counted		
			Total	Avg. (all yrs.)	Range
Rice Lake, Minn.	2	2 (1964–65)	1,350	675	300–1,100
Union Slough, Ia.	2	4 (1962–65)	1,228	614	365–1,901
Mark Twain, Ia., Ill., and Mo.	2	1 (1965)	2,000	1,000	—
Ottawa, Ohio	1	4 (1962–65)	525	525	400–700
Upper Mississippi, Ia., Minn., Wis., Ill.	20	6 (1960–65)	8,547	427	39–1,925
Tamarac, Minn.	3*	1 (1965)	1,000	1,000	—
Necedah, Wis.	1	1 (1965)	100	100	—

* One roost was located and checked once in 1965; two more roosts were tentatively located but not counted.

ESTHETIC VALUES

Because of its proclivity for nesting in trees, often near rural homes or even within city limits, the wood duck has a tremendous natural appeal to most people. A description of the descent of ducklings from nesting cavities is prime material for any naturalist addressing a group. And the fact that wood ducks may be induced to use a nest house located near the family home or lake cottage is the clincher for a successful presentation of this type.

Therefore, it is logical to assume that the colorful wood duck, together with other important species of wildlife, should play increasingly prominent roles in programs aimed at increasing public interest and enjoyment of this tremendously interesting bird at many of our national wildlife refuges.

SUMMARY

The management objectives for the wood duck on Midwest national wildlife refuges are:

1. To preserve breeding and rearing habitat.
2. To provide migrational habitat with adequate food and sanctuary to assure survival of the species.
3. To devise and apply management techniques for improving production, including forest management.
4. To band sufficient numbers to assess mortality rates, determine migration routes and identify distribution of hunting pressure.
5. To promote the interest and enjoyment by the public of this beautiful and valuable bird.

Seventeen Midwest national wildlife refuges annually have significant populations of migrational and breeding wood ducks. Based on 10 percent of the hardwood timber averaging 18 inches or more d.b.h. within one-half mile of water the assumption is made that 93,325 acres of timbered wood duck nesting habitat is present on these 17 refuges. The importance of emergent aquatic cover for rearing and molting is suggested by more extensive use by wood ducks of refuges, such as Horicon and Union Slough, which have but 45 acres of timber.

Timber harvest on Midwest refuges received some impetus as a result of the demand for wood during the war years. Emphasis has been placed on preservation of mature trees which produce cavities. There exists a need to learn management techniques for perpetuating thriving stands of cavity-producing trees. It is suggested that, if such techniques can be developed at refuges, their greatest application may be on much larger tracts of timber in public and private ownership.

At Tamarac, wood ducks have readily used small ponds ranging in size from ¼- to ⅓-acre. These ponds were built, or reclaimed in timbered areas and ranged in cost from $11.50 to $53.50 each. Ammonium nitrate was also used experimentally to create potholes in timbered areas.

A total of 982 nest houses were present on these refuges in 1965, some of which deteriorated rapidly. While the percent of nests destroyed by predators is relatively low, problems stem from occupancy by other species of birds and insects, and desertion caused by starlings and woodpeckers. However, it appears that a properly conducted nest house program associated with adequate habitat will increase production of wood ducks. At Chautauqua, 1.2 wood ducks were produced in nest boxes for each acre of timber on the refuge. Nest success in artificial houses was 81 percent in 1965. Natural cavities produced 0.1 duck per acre of timber and only 35 percent of such nests were successful. A fiberglass nest house was recently designed by me. It is an integral part of a larger fiberglass structure intended for use by other species of ducks and Canada geese. These structures will be tried at several Midwest refuges in 1966 and future years.

The pre-hunting season banding program at national wildlife refuges in Region 3 has resulted in a total of 42,058 bandings. An average of 6,642 wood ducks are banded annually at refuges. Band returns have been received from every state in the Mississippi Flyway and from Canada. Twice as many first-year recoveries were received from wood ducks banded in the public hunting area at the Mark Twain National Wildlife Refuge than in the area closed to hunting. This difference in first-year recovery rates points up the importance of this local sanctuary for wood ducks during the hunting season.

At seven refuges, 31 wood duck roosts were located. Roost counts afford valuable indices to populations of wood ducks in there areas as long as the habitat remains suitable.

The wood duck should assume a more prominent role in programs aimed at increasing public interest and enjoyment of many of our national wildlife refuges.

LITERATURE CITED

Bellrose, F. C., K. L. Johnson, and T. U. Meyers
1964. Relative value of natural cavities and nesting houses for wood ducks. J. Wildl. Mgmt. 28(4): 661-676.

Burnard, R. K.
1964. Waterfowl production potential of natural and reclaimed forest potholes. M.S. Thesis, Ohio State Univ. 72 p.

Hein, D.
1961. Wood duck roosting flights at Paint Creek, Iowa. J. Paper No. J-4087, Ia. Agr. and Home Econ. Expt. Sta., Ames, Ia. p. 264-270.

Kaczynski, C. F., and A. D. Geis
1961. Wood duck banding program-progress report, 1959 and 1960. U. S. Fish and Wildl. Serv., Spec. Sci. Rept.—Wildl. No. 59. 41 p.

A SURVEY OF WOOD DUCK NEST SITES ON MINGO NATIONAL WILDLIFE REFUGE IN SOUTHEAST MISSOURI[1]

R. WAYNE WEIER

Missouri Cooperative Wildlife Research Unit, Stephens Hall, University of Missouri, Columbia.

This paper reports a study of tree cavities in relation to wood duck (*Aix sponsa*) nesting on the Mingo National Wildlife Refuge in southeast Missouri. Research objectives were to compare cavity abundance in different timber types and under different methods of timber management and to determine the extent and nature of wood duck nesting in cavities.

Wood duck populations in many areas apparently are limited by a lack of nest sites (Bent, 1923; Hawkins and Bellrose, 1941; Grice and Rogers, 1965). Game managers have increased the number of nest sites in some areas by providing nest boxes, but over most of their breeding range the birds nest primarily in natural cavities.

Only a few studies of tree cavities in relation to wood duck nesting have been made. Little information is available on the species or sizes of trees most likely to contain suitable cavities. Several authors (Bent, 1923; Dixon, 1924; Gigstead, 1938; Grice and Rogers, 1965) list the trees in which wood duck nests were found but do not indicate their relative abundance. Bellrose, Johnson, and Myers (1964:662-663) found that black oak (*Quercus velutina*) was predominant in the woodlots they studied, and this species also was the best cavity producer. Other studies (Baumgartner, 1939; Allen, 1943; Stuewer, 1943; Dalke, 1948; Gysel, 1961) provide information on cavity formation, density, size, and usage, but were not oriented toward wood duck management. Most authors agree that large or mature trees contain the most cavities, but little quantitative data is available.

On the Mingo Refuge it was formerly thought that natural cavities were abundant and that many wood ducks nested in them. However, broods were seldom seen, and when nest boxes were provided in one portion of the refuge, they were readily used. Furthermore, workers engaged in timber stand improvement programs observed few cavities. These observations suggested that cavities were not abundant. There was growing concern that current timber management practices, oriented toward lumber and mast production, might be eliminating

[1]Financial support for the study was provided by the Division of Wildlife Refuges, U. S. Bureau of Sport Fisheries and Wildlife; The Gaylord Memorial Laboratory; and the Missouri Cooperative Wildlife Research Unit. I express thanks to John P. Rogers, Director of the Gaylord Memorial Laboratory, University of Missouri, and to John E. Toll, Manager, Mingo National Wildlife Refuge, for direction and supervision.

many natural cavities. The uncertainty about cavity abundance and about the effects of timber management prompted this study.

DESCRIPTION OF THE AREA

Mingo National Wildlife Refuge is located near Puxico, in southeast Missouri. It occupies portions of Stoddard and Wayne counties. Most of the refuge lies within an old abandoned flood plain of the Mississippi River (Marbut, 1902). Steep limestone bluffs on the western and southeastern edges of the refuge rise 100 feet above the valley floor. The flat topography of the bottomland is interrupted only by low sand ridges. Drainage ditches run through the bottomland in a north-south direction at one-mile intervals; but water drains away slowly, and much of the basin floods during periods of heavy rainfall. The refuge occupies 21,700 acres, of which 12,000 are timbered, 6,000 are water and marshland, and the remaining 3,700 are used for farming and miscellaneous purposes.

There are two types of timber in the bottomland: the pin oak-overcup oak type, and the elm-ash-maple type. The first type occupies most (10,500 acres) of the forested area of the refuge. Pin oak (*Quercus palustris*) and overcup oak (*Quercus lyrata*) are the predominant species, but willow oak (*Quercus phellos*) and sweetgum (*Liquidambar styraciflua*) are important on the sand ridges. Baldcypress (*Taxodium distichum*) is prominent in low, wet areas.

The elm-ash-maple type is found in slough situations where it is often flooded for most of the year. About 600 acres are forested with this type. Green ash (*Fraxinus pennsylvanica*), pumpkin ash (*Fraxinus profunda*), American elm (*Ulmus americana*), and red maple (*Acer rubrum*) are characteristic species.

In addition to the bottomland forests, about 900 acres of upland hardwood timber occur along the bluffs on the southeastern and western edges of the refuge. White oak (*Quercus alba*), black oak, and mockernut hickory (*Carya tomentosa*) predominate.

Because of "high-grade" logging and repeated fires, most of the timber was in poor condition when refuge acquisition was completed in 1946. The effects of such abuse are still evident, for many of the stands are of poor quality, and fire scars are common. Large trees are scarce over most of the refuge, especially in areas where timber harvesting and timber stand improvement have been done.

METHODS

Field work was done during the periods June to September, 1964, and February to September, 1965. The study was divided into two

parts: (1) a general cavity survey of all timber types, and (2) a study concerning the effect of a recent timber harvest on cavity abundance.

General Cavity Survey

The literature (Dixon, 1924:46; Bellrose, 1955:12; Grice and Rogers, 1965:17) and preliminary observations at Mingo indicated that cavities big enough for wood duck use were located almost exclusively in large trees. Therefore, in order to conduct the survey most efficiently, areas of each timber type containing some large, mature and overmature trees were selected for study. The areas chosen were slightly biased toward older stands. Thinly stocked stands were somewhat underrepresented, and areas managed or cut since establishment of the refuge were not represented at all in this part of the study.

Belt transects two chains wide and from one-fourth mile to nearly three miles long were laid out along compass lines through each area. All transects were located within one-half mile of permanent water because wood ducks seldom nest farther than this from a suitable water area (Bellrose, 1955:12). The transects generally ran parallel to roads or drainage ditches but at a distance from them.

Species composition and size of the timber were sampled by tallying trees within a chain-wide strip down the center of each transect. All trees, dead or alive, with a diameter at breast height (d.b.h.) of 9.5 inches or more were tallied. This method, in which only one-half of each transect was sampled, was necessary because of limited time. The results were doubled to obtain an estimate for the entire transect.

In cavity searching, the entire width of each transect was sampled. Most searching was done in the spring to take advantage of the lack of foliage. Searching was done by three men walking down the transect and using binoculars to inspect the trees.

Trees 9.5 inches or larger in diameter containing cavities of promising appearance were marked for later examination with colored surveyor's ribbon. In the subsequent more thorough examination, all marked trees not too decayed were climbed and the cavities measured. The final tallies included all trees, 9.5 inches d.b.h. or larger, having cavities with entrance dimensions of at least 3½ by 2½ inches and nesting platforms of at least 5 by 7 inches. Such trees were termed *cavity trees*. For each of these, species, d.b.h., and crown class were recorded. The minimum acceptable cavity dimensions were derived from data published by Grice and Rogers (1965:17) (entrance dimensions) and by Bellrose *et al.* (1964:664) (platform dimensions). For each cavity sampled, entrance and interior dimensions, entrance height from the ground, and cause of formation were recorded. Usage was determined by noting the presence of "sign," such as hair or nesting

material. Many of the cavities, though of adequate size, were judged not to be suitable for wood duck nesting because they contained water or excessive debris or had open tops. Accordingly, the term *suitable cavities* henceforth refers only to cavities with adequate dimensions and lacking the adverse features just mentioned.

Study Concerning the Effect of a Timber Harvest

Two adjoining areas of pin oak-overcup oak timber were compared with respect to cavity abundance. In one, the *unmanaged area,* no disturbances had occurred for 20 years. In the other, the *managed area,* a timber harvest for stand improvement was completed in 1960. However, trees found containing honeybees or possible wood duck cavities were not cut; and no baldcypress trees were cut. Both areas were subjected to frequent fires and severe cutting before the refuge was established; therefore, the stands are thinly stocked and of poor quality.

In each area straight belt transects 40 feet wide were laid out. They were divided into plots 200 feet long and alternate plots were searched for cavities. All live trees 10 inches or larger in d.b.h. were searched. In contrast to the general survey, which included only potential wood duck cavities, this survey included cavities with entrances at least 2 inches in diameter and at least 6 feet from the ground. Trees that could not be examined adequately from the ground because of foliage were climbed and inspected, so it is doubtful that many cavities were missed. Trees with cavities were climbed and the cavities were measured. If the cavities had 2-inch entrances, they were included in the sample, and the same data recorded as in the general survey; other cavities were disregarded. In this part of the study, then, a *cavity tree* is defined as a live tree 10 inches or larger in d.b.h. containing a cavity with an entrance at least 2 inches in diameter and at least 6 feet from the ground.

Species composition and size of the trees were determined for each study plot by tallying all live trees that were 10 inches or more in d.b.h.

MATERIALS

Tree climbing was done most rapidly and safely with the aid of climbing spurs, plus a 150-foot length of one-half inch nylon rope, and a leather saddle. A safety belt was used after the climber reached the desired location in the tree. A bow-fishing apparatus was used to place the rope over a limb (Gysel, 1960). With the rope over a solid limb, the climber fastened his saddle to one end of the rope and the helper obtained a firm hold on the other end. The

climber went up by using the spurs while the helper kept the rope taut, usually by backing away from the tree. When the climber was ready to come down, he released his hold on the tree, and the helper lowered him to the ground with the rope.

Cavity measurements were made with a flexible steel tape. Height of the entrance from the ground was estimated. A forester's diameter tape was used to measure d.b.h.

Inspection of some cavities required the use of a mirror on a handle and a flashlight suspended inside the cavity by a cord. In cavities too deep for visual inspection a small amount of debris was obtained for examination by lowering a weight covered with glue to the bottom.

RESULTS OF THE GENERAL CAVITY SURVEY

Pin Oak-Overcup Oak Type

Cavity density in this type was quite low. In a 70-acre sample, only 31 cavities were found: 28 in live trees (Table 1), and three in dead trees. Cavity density was thus about one per two acres.

The two predominant species, pin oak and overcup oak, contained few cavities until they reached large size. To illustrate, six of the eight pin oak cavity trees and three of the five overcup oak cavity trees listed in Table 1 were 27.5 inches d.b.h. or larger.

TABLE 1. SPECIES COMPOSITION AND CAVITY ABUNDANCE IN PIN OAK-OVERCUP OAK TIMBER ON MINGO NATIONAL WILDLIFE REFUGE (ACRES SAMPLED = 70.0)

Species	Number of Trees*	Number with Cavities	Number of Trees Per Acre*	Percent with Cavities
Pin Oak *Quercus palustris*	1,198	8	17.1	0.7
Overcup oak *Quercus lyrata*	950	5	13.6	0.5
Willow oak *Quercus phellos*	340	1	4.9	0.3
Sweetgum *Liquidambar styraciflua*	232	0	3.3	0.0
Baldcypress *Taxodium distichum*	220	5	3.1	2.3
Elm, American and slippery *Ulmus americana* and *U. rubra*	124	0	1.8	0.0
Ash, green and pumpkin *Fraxinus pennsylvanica* and *F. profunda*	76	1	1.1	1.3
Red maple *Acer rubrum*	52	2	0.7	3.8
Blackgum *Nyssa sylvatica*	16	6	0.2	37.5
All others	308	0	4.4	0.0
Totals	3,518	28	50.2	0.8

* 9.5 inches d.b.h. or larger and includes only live trees.

In willow oak, sweetgum, and elm the low percentage of trees with cavities may be due mostly to a preponderance of small trees in the sample. In 70 acres, only 14 willow oaks, four sweetgums, and four elms were larger than 21.5 inches. On the other hand, the high incidence of cavities in blackgum (*Nyssa sylvatica*) is partly due to a slight bias toward large trees. Nevertheless, blackgum was the best cavity producer of all the species. It was only a minor component of the stand, however.

Of the 31 cavities examined, only three (one per 23 acres) were suitable for wood duck use. Two of these were located in blackgum trees measuring 18 and 25 inches in d.b.h., respectively. Both cavities contained evidence of use by squirrels (*Sciurus carolinensis* and *S. niger*) and by raccoons (*Procyon lotor*). The third cavity was in a 33-inch pin oak and was occupied by a gray squirrel.

Elm-Ash-Maple Type

This type had the highest cavity density of all types. Thirty-one cavity trees containing 35 cavities were found in a sample of 15.9 acres. Thirty of the trees were alive (Table 2) and one was dead. Four of the live trees contained two cavities each. Cavity density was 2.2 per acre, or four times greater than in the pin oak-overcup oak type. The abundance of cavities was due both to a high density of trees and to a high proportion of cavity-prone species in the stand.

Green and pumpkin ash accounted for nearly half of the trees

TABLE 2. SPECIES COMPOSITION AND CAVITY ABUNDANCE IN ELM-ASH-MAPLE TIMBER ON MINGO NATIONAL WILDLIFE REFUGE (ACRES SAMPLED = 15.9)

Species	Number of Trees*	Number with Cavities	Number of Trees Per Acre*	Percent with Cavities
Ash, green and pumpkin *Fraxinus pennsylvanica* and *F. profunda*	542	10	34.0	1.8
American elm *Ulmus americana*	118	3	7.4	2.5
Overcup oak *Quercus lyrata*	92	0	5.8	0.0
Red maple *Acer rubrum*	82	9	5.2	11.0
Waterlocust *Gleditsia aquatica*	62	0	3.9	0.0
Baldcypress *Taxodium distichum*	54	2	3.4	3.7
Pin oak *Quercus palustris*	54	0	3.4	0.0
Black willow *Salix nigra*	40	3	2.5	7.5
All others	118	3	7.4	2.5
Totals	1,162	30	73.0	2.6

*9.5 inches d.b.h. or larger and includes only live trees.

sampled and produced the most cavities. Red maple had the highest cavity incidence but was not as common in the stand. The sample of red maple was somewhat biased toward large trees, thus the cavity incidence is slightly inflated. Most of the cavities in baldcypress trees were near the base and resulted from fire scars or logging damage. Therefore, the data presented in Tables 1 and 2 for this species may somewhat overrate its present value as a cavity producer. However, most of the cypress trees are young; and since older cypress trees seem to have many good cavities, the species will probably contain more cavities of value as time passes.

Of the 35 cavities examined, only two (one per eight acres) were suitable for wood duck use. One of these was located in a 16-inch black willow (*Salix nigra*) and contained evidence of squirrel use. The other was found in a 31-inch red maple and was heavily used by raccoons.

In other studies of bottomland timber Dreis and Hendrickson (1952:20) found one suitable cavity per 24 acres in Iowa, and Bellrose *et al.* (1964:663) found one suitable cavity per 16 acres in Illinois. The authors did not indicate the timber types studied nor the condition of the stands.

Upland Hardwood Type

In a sample of 41.1 acres, 38 cavity trees containing 43 cavities were found. Thirty-five of the trees were alive (Table 3), and three

TABLE 3. SPECIES COMPOSITION AND CAVITY ABUNDANCE IN UPLAND HARDWOOD TIMBER ON MINGO NATIONAL WILDLIFE REFUGE (ACRES SAMPLED = 41.1)

Species	Number of Trees*	Number with Cavities	Number of Trees Per Acre*	Percent with Cavities
White oak *Quercus alba*	392	3	9.5	0.8
Black oak *Quercus velutina*	224	5	5.5	2.2
Northern red oak *Quercus rubra*	174	0	4.2	0.0
Hickory (6 species) *Carya sp.*	300	1	7.3	0.3
Sweetgum *Liquidambar styraciflua*	102	2	2.5	2.0
Scarlet oak *Quercus coccinea*	100	0	2.4	0.0
White ash *Fraxinus americana*	96	4	2.1	4.2
Elm (3 species) *Ulmus sp.*	138	6	3.4	4.3
Blackgum *Nyssa sylvatica*	68	8	1.7	11.8
All others	370	6	9.2	1.6
Totals	1,964	35	47.8	1.8

* 9.5 inches d.b.h. or larger and includes only live trees.

were dead. Four of the live trees and one of the dead trees contained two cavities each. Cavity density was about one per acre.

Although blackgum comprised only a small percentage of the trees sampled, it contained more cavities than any other species. Hickory and scarlet oak (*Quercus coccinea*) had a low incidence of cavities, due partly to a preponderance of small trees in the sample. The sample of northern red oak (*Quercus rubra*) included all sizes of trees and indicated a low incidence of cavities in this species. In elms the percentage of trees with cavities was slightly inflated because the sample was biased toward large trees.

Gysel (1961:17) studied cavities of all sizes in upland hardwood stands in Michigan and found that the number of cavities occurring in a tree species was approximately proportional to its basal area. This relationship was not observed for the large cavities studied at Mingo. For example, blackgum with little basal area contained more cavities than white oak with much basal area.

Of the 43 cavities examined, 12 (one per 3.4 acres) were suitable for wood duck use. Four of these were in blackgum trees, three were in elms (one elm was dead), and one each was in white oak, sweetgum, black oak, white ash (*Fraxinus americana*), and sugar maple (*Acer saccharum*). The 12 suitable cavities were all used by species other than the wood duck: squirrels alone used six; five were used by both squirrels and raccoons; and one was used for nesting by a pileated woodpecker (*Hylatomus pileatus*). In the only other study of wood duck nesting in upland hardwoods, Bellrose *et al.* (1964:663) found that one-third of the suitable cavities in black oak woodlots near Havana, Illinois, were used by wood ducks. Density of the suitable cavities was about one per five acres.

Tree Size and Cavity Abundance

In all timber types the occurrence of cavities increased with increasing tree size (Table 4). Few cavities were found in trees smaller than 15.5 inches in diameter, although many trees of this size were sampled. Most of the cavities were in trees of intermediate or large sizes. Large trees (over 27.5 inches d.b.h.) were most likely to contain cavities, but these were sparsely distributed in the stands. A few of the intermediate and large trees contained two cavities each. Some species produced cavities at smaller diameters than others. Black willow and ash trees, for example, produced cavities before reaching 15 inches d.b.h.; while overcup oak trees contained few cavities until they reached about 27 inches d.b.h.

Cavity Formation

Broken or dead limbs were the origin of 61 percent of the cavities.

TABLE 4. RELATIONSHIP BETWEEN TREE SIZE, TREE DENSITY, AND CAVITY OCCURRENCE IN FOREST TYPES OF MINGO NATIONAL WILDLIFE REFUGE

Timber Type	D.B.H. Size Classes									
	9.5–15.5		15.5–21.5		21.5–27.5		27.5—		Totals	
	Trees per Acre*	Percent with Cavities	Trees per Acre	Percent with Cavities	Trees per Acre	Percent with Cavities	Trees per Acre	Percent with Cavities	Trees per Acre	Percent with Cavities
Oak-Overcup Oak	30.6	0.2	15.3	0.7	3.2	3.1	1.1	12.5	50.2	0.8
Ash-Maple	43.4	0.4	21.8	3.8	5.5	6.8	2.3	22.2	73.0	2.6
nd Hardwood	37.1	0.5	9.1	4.6	1.5	13.3	0.1	33.3	47.8	1.8

nly live trees are included.

About 18 percent were due to fire scar decay. Lightning and logging damage accounted for 8 percent, and woodpeckers made 4 percent. Woodpeckers, however, made many entrances and also may have aided the formation of cavities originating from other sources. About 9 percent of the cavities were of undetermined origin.

Cavity size was directly related to tree diameter. In the upland hardwood type the average diameter of cavity trees was 19 inches, and the average size of the cavity nest platforms was 58 square inches. Cavity trees in the pin oak-overcup oak type and in the elm-ash-maple type had mean diameters of 25 and 24 inches, respectively; and the nest platforms averaged 115 and 103 square inches, respectively. Cavities in big trees were also located at a greater height from the ground.

Most cavity entrances originated through dead or broken limbs; and small, rapidly growing trees with small limbs produced cavities with small entrances. The entrances tended to be reduced even smaller through growth. Big trees with big limbs and slow growth formed cavities with big entrances. Trees in the elm-ash-maple type and in the upland hardwood type contained cavities at smaller diameters than trees in the pin oak-overcup oak type (Table 4). The average entrance sizes of cavities in the former types were 31 and 33 square inches, respectively. In comparison, entrances of cavities in the pin oak-overcup oak type averaged 68 square inches.

Cavity depth was probably related both to cavity age and to the rate of decay. Cavities in the elm-ash-maple type were deepest. Trees in this type not only formed cavities early, but may also have formed them more rapidly. The moist site upon which this type grows may have contributed to rapid decay.

Although rapid decay would enable rapid cavity development, it would also shorten cavity life. As decay proceeded, the bottom of the cavity would recede farther from the entrance until it would no longer be a desirable wood duck nest site. Bellrose *et al.* (1964:664) found that, "Cavities less than 50 inches deep were preferred for nest sites. . . ." Woodpeckers or limb scar decay, however, may provide additional entrances at locations closer to the nest platform; and a cavity may thereby regain its utility. Squirrels often add new nest material to cavities, and this may lengthen cavity life. The bole of one tree in this study was completely hollow except for a two-foot section filled with twigs and leaves wedged tightly inside the cavity to form a nest platform. Squirrels in this case had made a potentially useful wood duck nest site from a decadent cavity.

Cavity Usage in Different Timber Types

Table 5 summarizes cavity usage by wildlife. The data represent

TABLE 5. TREE CAVITIES USED BY WILDLIFE ON MINGO NATIONAL WILDLIFE REFUGE

Species	Pin Oak-Overcup Oak (31 cavities)		Elm-Ash-Maple (35 cavities)		Upland Hardwood (43 cavities)	
	Number	Percent	Number	Percent	Number	Percent
Squirrel only *Sciurus niger* and *S. carolinensis*	13	42	12	34	24	56
Raccoon only *Procyon lotor*	4	13	4	11	1	2
Both squirrel and raccoon	5	16	1	3	13	30
Pileated Woodpecker *Hylatomus pileatus*					1	2
Barred owl *Strix varia*	1	3				
Totals	23	74	17	48	39	90

not only recent use but also use during some past period for which evidence still remained. This method probably overestimates current usage. In addition, it may overestimate usage by species that leave much evidence, as squirrels, and underestimate usage by species that leave little evidence, as birds or snakes. For the purposes of this study, however, the method appeared to be satisfactory.

Use by squirrels was the most evident, and total cavity usage appeared to be mainly related to squirrel density. The highest squirrel population seemed to be in the upland hardwood timber, which also had the highest cavity usage. The elm-ash-maple timber was poor squirrel habitat, and this type showed the lowest cavity usage. However, the lower usage in bottomland timber is partly due to the lower quality of cavities. For example, a higher proportion of bottomland cavities were near the ground where they were subject to flooding. In addition, shallow open-top cavities, which are little used, were more prevalent in the elm-ash-maple type than in the other two types.

Evidence of raccoon use was found in all timber types. In the upland timber, nearly all of the cavities were also used by squirrels; but, in the bottomland, most were not. If frequent occupancy by raccoons prevents use by squirrels, some of these bottomland cavities may have been raccoon dens, which squirrels avoided.

Cavities Used by Wood Ducks

Most cavities suitable for wood duck use were checked once during and once after the nesting season. None of the cavities on the transects was used by wood ducks, but six cavities used by them were found in other locations by contacting local people and by general observation. Of the six cavities, one each was in a willow oak, pin oak,

white oak, and a dead slippery elm (*Ulmus rubra*). Two more were in sycamores (*Platanus occidentalis*) which leaned over creeks. These two contained the only successful nests. A local resident reported that one of the sycamore cavities had been used for nesting nearly every year for the past 11 years. This cavity was the only one of the six found that did not contain evidence of squirrel or raccoon usage. Of the four unsuccessful nests, three were apparently destroyed by raccoons and the fourth by a snake.

Dimensions of the cavities used by wood ducks are given in Table 6.

TABLE 6. MEASUREMENTS OF SIX CAVITIES USED BY WOOD DUCKS DURING THIS STUDY

Dimension	Mean	Range
Tree d.b.h. (in.)	21	13–27
Entrance size (in.)	3 3/4 × 3 1/4	3 1/2 × 3 to 4 1/2 × 3 1/2
Nesting platform size (in.)	8 1/2 × 8 1/2	7 × 7—10 × 10
Cavity depth (in.)	22	12–42
Height from ground (ft.)*	32	18–52
Distance from water (ft.)*	240	0–1, 320

* Estimated—not measured.

The cavity entrances were uniformly small. Wood ducks at Mingo may tend to nest in cavities with small entrances which raccoons would be less likely to enter. Bellrose *et al.* (1964:665) found that cavities containing successful nests were more likely to be used in following years than those containing nests that were destroyed. They also found that wood ducks preferred to nest in high cavities and in those with small entrances (1964:663-664). The two successful nests found in the present study were both located 50 feet or more from the ground. Five of the six nest trees were located either on roadsides or on streambanks. The sixth was in an open stand of upland hardwoods. Four of the six cavity entrances apparently had been made by pileated woodpeckers. The cavities originated from other sources and developed through heart rot.

CAVITY ABUNDANCE RELATED TO TIMBER HARVEST

Unmanaged Area

In 3.7 acres, nine cavity trees containing 14 cavities were found (Table 7). Three of the trees contained more than one cavity. Cavity tree density was 2.4 per acre, but it would have been much higher if the stand density of this area had been comparable to the unmanaged areas that were studied in the general survey (Table 1). Most of the

TABLE 7. SPECIES COMPOSITION AND CAVITY ABUNDANCE IN UNMANAGED PIN OAK-OVERCUP OAK TIMBER ON MINGO NATIONAL WILDLIFE REFUGE (ACRES SAMPLED = 3.7)

Species	Number of Trees*	Number with Cavities	Number of Trees Per Acre*	Percent with Cavities
Pin oak *Quercus palustris*	34	4	9.2	12
Overcup oak *Quercus lyrata*	24	0	6.5	0
Willow oak *Quercus phellos*	12	0	3.3	0
Baldcypress *Taxodium distichum*	8	2	2.2	25
All others	7	3	1.9	43
Totals	85	9	23.1	11

* 10.0 inches d.b.h. or larger and includes only live trees.

cavities were too small for wildlife use, but three were used by squirrels. None of the cavities was suitable for wood duck use, and no wood duck nests were found.

Managed Area

In 4.2 acres (adjacent to the unmanaged area), five cavity trees (Table 8) containing one cavity each were found. Squirrels used one of the cavities, but none was suitable for wood duck use, and no wood duck nests were found. Cavity tree density was 1.2 per acre, or only half that of the unmanaged area.

Examination of this small sample suggests that timber harvest in

TABLE 8. SPECIES COMPOSITION AND CAVITY ABUNDANCE IN MANAGED PIN OAK-OVERCUP OAK TIMBER ON MINGO NATIONAL WILDLIFE REFUGE (ACRES SAMPLED = 4.2)

Species	Number of Trees*	Number with Cavities	Number of Trees Per Acre*	Percent with Cavities
Pin oak *Quercus palustris*	29	1	6.9	3
Overcup oak *Quercus lyrata*	23	0	5.5	0
Baldcypress *Taxodium distichum*	23	2	5.5	9
Ash, green and pumpkin *Fraxinus pennsylvanica* and *F. profunda*	9	0	2.1	0
All others	6	2	1.4	33
Totals	90	5	21.4	6

* 10.0 inches d.b.h. or larger and includes only live trees.

the managed area reduced cavity-tree density by half. Such a reduction is in general agreement with the experience of Mingo Refuge workers who have cruised and appraised the timber. Although tree density was nearly equal in both areas (Table 9), most of the trees in the managed area were small. With the exception of baldcypress, none of which was cut, pin oak was the only species on the managed area occurring in diameters larger than 15.5 inches. In the entire sample only two pin oak trees were larger than 21.5 inches. In addition, trees in the managed area had a slightly lower incidence of cavities than those of similar size in the unmanaged area. The primary reason for the lower cavity tree density, though, was the scarcity of large trees.

DISCUSSION

This study indicates that natural cavities suitable for wood duck nesting are extremely scarce over most of the Mingo National Wildlife Refuge. Although the time-consuming nature of the work permitted only a portion of the refuge to be surveyed, it is believed that the areas selected for the general cavity survey were representative of those *most likely* to contain wood duck nest cavities. Because the refuge timber contains so few of the kinds and sizes of trees in which suitable cavities occur, it is unlikely that additional study would reveal a higher cavity density.

Cavities are most abundant in older upland hardwood and elm-ash-maple forests, but these types comprise only a small part of the total timbered acreage on the refuge. The pin oak-overcup oak type, which is predominant, contains few suitable cavities, partly because large trees are scarce and partly because the dominant species are not good cavity producers.

Not only are suitable cavities scarce on the refuge, but competition for them, especially by squirrels, appears to be heavy. This further reduces the availability of cavities to wood ducks. Thus, it is concluded that a shortage of nest sites probably limits the wood duck nesting population. Since wood duck production is a primary objective of the refuge, consideration should be given to correcting this situation.

SUGGESTIONS FOR MANAGEMENT

The literature indicates that park-like stands of large trees may provide optimum nesting habitat for wood ducks. The six cavities used by wood ducks in this study were all located in open situations. Bellrose (1955:36) found that nest boxes in open woodlots were more frequently used than those in dense woods. Grice and Rogers (1965:17) found wood ducks nesting in clusters of large trees

TABLE 9. RELATIONSHIP BETWEEN TREE SIZE, TREE DENSITY, AND CAVITY OCCURRENCE IN MANAGED AND UNMANAGED PIN OAK-OVERCUP OAK TIMBER ON MINGO NATIONAL WILDLIFE REFUGE

	D.B.H. Size Classes									
	10.0–15.5		15.5–21.5		21.5–27.5		27.5—		Totals	
	Trees per Acre*	Percent with Cavities	Trees per Acre	Percent with Cavities	Trees per Acre	Percent with Cavities	Trees per Acre	Percent with Cavities	Trees per Acre	P Ca
Unmanaged	11.4	7.1	8.1	6.7	2.2	25.0	1.4	40.0	23.1	
Managed (cut)	14.5	4.9	5.7	4.2	.7	0.0	.5	50.0	21.4	

* Only live trees are included.

rather than in large trees standing alone or surrounded by trees of smaller size. An attraction for clusters of large trees may partly explain nesting in yards, near roads, and in city parks, reported by many workers (Dixon, 1924:42; Gigstead, 1938:605; Musselman, 1948:197; Bellrose, 1955:10; Grice and Rogers, 1965:16).

If open stands of large trees are preferred for nesting, then it appears that timber management for lumber production is detrimental to nesting habitat. Merchantable trees are cut before cavities can develop in them, and the few large trees that remain may become surrounded by dense stands of young trees within a short time.

On Mingo and on other areas where wood ducks are of primary interest, management for nesting habitat should aim toward developing a self-propagating forest that is well stocked with cavity-prone species. The forest should be relatively open and should contain a maximum number of mature and overmature trees. It could be produced by selective thinning to favor cavity-prone species. Such thinning requires constant good judgment by the worker, for rigid guidelines cannot be established. However, thinning should be confined to intermediate and overtopped trees. Opening the canopy should be avoided, for shading kills limbs and thus aids cavity formation. In addition, shading prevents the rapid growth of an understory which eventually would destroy the open nature of the stand. If selective thinning is too expensive or time-consuming, the forest could be left unmanaged. It would take longer to obtain the desired conditions by this method, but less effort and expense would be needed. At Mingo mast production is also a forest management aim, but management for cavities would not conflict with management for mast production since in both cases a good supply of large trees is needed.

Because wildlife management is the most important objective of the Mingo Refuge, there are no obstacles to applying these methods to all of the timber there. However, this is not true on areas where lumber production is the primary objective. On these areas, though, perhaps strips of deciduous timber along streams and around ponds or lakes could be left unmanaged. In deciduous forest areas strips, one-half mile wide would be ideal, because this width would include most of the wood duck nesting habitat. However, even narrower strips would be beneficial. In most forest lands, setting aside only a small portion of the total acreage would be required. In view of the increased demand for recreational use of public land, this method would be useful in other ways as well. For example, erosion might be better controlled; stream and lake-side recreation would be more aesthetic; and the strips could serve as small "natural

areas" in which uncommon plants and animals might find suitable habitat.

It is recognized that many facts concerning the management of wood duck nesting habitat remain unknown. For example, we do not know how many cavities per acre are sufficient for high wood duck production, but it would be better to provide too many cavities than too few. Even areas where a cavity shortage does not now exist may become deficient in cavities if other habitat factors are improved and the nesting population increases.

The argument has been made that a less expensive method for providing nest sites would be to erect nest boxes rather than to manage timber for cavities. It is true that, if cavities are scarce, the erection of nest boxes may increase wood duck production; and on a small scale, this is an acceptable method. If timber is managed for lumber, however, nest boxes would need to be used on a wide scale; and the disadvantages of such use are often overlooked. For example, much time and money would be needed each year to construct, erect, and maintain the boxes. Box maintenance is often neglected; and if nest boxes are allowed to deteriorate, a severe drop in wood duck production can result. Since it is not feasible to produce all wood ducks in nest boxes, primary emphasis should be placed on increasing the numbers of natural cavities.

Cavity formation is a process requiring many years to complete, and mistakes made in timber management are not soon corrected. Where wood duck production is a primary objective, wildlife managers should produce an abundant and continuing supply of natural cavities before considering management of the timber for lumber.

SUMMARY

A study of natural tree cavities in relation to wood duck nesting was made on Mingo National Wildlife Refuge. Belt transects were used to sample both managed and unmanaged timber. Three different timber types had different cavity densities which were determined by species composition, stand density, and tree size. Cavity formation and cavity use by wildlife are discussed. Timber management for lumber production appears detrimental to wood duck nesting habitat. Management sugestions for improving and maintaining nesting habitat are presented.

LITERATURE CITED

Allen, D. L.
1942. Michigan fox squirrel management. Mich. Game Div., Publ. 100. 404 p.
Baumgartner, L. L.
1939. Fox squirrel dens. J. Mammal. 20(4): 456-465.
Bellrose, F. C.
1955. Housing for wood ducks. Ill. Na. Hist. Survey, Circ. 45. Second printing, with revisions. 48 p.

———, K. L. Johnson, and T. U. Meyers
1964. Relative value of natural cavities and nesting houses for wood ducks. J. Wildl. Mgmt. 28(4): 661-676.
Bent, A. C.
1923. Life histories of North American wildfowl, order Anseres. U. S. Natl. Museum, Bull. 126. 244 p.
Dalke, P. D.
1948. Some observations on den trees in the Missouri Ozarks. J. Wildl. Mgmt. 12(1): 107-109.
Dixon, J.
1924. Nesting of the wood duck in California. Condor 26(1): 41-66.
Dreis, R. E., and G. O. Hendrickson
1952. Wood duck production from nest boxes and natural cavities on the Lake Odessa Area, Iowa, 1951. Iowa Bird Life 22(2): 18-22.
Gigstead, G.
1938. Wood ducks in the Illinois river bottoms. Trans. N. Amer. Wildl. Conf. 3: 603-609.
Grice, D., and J. P. Rogers
1965. The wood duck in Massachusetts. Mass. Division of Fisheries and Game. Final Report, Federal Aid Project No. W-19-R. 96 pp.
Gysel, L. W.
1960. An aid for climbing with a rope and saddle. J. Forestry 58: 517.
———.
1961. An ecological study of tree cavities and ground burrows in forest stands. J. Wildl. Mgmt. 25(1): 12-20.
Hawkins, A. S., and F. C. Bellrose
1941. Wood duck habitat management in Illinois. Trans. N. Amer. Wildl. Conf. 5: 392-395.
Marbut, C. F.
1902. The evolution of the northern part of the lowlands of southeastern Missouri. Univ. Mo. Studies. 63 p.
Musselman, T. E.
1948. A changing nesting habitat of the wood duck. Auk 65(2): 197-203.
Stuewer, F. W.
1943. Raccoons: their habits and management in Michigan. Ecol. Monographs 13(2): 203-257.

DISCUSSION
SESSION III

CHAIRMAN JESSEN: This session on knowledge and voids in our understanding of habitat management for wood ducks is now open for discussion.

A. D. GEIS (*Bureau of Sport Fisheries and Wildlife*): We all come here with the handicap of asking questions on the wood duck based on our own experience. I couldn't help but think, as I listened to Frank McGilvrey's discussion of production habitat, that there must be an awful lot of wood ducks produced in habitat types other than those described. This is particularly true in the East, where so much production is associated with streams that have a fairly substantial width. There must be a great many broods reared in areas that lack 75 percent cover that is suggested as desirable. So I wondered if we couldn't benefit from others' impressions concerning whether it is necessary to have the extreme density of cover that Frank observed being used heavily at Patuxent. I know my own observations in other portions of Maryland and West Virginia suggest that wood ducks seem to be getting along very nicely in areas with much less than 75 percent cover.

CHAIRMAN JESSEN: I agree with you, Al. I know that in Minnesota wood ducks have increased in numbers in recent times, just as was reported for the Chippewa National Forest. Some game managers report more wood ducks than mallards outside of the range that has been designated as the historical breeding range. These areas are in prairie country, and they don't agree with what Frank described as typical wood duck habitat in the East. Though the birds are apparently breeding successfully in some prairie areas, we don't understand the relationships involved.

F. B. MCGILVREY: This is a good point. We need to pool individual observations from many people to find out what really constitutes good wood duck brood habitat.

A. D. GEIS: One thing that's very difficult is to differentiate between actual habitat needs and uses. The birds obviously like very dense cover when it's

available to them. Whether they really need it in order to develop successfully is another question.

R. A. HUNT: I'm curious about the paper that Bob Jessen read on cavity formation. I recall reading that woodpeckers were at one time considered important in providing cavities for wood ducks. Could Frank Bellrose, or someone else, comment on whether we rely primarily on natural fungi to form cavities, or whether woodpeckers also make cavities?

F. C. BELLROSE: We have pileated woodpeckers in the Illinois Valley. But the woodpecker holes we have seen have not been large enough for wood ducks. Perhaps woodpecker holes would be used by wood ducks if they were enlarged by decay, squirrels, or other activities.

W. WEIER: At Mingo Swamp there is at least one cavity made by a woodpecker which is deemed suitable for wood ducks. Apparently this cavity was made by woodpeckers and was used by wood ducks in the same year. I also managed to find six cavities that were used by wood ducks in the general vicinity of my study area. Entrances to four cavities apparently had been made by woodpeckers. The entrances seemed to have been built from the outside, not from the inside of the cavity.

R. A. HUNT: Did woodpeckers make the cavity, as well as enlarge the entrance?

W. WEIER: Yes, apparently they opened the cavity through their work. The cavity was already present and the woodpecker seemed to have made an entrance available.

J. P. ROGERS: I'd like to add to Wayne's comment on the Mingo Swamp. While I don't have any idea what density of pileated woodpeckers are present, I think they are abundant. We need to know how important they are in formation of cavities for the wood duck.

F. C. BELLROSE: We have heard many comments on types and values of brood habitat. I believe we must determine how essential different cover types are to the welfare of wood ducks. Brood counts are valuable for making evaluations because frequently the tremendous loss in wood duck broods occurs between Class One and Class Two. Through 25 years we obtained hundreds of brood counts, but unfortunately we have never tabulated and analyzed them all, except on the broadest basis. But it looks to us that the more open an area is, the higher the loss of ducklings. Where woody cover is abundant, duckling survival is better. Records on open areas, such as farm ponds and the like, show that entire broods were lost in a few days.

W. E. GREEN: I'd like to address a question to Frank McGilvrey. I think one of the very interesting things he observed at Patuxent is a rather substantial brood shrinkage in that superb production habitat. What brood shrinkage did you find?

F. B. MCGILVREY: It depends on what you call substantial shrinkage. In the last two years, 10 ducklings per brood hatched and 5 ducklings were raised. This is 50 percent survival, which I think is not too bad in any species.

To get information on brood survival hens were marked. Hens were painted year before last. This didn't work well at all. Neck banding was tried this year for the first time. So anything I tell you now is preliminary.

Several hens that hatched in open impoundments either lost their broods entirely on the way to heavy cover, or the broods were reduced to very small sizes. Very large broods were reared by other hens that both hatched and reared their ducklings in heavy cover types. An exceptional example involved a hen that reared 13 out of 15 ducklings she hatched. Based on a small number of breeding birds, I believe we get substantially better survival where broods don't have to do a lot of moving—where cover is readily available. However, for some unknown reason, some hens tend to move all over creation, no matter how good the brood habitat is. I don't have the foggiest idea why this movement occurs.

Progress reports on our studies are available in the back of the room. We are just starting on this study. We hope to have additional information in a few years

on relationships of brood survival to brood cover. A real high population of snapping turtles is present at Patuxent, and I suspect this is our major predator.

F. C. BELLROSE: Available information shows that brood shrinkage is greater on areas having less brood cover than on areas with an abundance of brood cover. A gentleman in western Pennsylvania told me about two broods. One brood was on a pond in his estate where there was an abundance of vegetation, and the other brood was on a pond lacking vegetation. The brood on the pond without vegetation shrank to zero within a week, while the other brood survived well on the pond having an abundance of vegetation. This is just one isolated case, but it is typical of other observations that we have made.

C. G. WEBSTER: This summer Frank McGilvrey and I had the pleasure of visiting the White River Refuge in Arkansas. I was astounded at the number of sycamore and cypress trees with cavities that apparently were quite suitable for wood ducks. I am sure most of the cavities were started by woodpeckers. They were so located that they were not started from limbs breaking off. I think this is another situation where we should stop speculating and learn the facts involved. They might be extremely important in managing forests for squirrels and woodpeckers where they are important to wood ducks.

G. F. PUSHEE (*Massachusetts Division of Fisheries and Game*): Dave Grice has made studies of wood duck brood survival in Massachusetts. In years of good production, when we figured our wood duck population was expanding, he figured about 40 percent brood survival. He found less than that now, and we don't know why. These survival figures were obtained in an area of heavy cover, what Frank McGilvrey called optimum brood cover.

Determining brood survival is difficult. Dave's feeling is that unless the ducklings are young, it's difficult to determine what exactly constitutes a brood. As ducklings get older, members of different broods combine. This behavior pattern was established by trapping and tagging ducklings continually through the growing season. Because ducklings of different broods tend to come together, you may be misled by establishing brood survival on the basis of the number of ducklings observed in a brood.

H. L. DILL: There are cases where dense brood habitat may not be needed to insure survival of broods. At the Union Slough National Wildlife Refuge in Iowa we recorded a breeding wood duck population of 25 pairs. Admittedly the population could have been larger because wood duck are difficult to see.

We know there are only 25 acres of timber on the refuge, which is located in the prairie of northern Iowa. Small farm groves are the only other timber in the vicinity. However, most of the trees in these farm groves are box elders, which have "chimneys." Nevertheless, a molting population of 200 wood ducks is recorded. In addition, there are two roosts on the refuge where a total of 1,300 woodies is recorded. Refuge personnel have banded nearly 300 wood ducks yearly. This stretch of wetland habitat is almost completely disassociated with timber, yet it has an abundance of heavy cover that I consider suitable for wood duck broods, molting adults, and migrants.

G. F. MARTZ (*Wisconsin Conservation Department*): I want to direct this question to the group. What is known about the ability of wood ducks to move broods some distance over uplands?

F. C. BELLROSE: We have found wood duck broods less than 48 hours old 2 to 2½ miles from water. But ordinarily hens don't nest this far from water. In Illinois we have never found broods moving over land from one body of water to another, except for very short distances.

In the Canadian prairie it is common to find half-grown broods, three-quarter grown broods, and full-grown broods of ducks traveling overland from one prairie slough to another. But our observations in Illinois indicate this is very uncommon in the wood duck. However, wood duck ducklings commonly make short treks from the nesting cavity to rearing cover.

F. B. MCGILVREY: My marked hens with broods provide some information

on distances ducklings move. Some broods were taken as much as 1 to 1½ miles from an impoundment with no cover, to an impoundment with cover. I can't be absolutely sure how they got there. I suspect they went over land to the river, down the river, and then left the river to enter the impoundment.

There is apparently a lot of nesting along the Patuxent River, but we never see broods along the river. It is very poor habitat within the the Patuxent Refuge boundaries. Apparently all the hens take their broods from the river to impoundments for rearing.

P. F. SPRINGER (*South Dakota Cooperative Wildlife Research Unit*): I think we ought to consider the economics of habitat management. George Brakhage mentioned three methods of providing food. I think they were clearing, flooding, and supplemental planting. I wonder if he has any information on the relative costs of using the three different methods?

G. K. BRAKHAGE: The cost of cull clearing was $30 per acre, but the operator went broke. Millet planting only cost a little over $5 an acre. This was without fertilization. I have no way of giving information on the cost of flooding. It involves too many gates to control water. We didn't pump. We flooded by gravity flow from a reservoir designed for this purpose.

Duck use by wood ducks and mallards is routine in these pools. We find a good deal more use by wood ducks and mallards in pools which are cull cleared and those which have millet planted. This is shown in a 1964 paper by Merz and Brakhage in the *Journal of Wildlife Management*. We demonstrated the value of millet plantings in timber by using duck kill per hunter as an index to duck use of specific habitat types.

W. A. AULTFATHER (*Bureau of Sport Fisheries and Wildlife, Minneapolis*): I think we would be amiss if we didn't mention that mallards play an important part in wood duck management throughout the United States. I am sure that if we took a poll of all public areas managed primarily for wood ducks, we would find they are a rather insignificant portion of the total land area having potential for wood ducks.

Waterfowl refuges can serve as practical demonstration areas. However, there is a question in my mind as to how practical it might be to approach a bottomland woodland owner and suggest that he maintain short-bolled, open-crowned, high mast-producing oaks. Likewise, I think considerable opposition might be met if bottomland trees were to be flooded and killed, rather than being retained as productive timber. We have to remember that suggested practices should have economic application to lands other than those held primarily for wood ducks.

C. G. WEBSTER: There is an important point I'd like to make concerning provision of brood habitat in connection with green tree reservoirs. Some of us recently visited an experiment station in Mississippi and saw two timbered impoundments that had been flooded periodically for over 10 years, if I remember correctly. Water was held on one impoundment for the first four years until the first of July. Then the other impoundment was flooded. Water was held on it for six consecutive years. From what we could gather from the researcher who took us around and from what we could see, the flooding had little or no effect on the health of the trees or on mast production. I think we ought to be a little more objective in determining what we can and can't do in the way of flooding timber. We need to do a little experimenting. We might be able to use these reservoirs for brood habitat, as well as for feeding waterfowl. We can kill two birds with one stone that way.

F. E. HESTER (*Bureau of Sport Fisheries and Wildlife, North Carolina*): I'd like to cite a couple of observations to help you visualize brood-rearing habitat for wood ducks and overland travels of broods. We have a pond where we attracted nesting wood ducks to the extent that a large number of broods are produced there each year. But apparently the ducks do not recognize this pond as a suitable brood-rearing area. They lead their broods to a mill pond 1½ miles away after the ducklings are out of the nest a few days. We have web-tagged

ducklings and found them on the mill pond, so we know these are the same birds. They are on the pond long before they can fly. This mill pond very closely resembles what Frank McGilvrey described as his example of brood-rearing habitat.

In making the trip from the nesting site, which is at a pond on a small tributary stream, the broods do not follow the stream to the main river. Rather, they cut overland in the most direct route to the river on which the mill pond is located. This is a rather short trip of something like 300 yards, but I think it is of some importance that the ducks do not follow the water course. They stride directly overland to the river and subsequently go up the river to the mill pond.

R. A. MCCABE (*University of Wisconsin*): I'm a little surprised that not more was mentioned about the natural predator base in the various areas being considered as brood-rearing areas. It is entirely conceivable that there is a spectrum of predators on these various natural habitats. Thus, you could be comparing dying timber and brush, which could have numerous natural predators, against a relatively open area, which could have few natural predators. I think there's a tendency here to concentrate so much on what's happening to the wood duck that we haven't been looking enough at the predator and the complete ecological picture. We must take a broader view in making judgments about what is quality brood habitat.

F. B. MCGILVREY: The gentleman was commenting that perhaps there would be less predator pressure on areas having less cover. He's absolutely right. On the open ponds, where broods do not stay, we get practically no predation on Canada geese or mallards that stay there and nest. Yet wood ducks seem to have a psychological urge that apparently is satisfied by going to a timbered area. They don't stay in an open area. Whether there are predators or no predators doesn't seem to make a bit of difference to wood ducks. If there are timbered areas within walking distance of the brood, and the Lord only knows what that is, the ducklings will go there. If there isn't any dense coverage within a reasonable distance, as at Union Slough, the broods apparently stay put. But if they have a choice of habitat types, I don't think the predator level will influence which habitat type is used.

SESSION IV

Wednesday Evening, December 8

Toastmaster: A. S. HAWKINS
Bureau of Sport Fisheries and Wildlife,
Minneapolis, Minnesota

GROUP DINNER

EXPERIENCES WITH HOME-GROWN WOOD DUCKS

FREDERIC LEOPOLD
The Leopold Company, Burlington, Iowa

I was pleased to have a telephone call several months ago from Art Hawkins offering me an opportunity to join you here and to tell you something of my project involving nesting wood ducks. In fact, it was Art and Frank Bellrose who got me started in this hobby about 1938 or 1939. In the beginning I knew nothing about the subject, and my tutors still had much to learn too. Time is short, so I won't reminisce. But I have enjoyed the experience. Though this material is presented as a lecture illustrated with slides, a manuscript will be submitted for the proceedings of this symposium.

DESCRIPTION OF PROJECT

My operating area comprises about a square block of town property located on a steep bluff rising about 120 feet above the main channel of the Mississippi River in Burlington, Iowa. The ducks visit my place for nesting purposes only, there being no marsh or feeding or loafing water on my side of the river.

Across the channel, a half mile or more away in Illinois, there is wild swamp land and timber where the birds live, feed, have their territories and rear their young.

To give you an idea of the information collected on my project, I have listed the years showing the number of nesting attempts, number of available nest sites or boxes, total eggs for the year, total ducklings hatched and, lastly, nest or broods lost to predators (Table 1).

My nesting project has had substantial local newspaper publicity

TABLE 1. WOOD DUCK NESTING RECORDS FOR WOODEN BOXES ERECTED AT BURLINGTON, IOWA, 1943-65.*

Year(s)	Nesting Boxes			Eggs			Nests Destroyed By Predators	
	No. Available	No. Used	Percent Used	No. Laid	No. Hatched	Percent Hatched	No.	Predator(s)
1943	3	3	100	35	30	86	0	
1944	14	5	36	67	57	85	0	
1945	12	9	75	133	99	74	0	
1946	12	6	50	82	76	93	0	
1947	14	8	57	108	83	77	0	
1948	15	13	87	156	117	75	0	
1949	14	9	64	180	129	72	0	
1950	16	10	63	142	102	72	0	
1951	19	17	89	237	182	77	0	
1952	19	17	89	205	174	85	0	
1953	24	19	79	232	195	84	0	
1954	20	8	40	108	75	69	0	
1955	22	5	23	61	61	100	0	
1956	21	7	33	83	76	92	0	
1957	19	9	47	116	102	88	1	Squirrel
1958	19	12	63	149	142	95	1	Raccoon
1959	17	16	94	214	188	88	0	
1960	22	18	82	257	152	59	1	Raccoon
1961	20	20	100	248	166	67	5	All squirrels
1962	17	20	118**	328	168	51	0	
1963	16	19	119**	258	178	69	3	Raccoon, owl, rat snake
1964	21	15	71	191	135	71	4	Raccoon (1), squirrels (2), ? (1)
1965	22	16	73	218	173	79	2	Squirrel, snake
TOTAL	398	281	71	3,808	2,860	75	17(6%)	

through a near neighbor who, for years, was editor of our daily paper. As a result, many citizens have become interested and have erected nesting boxes. Our park superintendent must have 30 nesting sites, many of which are occupied each year. All told, there may be over 100 boxes in or near Burlington. I attempted to get annual reports on these boxes, but the data were not considered reliable enough to be acceptable.

Several approaches were used to stimulate and help people wanting to aid wood ducks. On request, I mail a mimeographed sheet of instructions for making, erecting, and completing annual maintenance of nest boxes. I have shown my pictures and given a talk on nesting wood ducks to perhaps 25 groups in Burlington and surrounding towns.

LOCATION OF NEST BOXES

My placement of boxes was affected early by the noticeable preference by ducks for locations well away from the brushy edge of the bluff which rises from the river. Ducks used boxes in trees surrounded by mowed lawn. Several most popular locations are less than 20 feet from two homes. In fact, I placed one box so I could see it clearly through a window in my bedroom when my head rested on my pillow. It was occupied in the second year. I have also hung one box on the east wall of my home. No takers, as yet, but I wouldn't be too surprised if it were used. I hung it just below a bedroom window for easy inspection and for taking pictures when the time comes.

This very evident preference for nesting sites near dwellings must be based on an attempt of the breeders to get away from predators. Certainly the ducks greatly fear people, but their fear of predators must be even greater.

This brings up the question, why do woodies nest right in the middle of populated residential areas where their broods have almost no chance for survival? I think it is, in part, because their forebearers have used these same areas through the centuries. We are the intruders, not they. In Burlington, and I'm sure we are no exception, these birds bring off broods year after year as far as a mile, or even more, from the river or from the nearest water area. We can, therefore, safely assume that through the centuries woodies nested that far from rearing areas. Only those habits or customs which succeed are perpetuated.

The first birds arrive in my yard in late March and the last bring off their broods as late as late July. Each pair goes through three stages or phases during their occupancy: (1) nesting, (2) incubation, and (3) hatching and departure.

NESTING

Nest-Site Selection

First comes the period of nest-site selection late in March and early April. The mated pairs arrive in my yard soon after sunrise and leave by mid-morning. They sit around in the leafless trees just looking things over. Soon the hen will approach a nest box which she may enter, while her spouse awaits nearby. It is not unusual to see at a given time a half dozen or more pairs so engaged. I have never seen the male enter a nest box. I'm sure a particular hen will investigate several nest boxes. She will often scoop out a shallow depression in the litter of several boxes. After a series of mild days, her first egg is laid. This ends the nest-selection period of perhaps five or six days.

Egg Laying

Egg laying occupies 12 to 14 days and is followed by the incubation period, which averages 30 days. So, a given hen or pair will be with me about 50 days before the hen departs with her brood if all goes well—hopefully to return a year later.

A study of egg laying showed that out of 297 potential egg days, only 13 days were skipped. In terms of percentage this means the "egg-a-day" expression was 96 percent correct. From a practical standpoint, this result may be said to "prove-the-rule." The average clutch for early nests was 13.9 eggs. Later nests, usually second attempts, contained a lesser number and dropped to as low as six eggs.

The first four to six eggs are normally buried in the litter. Then there is the abnormal nest called a "dump nest." In these nests the eggs are left exposed (unburied) except in some instances where one hen may get broody and drive the other egg layer out and proceed to incubate in a normal way. I have had dump nests in which as many as four eggs have been added in one day. Total egg count in dump nests have reached the upper thirties in my boxes.

Getting back to normal nest procedures, the hen starts picking down from her breast with the fourth to the eighth egg. Coincidentally, the eggs are no longer buried in the litter.

Egg laying is generally in the first hours of daylight. While the hen is busy in the box, the drake awaits nearby. When she has finished her chore for the day, the two birds depart—not to return until next morning.

An exception is often made during the time the last two or three eggs are being dropped. At this time the hen may return in late evening and spend the entire night in the box, presumably picking

down. This overnight stay of the hen does not start development in the eggs. This development seems to require the continuous presence of the hen, both day and night. If this were not so, the eggs would not all hatch the same day.

PREDATION

Those of you who have managed nesting projects in much wilder areas than my city will probably marvel at my comparative freedom from predation. I know that when Frank Bellrose was most discouraged by his raiding predators in the 1950's, I was still practically free of predators.

Note in Table 1 that for the first 14 years no nests were destroyed by predators. Gray squirrels spoiled this record and damaged nests in two ways. On one occasion they buried eggs being incubated under nearly a foot of leaves. Hidden in and under the leaves I found four live adult squirrels. I grasped their tails and quickly heaved the animals overboard. The duck had deserted, probably several days earlier. This situation was never repeated. In subsequent years gray squirrels commenced removing and eating eggs, usually several per day. This was usually during the egg-laying period when the hen was not present. Some hens continued to lay each day, until either they or the squirrels gave up. In 1961, five nests were destroyed this way.

In 1958, my first raccoon problem appeared when a box lid was removed and all eggs destroyed in one day. Most of the cleanly lapped egg shells were left in the box. Case number two was recorded two years later. Then, in 1963, a raccoon killed an incubating hen and largely devoured her and the eggs in the box. This box was an old one with a 4-inch diameter round hole. The same year, presumably a horned owl killed and then devoured a hen on the lid of the nesting box, leaving the eggs undisturbed.

In 1963, I discovered a rat snake swallowing incubated eggs. Three eggs had already been eaten. I removed the snake. Later the hen returned and some days later successfully hatched the remaining eggs. In 1965, a rat snake was observed entering a nest from which ducklings had departed that very morning. Two unhatched eggs remained, one of which the snake swallowed. As I was taking photos down into the box, a second rat snake climbed the oak tree, looked me in the face at a range of about 18 inches and joined the other snake in the box. Both were removed and later released some miles away.

Raccoons have trouble entering 3-inch x 4-inch oval holes. Edges of such holes are frequently heavily gnawed by frustrated predators. Successful hatches have occurred in numerous gnawed boxes.

Ducks have never succeeded in driving off nesting screech owls from my boxes, but ducks have displaced screech owls that were using boxes as a daytime refuge only.

Winter screech owls seem to specialize on cardinals as prey. Duck boxes, used as havens during the day and as headquarters for dining on prey, contained many cardinal feathers, mostly primaries and tail feathers. Mandibles, clearly of cardinals, were found. Apparently most bones were removed and disposed of elsewhere. Feathers of other bird species were also present, but I believe not in a normal ratio with available bird populations.

INCUBATION

Incubation usually commences immediately after the last egg is laid. Infrequently the hen may take a day off before settling down to incubate.

Normal procedure during this period is for the hen to take two rest flights per day, very early in the morning and in late afternoon. Forty minutes to an hour are usually devoted to this purpose. On departing from the nest, the hen joins her drake at his territory. He normally accompanies her on the return flight. He seldom stops, usually turning about and returning to his marsh territory.

On first nestings, the drake attends the hen well into the fourth week of incubation. Cessation of this habit may be due to the hen no longer seeking him out or to his loss of interest. Probably the purpose of the drake's attendance is a matter of insurance. If the hen's nest is destroyed, she will still have a mate ready to fertilize her eggs in the second nesting attempt.

Duration of incubation varies from 27 to 33 days but about half the nests hatch in 30 days and two-thirds in from 29 to 31 days.

Observers interested in determining probable hatching dates can use the following formula with fair chance of success. First, determine the date on which the last egg of the clutch is laid. Since most eggs are deposited at the rate of one per day, only one observation count taken during the egg-laying period is needed, plus a second observation after all eggs are laid. For example, assume 8 eggs are observed on April 10th, and 13 eggs on April 20th. This is confirmed the next day when 13 eggs are counted. Therefore, 5 eggs were laid after April 10th, making April 15th the probable date of the last egg. Most clutches hatch in 30 days. Therefore, the probable hatching date is May 15th. Since wood duck eggs are first pipped two days before they hatch, start making nest inspections during the rest flight period on May 13th. You will soon know the hatching date, and, therefore, the date of exodus of the ducklings.

Unusual Incubation Observations

In 1947, I observed a nest in a natural cavity containing 21 eggs on which incubation started on April 15th and continued without interruption until June 16th, a period of 62 days before the hen gave up. The floor of this nest was very broad and, in my opinion, the eggs spread widely and allowed the outer eggs to chill. All embryos died.

In 1965, a hen completed her clutch of 12 eggs on June 28th. I checked her almost daily from July 27th through August 27th, when she failed to return. Incubation had lasted 59 days. Upon examination, all of the deserted eggs appeared to be infertile. This hen was so late in laying eggs, that she may have lacked a mate or her drake may have left her too soon.

In 1949, I watched a nest which seemed normal during egg laying, but at hatching time I discovered a hen wood duck carcass at one edge of the nest covering five or six spoiled eggs. Her flesh and intestines were almost all gone, only bones and feathers remained. Alongside, snuggled against the decaying hen, was a second wood duck who eventually brought off 12 ducklings. Does this case indicate that wood ducks have a poorly developed sense of smell?

HATCHING AND DEPARTURE

When the eggs are hatching the hen usually remains at her nest constantly, thus making it difficult to determine the exact hatching period. Normally, I believe, a period of four to six hours will span the time from hatching of the first egg to the last one. Exceptions can be caused by an intruding hen depositing an extra egg in the nest during the first day or two of incubation. Such eggs, of course, would be correspondingly later in hatching.

Leaving the Nest

The newly hatched young are, for a few hours, nearly helpless, but they soon transform into vital little bodies of soft down. They become alert, and in half a day they attain a remarkable degree of physical activity. A day later, they can run, dodge, dive under water for several yards, and jump out of most any container you may try to gather them into, except a soft cotton sack, which I use for such occasions.

Ducklings usually spend one night in the nest box before the mother calls them out. Normally, on the day of exodus, the hen takes a morning rest flight. An inspection of the nest while she is gone will show the young "frozen" in the nest. All heads are apt to be down, and scarcely a quiver can be detected. The lighter markings

on head and belly are hidden from view, and most eyes are closed. The down, which may have been a layer 1½ to 2 inches thick, has mostly been solidified by contact with the ducklings' wet bodies. Most egg shells have been reduced to chip size, and the sacks or membranes are hidden under the babies. If this inspection is made with the hen at home, she will be defensive and several little heads may appear on the edge of her plumage, but no peeps are given.

When the mother returns from her rest flight, she broods her young for an indeterminate period. Given a bright warm day, she may start preparations to leave with her brood within an hour, or even less. However, on a chilly rainy morning, she tends to wait until the rain stops, or the grass dries a bit and the temperature improves.

When she decides the time is propitious, she climbs to the entrance hole and surveys the area for signs of danger to her precious brood. A slammed door, a passing dog or person, or any unusual sound or sight will discourage or frighten her. She then drops back into her box. No sounds from the hen or her brood are heard at this point. This up-and-down procedure may be repeated many times or only a few times.

After the hen decides the coast is clear, she makes a few low calls, which sound to me like *kuk, kuk, kuk*. She drops to the ground quite near the nest tree and continues her low calls. Very soon answering peeps come from the box. Ducklings climb to the opening and after a brief hestiation, they jump. This is not just a fall, but an outward jump. Often they strike the ground four to six feet out from the tree.

Upon alighting on short cut lawn and hard ground, the ducklings may definitely bounce four to six inches high. When they make a bad landing, as on their back or head, they seem stunned, but this is usually only momentary. In watching many hundred jumps, I have seen only one duckling killed. Normally they are immediately on their feet, peeping loudly to call the mother's attention. As soon as they locate their mother, they run to join her.

Never have I seen a baby wood duck make the descent by any method other than this jump. Once or twice I have seen the hen re-enter the box after a few babies have jumped, but she never, in any way, assisted the young in their descent. Once or twice a hen has called to her young while she perched on a nearby limb, but she has dropped to the ground long before the last duckling was out.

If danger in the form of a dog or cat or person appears during the exodus, she will depart with those ducklings she has with her. If the danger is only momentary and she is still quite close, she may wait

for laggards or return in answer to their distress calls, bringing her little ones with her. Usually the young string out behind their mother, more or less in single file, especially in open ground.

Occasionally when the hen departs before all the ducklings have jumped out, I put the deserted young in a cotton sack immediately after the hen departs and proceed to the railroad track at the river bank. There I watch to see exactly where the hen and young cross the track at the river's edge, which is against the railway embankment. When she has crossed, I quickly advance, concealed in the ditch on the landward side of the tracks, and move quietly to the exact spot where the brood crossed. Here I take out a duckling, which is now peeping loudly. The hen, being nearby, answers with her call. I then release all the ducklings, and they scramble down the embankment and join the rest. This has worked many times for me.

A successful way was developed for joining orphan ducklings to a foster mother. I often receive telephone calls to the effect, "I have X number of ducklings; can you help me?" If I happen to have a brood due to exit next morning, I receive the orphans. They are either inserted in the nest box after dark, or, if I plan to watch the exodus next day from my blind, I keep the ducklings overnight in a padded bucket placed over a gas pilot burner or in some other improvised brooder. Next morning I take them to the blind and, while the hen is calling her brood from the box, I release my ducklings and they join the brood. The hen readily accepts them.

Now and then I get a call advising me that someone has captured not only ducklings, but the hen as well. A method was perfected for executing a calm and peaceful release of such a family. Put the young in one thin cotton sack and the hen in a second sack. Take along a sizable corrugated carton and a ball of string. Carry everything to a suitable release area at the border of a swampy spot. Place the carton open side to the ground and cut a 6-inch opening in the top of the box, leaving one edge uncut to act as a hinge. Drop the hen first and then the ducklings through the hole into the box, which will be dark when the flap is closed. Fasten your string to the front or release side of the box. Wait 10 minutes for the ducks to calm down. Then, standing 50 feet behind the box, slowly pull the string.

This raises the desired edge of the box to clear the ground. When the opening is sufficient, the hen quietly walks out with her ducklings following. Thus, you have a calm, peaceful release of the entire family at a proper pre-selected spot.

Duckling Mortality

Newly hatched ducklings may be lost in a variety of ways, as I

found to my great regret several years ago. In one nest, five healthy ducklings were deserted because they were unable to climb to the hole. The lumber from which I had built several new boxes was not rough enough to give them a secure toe hold. I watched for over an hour from my portable blind while the hen wandered around under the tree calling to the remaining nestlings. Following her closely were the ducklings that had succeeded in escaping. The hen finally had to leave the 5 young in the nest.

Seeking to prevent a repetition of this tragedy, I decided to cut a strip of old carpet to serve as a gangplank to the exit hole for the next brood. On this occasion I watched from my blind until the duck left for her morning rest flight. Then I climbed to the nest and fastened the strip of rug in place with three small tacks, each requiring only two or three light taps of a tack hammer. I immediately closed the lid and climbed down the ladder. As I removed the ladder, the first duckling appeared at the hole and jumped out. In a moment all 11 young were on the ground around me peeping loudly and scattering through the lily-of-the-valley surrounding the tree. Very evidently the "freezing" reaction had broken down under the stress of the tack hammer blows on the box. The hen never found these scattered young.

Trek to Rearing Cover

Getting back to my typical brood. As soon as the last duckling emerges from the nest, the hen heads for water. In my case, this means the big river which lies 120 feet below my yard. Those broods hatched well back from the bluff follow a course which takes advantage of every bit of available cover. When openings must be crossed, the pace is rapid and the mother stretches her body as low as possible. At the next covert she slackens the pace to allow the trailing young to catch up.

The passage down the bluff is very rough and very steep. Then comes a single railroad track. The hen rests her brood before tackling the crossing of the rails. Despite her fears, the ducklings jump over the rails quite easily. The river bank lies 15 to 20 feet below the track. In times of fairly high water, there is enough flooded emergent cover to give a feeling of security. But during periods of low water, when a bare mud bank borders the water, the hen marshals her brood and immediately sets out to cross to the Illinois shore a half-mile away. The young cluster close to the hen, and some seem to engage their little toes in her plumage to get assistance. If the group is not forced to return to the Iowa shore by passing boats, large and small, they complete the crossing in about 20 minutes. I

have watched pleasure craft pass quite close to broods as they made their voyage, but in no case have the boat people showed any sign of noticing the ducks.

Once across, there is plenty of swamp and water with emergent cover to provide the ducks a bit of security. There is no practical way for me to follow the broods to their new homes, so my story ends here.

SESSION V

Wednesday, December 8

Chairman: R. D. VAN DEUSEN
Kellog Bird Sanctuary, Michigan State University

ARTIFICIAL METHODS OF HELPING BREEDING WOOD DUCKS—APPROACHES AND NEEDS

CHARACTERISTICS AND VALUES OF ARTIFICIAL NESTING CAVITIES

F. C. BELLROSE and F. B. MCGILVREY
Illinois Natural History Survey, Havana, Illinois and Patuxent Wildlife Research Center, Laurel, Maryland

Wood ducks readily accept artificial nesting devices in many regions of the United States. Although a truly amazing variety of nesting houses erected in various places have been used by woodies, this does not guarantee that every nest house program will be crowned with success. Some projects have been dismal failures.

We learned much about the nesting requirements of this duck from studies of natural cavities and nest houses. But until we know more about the responses of wood ducks to artificial nesting houses throughout their range, we must proceed carefully in forming recommendations to use nest houses as a means of augmenting natural production.

CHARACTERISTICS

The greater the availability of natural cavities for wood ducks, the more nearly predator-proof the nesting houses must be to contribute substantially to production. Where natural cavities are scarce or wanting, nest houses should be at least as safe as natural cavities. Because they are conspicuous, artificial houses are more apt to attract the attention of predators than are natural cavities. To be of value, nest houses must have some built-in predator deterrents, or must be erected in a way that deters predators.

NEST PREDATION

The list of animals preying upon wood duck nests varies from year to year and from place to place. The raccoon (*Procyon lotor*) is

at the top of the list almost everywhere that studies have been made. Fox squirrels (*Sciurus niger*), mink (*Mustela vison*), bull and rat snakes (*Pituophis melanoleucus* and *Elaphe obsoleta*), starlings (*Sturnus vulgaris*), and woodpeckers (*Melanerpes* spp.) are other important predators that destroy wood duck eggs and nests.

Raccoon Problem

Raccoons can be deterred from reaching nests in several ways. Elliptical entrances, 3 x 4 inches (Bellrose, 1953), and tunnel guards, 4 inches in diameter and 10 inches long (McLaughlin and Grice, 1952; Grice, 1960), have been used to prevent or deter raccoons from entering nest houses. Unfortunately, south of the Mason-Dixon line, adult raccoons are small enough to enter nest houses equipped with special entrances (Webster and Uhler, 1964). Both north and south of the Mason-Dixon line raccoons are also able to reach nests in many houses placed on posts in farm ponds and small impoundments.

To keep raccoons and other arboreal animals from reaching nest houses placed on posts, Uhler and McGilvrey (1965) used aluminum guards, 9 inches wide by 38 inches long, sandwiched around the posts. In five years of testing at the Patuxent Wildlife Research Center no raccoon or other arboreal animal has reached a nest house so shielded.

The elliptical entrance of the galvanized-pipe nesting house developed by Bellrose (1953) to reduce predation of nests by fox squirrels, mink, and bull snakes also prevented raccoons 10 pounds or larger from gaining access to nests. Although, in Illinois, nest predation by bull snakes was greatly reduced in metal houses, Smith (1961) reported that the larger rat snake in Louisiana continued to be the most important wood duck nest predator, even in metal houses. In Illinois in 1958-62, 73 percent of the wood duck nests in metal houses were successful, whereas in natural cavities in 1958-61, only 39.9 percent were successful (Bellrose *et al.*, 1964).

The galvanized-pipe nesting house is not initially as acceptable to wood ducks as the board house. The undercoat liner of the metal house appears to be objectionable to some wood ducks. Although liners of fiberboard are more readily accepted, they last through only one season of active use. A more satisfactory liner for metal houses is needed and should be developed in the near future.

Starling Problem

Although the problem of wood duck nest predation by arboreal animals has been partially solved, the problem posed by starling predation of nests appears more difficult. Fortunately, starlings consti-

tute a major threat only in populous areas where there is an interspersion of woods and farmland. Starlings did not become a menace to nesting-house wood ducks until the last decade. The loss of eggs in wood duck nests to starlings was not serious in Illinois until 1962, when 18.5 percent of the nests were destroyed; corresponding percentages for 1963 and 1964 were 23.8 and 20.6 percent respectively. Starlings also usurped large numbers of houses, many of which undoubtedly would have been used by wood ducks.

An indication that starling use of wood duck houses may eventually be reduced or eliminated lies in Francis Uhler's discovery that nesting starlings are more intolerant of light than are nesting wood ducks (Uhler and McGilvrey, 1965). At Patuxent, this fact was taken into account in the successful design of a horizontal nest house made of a cylinder 24 inches long and 12 inches in diameter provided with a 4- x 11-inch entrance (Fig. 1). Two types of material have been used for horizontal houses: galvanized metal pipe and woven wire covered with crushed-rock roofing paper. Wood ducks readily accepted both types of horizontal houses and the exceedingly large entrances. Starling use of these houses has been almost negligible. The houses were erected on metal posts in small impoundments. Metal guards around the posts prevented raccoons from gaining access to the large entrances. Further testing of this design is essential to determine whether wood ducks were conditioned to use these houses by their previous experience with vertical metal houses at Patuxent. Moreover, various starling populations may respond differently to large entrances.

The horizontal house for wood ducks is limited to installation on posts in water areas. It could not be used successfully in trees because of the potential destruction of nests by arboreal animals. Nor could the large entrance be used in vertical houses, at present, without resultant nest destruction by raccoons. To discourage starling depredation, we attempted in Illinois to permit more light to enter vertical houses and yet retain the raccoon-deterrent entrance. Five holes, each 2 inches in diameter, were bored in close proximity to the 3- x 4-inch elliptical entrance. In spite of the additional light entering the nest cavity, starlings nested in the new houses as readily as in the older models.

Most of the wood duck nesting houses in the Atlantic Flyway have been erected on fence posts placed in the shallow water of ponds and marshes. In the Mississippi Flyway, most of the nest houses have been erected on the trunks of trees, usually back from the water's edge. Severely fluctuating water levels prevalent on many

Figure 1. Horizontal Wood Duck Nesting House. Design of this new structure was based on F. M. Uhler's discovery that nesting starlings are more intolerant of light than are nesting wood ducks. Considerable light enters the 24-inch long, 12-inch diameter cylinder provided with a 4- by 11-inch entrance. Raccoons are prevented from gaining access to the large entrance by metal guards of .020 guage aluminum 9″ wide and 38″ long. They can be two strips bolted together (see left guard) or a single piece folded and bolted on one side (see right guard). When placed in small impoundments, the bottom of the guard need be no higher than maximum pool level. Structures erected in this manner were readily used by wood ducks, were seldom visited by starlings, and were easy to check by canoe at the Patuxent Wildlife Research Center. Additional tests of this house are needed at other locations.

water areas in the Mississippi Flyway preclude the extensive use of post-attached houses.

VALUE OF HOUSES

Unquestionably, nesting houses can increase local breeding populations of wood ducks. For example, at Quiver Creek in Mason County,

Illinois, only 10-15 pairs of wood ducks nested in a 4-mile stretch prior to the placement of wood duck houses. After nesting houses were erected, the breeding population rose to stabilize at 90-100 pairs.

On a more extensive scale, the value of wood duck houses to production can be measured by house use. Bellrose *et al.* (1964) have shown that a high rate of nest-house use indicates a high rate of nest success.

Natural cavities in Illinois provided sites for successful nests for 28 to 54 percent of the wood ducks using them during a 6-year period. Cavity use ranged from 26 to 55 percent.

Atlantic Flyway

The largest concentration of wood duck nest houses and some of the highest rates of use have been in New England. In Massachusetts, McLaughlin and Grice (1952) reported 45 percent use of 1,200 nest houses. Over a 10-year period, Beckley (1964) found 66 percent of 6,225 houses used in Connecticut. Cronan (1957) reported that, in Rhode Island, wood ducks occupied 53 percent of 102 boxes in 1955, and 72 percent of 85 houses in 1956. In Vermont, Miller (1952) reported that the rate of use of 60 to 100 houses ranged from 70 percent in 1949 to nearly 90 percent in 1951.

Elsewhere in the Atlantic Flyway, Klein (1955) found that 22 percent of 135 nest boxes on 38 marshes on farms in New York were occupied by wood ducks. Decker (1959) had rates of use of from 15 to 57 percent of 32 to 79 houses on a marsh in northwestern Pennsylvania. At the Patuxent Research Center in Maryland, wood ducks occupied 26 percent of 136 houses of various types in 1964, and 30 percent of 137 houses in 1965 (Uhler and McGilvrey, 1964 and 1965). Hester (1962) reported a high rate of use of nest houses by wood ducks on a series of small ponds near Raleigh, North Carolina.

Mississippi Flyway

Most of the nest-house programs in the Mississippi Flyway have been in the northern half of the flyway. The largest number of wood duck houses have been erected in Ohio, where from 874 to 1,569 boxes were available between 1954 and 1962 (Martinson, 1962). The occupancy of these houses varied from 15.6 percent to 31.7 percent. Illinois has had the second largest number of houses in the flyway: from 334 to 723 board houses were available between 1939 and 1945 (Bellrose, 1953) and from 273 to 308 metal-pipe houses were available between 1958 and 1962. The average rate of use of the board

houses by wood ducks was 49 percent; average for the metal houses was 40 percent.

At Burlington, Iowa, Leopold (1951) had from 3 to 17 houses in his yard, in 1943-50, and found from 3 to 12 of these houses occupied each year. Farther up the Mississippi River at Lake Odessa, Iowa, wood ducks nested in 69 percent of 26 board houses in 1950 (Shreiner and Hendrickson, 1951).

The rate of use of wood duck houses in Wisconsin has been low (Jahn and Hunt, 1964). Of 345 to 404 houses examined between 1965 and 1958, an average of only 9 percent were used. From 1951 to 1961, Louisiana biologists checked a total of 1,229 houses for wood duck nests and found that 33.8 percent had been used (Smith, 1961).

CONCLUSIONS

Many wood duck nesting houses, besides those mentioned, have been erected in both the Atlantic and Mississippi Flyways, but no published records of their use are known. Enough is now known about the use of nesting houses in many areas of the wood duck's range for us to realize the potential value of this management tool. However, nesting houses will not be of optimum value until the following improvements are made:

1. Wood duck houses erected in trees south of the Mason-Dixon line need deterrents to small raccoons and rat snakes.
2. Galvanized-pipe houses need liners which are initially more acceptable than undercoat to wood ducks.
3. A vertical box needs to be developed which will deter starlings from using it for nesting.

When these challenges are met, artificial nesting devices can be recommended for large-scale programs designed to increase the production of wood ducks on a flywaywide basis. Until better wood duck houses are devised, more pilot house programs should be inaugurated, especially in the southern states. Investigations should provide information on occupancy by wood ducks in relation to habitat, predator pressures, desirable grouping and density of houses, optimum placement of houses, and similar factors.

Woods in the Mississippi Delta country and along major streams are being bulldozed at an increasing rate to create more farmland. We can anticipate only a continuing decline in natural nest sites for wood ducks as our human population increases. As our waterfowl resource becomes more valuable in the years ahead, management measures that at one time were economically impractical become more

and more feasible. In this context we should keep in mind the use of wood duck houses as a tool in waterfowl production.

LITERATURE CITED

Beckley, O. E.
1964. Wood duck nesting box program. Conn. State Board of Fisheries and Game. 36 p. (mimeo.)

Bellrose, F. C.
1953. Housing for wood ducks. Ill. Nat. Hist. Survey, Circ No. 45. 47 pp.

Bellrose, F. C., K. L. Johnson, and T. U. Meyers
1964. Relative value of natural cavities and nesting houses for wood ducks. J. Wildl. Mgmt. 28(4): 661-676.

Cronan, J. M.
1957. Effects of predator guards on wood duck box usage. J. Wildl. Mgmt. 21(4): 468

Decker, E.
1959. A 4-year study of wood ducks on a Pennsylvania marsh. J. Wildl. Mgt. 23(3): 310-315..

Grice, D.
1960. An appraisal of the wood duck's status in Massachusetts. Proc. Northeast Wildl. Conf. 16: 1-12 (mimeo.).

Hester, F. E.
1962. Survival, renesting and return of adult wood ducks to previously used nest boxes. Proc. Southeast Wildl. Conf. 16: 1-15 (mimeo.).

Jahn, L. R., and R. A. Hunt
1964. Duck and coot ecology and management in Wisconsin. Wis. Conserv. Dept., Tech Bul. No. 33. 212 pp.

Klein, H. G.
1955. Wood duck production and use of nest boxes on some small marshes in New York. N. Y. Fish and Game 2(1): 68-83.

Leopold, F.
1951. A study of nesting wood ducks in Iowa. Condor 53(5): 209-220.

Martinson, K. R.
1962. The use of wood duck nest boxes in Ohio, and suggestions for a nest box program. Ohio Dept. of Nat. Resources, Olentangy Wildl. Expt. Sta. Release 8 pp. (mimeo.).

McLaughlin, C. L., and D. Grice
1952. The effectiveness fo large-scale erection of wood duck boxes as a management procedure. Trans. N. Amer. Wildl. Conf. 17: 242-259.

Miller, W. R.
1952. Aspects of wood duck nesting box management. Proc. Northeast Wildl. Conf. 8: 1-6 (mimeo.).

Schreiner, K. M., and G. O. Hendrickson
1951. Wood duck production aided by nesting boxes, Lake Odessa, Iowa, in 1950. Ia. Bird Life 21(1): 6-10.

Smith, M. M.
1961 Louisiana wood duck studies. Final report, July 1950-June 1961. La. Wildl. and Fisheries Comm. Tech. Rept. 25 pp.

Uhler, F. M., and F. B. McGilvrey
1964. Improvement of artificial nesting structures for waterfowl. Annual Progress Rept., Sect. of Wetland Ecol., Patuxent Wildl. Research Center. 12 pp. (mimeo.).
1965. Improvement of artificial nesting structures for waterfowl. Annual Progress Rept., Sect. of Wetland Ecol., Patuxent Wildl. Research Center. 12 pp. (mimeo.).

Webster, C. G., and F. M. Uhler
1964. Improved nest structures for wood ducks. U. S. Fish and Wildl. Serv., Wildl. Leaflet No. 458. 20 pp. (mimeo.).

AN EVALUATION OF HAND-REARED WOOD DUCKS AT GOOSE ISLAND, MISSISSIPPI RIVER, WISCONSIN

R. A. HUNT AND C. F. SMITH[1]
Wisconsin Conservation Department, Horicon and Babcock

In the years 1958 through 1960, the Wisconsin Conservation Department and Badger State Sportsmen Club of LaCrosse, Wisconsin conducted an experimental wood duck (*Aix sponsa*) rearing project at Goose Island in the Upper Mississippi National Wildlife Refuge. The principal objective was to determine if the release of hand-reared wood ducks resulted in an increased local breeding population. While this study did not prove measurably successful, various aspects of the propagation program and band recovery data seem worthy of presentation.

BACKGROUND INFORMATION

At the time this project was developed in 1957, Mississippi Flyway wood duck populations were at a relatively low level. Closed seasons had been in effect in Wisconsin since 1954. In our experience, erection of hundreds of nest boxes and several years of harvest restrictions were doing little to improve the status of the species. Nest box utilization was averaging only 9 percent. We considered wood duck stocking worth exploring as a way to help the situation. There was some evidence from reports of Hanson (1951), Hunt (1956), McKeever (1945), McCabe (1947) and Yeagley (1953 and pers comm. November 1956), that (1) wood ducks could be hand-reared in large numbers and (2) some birds survived to return and nest in release areas. However, no major studies had evaluated wood duck propagation.

For a number of years, the Badger State Sportsmen Club had been rearing 1,000 or more mallards (*Anas platyrynchos*) annually for released near LaCrosse. State support was provided in the period 1949-1953 (Hunt *et al.*, 1958). Because of discouraging results from mallard stocking, Conservation Department personnel proposed that the club shift their propagation program to wood ducks. Club members expressed keen interest in the proposal and a three-year study was planned.

In a formal agreement, state responsibilities included provision of 200 breeders, $2,000.00 annually for feed and other equipment, supervision, and record keeping for all breeding, rearing, banding and releasing activities. Club obligations included providing a caretaker, rearing facilities and assistance in releasing. As part of the study, the state provided 1,500 feet of lumber for the club to build 100 nest

boxes. These boxes were to be put up in the Goose Island area. No difficulty occurred in meeting terms of the agreement.

GENERAL ASPECTS OF THE PROJECT

Basic propagation techniques were patterned after those used by the Illinois Department of Conservation. An inspection tour of Illinois facilities at Des Plaines and Yorkville was made in 1957. Considerable numbers of wood ducks were being raised at these stations for stocking purposes.

Study Area

Goose Island is a 400-acre island located six miles south of LaCrosse, Wisconsin. As part of the Upper Mississippi River National Wildlife Refuge, the area serves as a park and access site to the river. Most of the federally owned land in the refuge is open to general public use. About 4,500 acres around Goose Island are closed to waterfowl hunting. The Federal Government had granted permission for the club to establish waterfowl and pheasant rearing projects on the island.

Breeding and Rearing Facilities

A three-acre pond and two acres of land were enclosed by a six-foot fence of 1-inch chicken wire. To our knowledge, no adult or young woodies climbed over the fence. The club built a new 32 by 20-foot brooder house. Other buildings used in mallard propagation were made available for storing feed, etc. Capacity of the brooder house was 1,200 ducklings. It was necessary to fence off the breeding wood ducks on about one acre of water and land during the laying and incubation period due to interference by semi-domestic mallards. Some mallard hens tried to enter the nest boxes used by wood ducks.

Breeding Stock

Breeders obtained from the Illinois Conservation Department in the winter of 1957-58, were moved to Goose Isand in late March of 1958. All breeders were kept flightless by wing-clipping. Some breeders escaped each year after molting and young birds produced on the project were added to compensate for the loss. Sex ratios were maintained at about one male per female. Breeders were moved to winter quarters at a near-by game farm in 1959, but were held on the project in 1960. Egg laying began on April 30 in 1958, April 20 in 1959 and April 13 in 1960. We feel early egg laying in 1960 occurred because the birds were maintained on the project. In our opinion, some females did not lay eggs each year. Crowding may have been the cause, although some nest boxes never were used.

Nesting

Nest boxes had walk-up ramps. Wood shavings ½-inch deep were placed on top of 3 inches of dirt in the bottom. A total of 75 boxes were available. Single boxes were placed at 3-foot heights on trees along the shore and some were located inland up to 200 feet from water. Groups of six boxes were placed on posts over water in 1958. These boxes were back to back in pairs, and each pair was 4 feet apart. Few of these battery-type boxes were used. In 1959 and 1960 individual houses were erected over water at spacings of 10 feet or more. These proved to be the most preferred houses.

The greatest number of eggs was laid in an isolated box on a tree about 200 feet from the water. There were also several ground nests by wood ducks. In 1958 hand-reared mallards were laying eggs in nail kegs set in rows in the ground. It was not uncommon to find wood ducks laying eggs in these nests. None of the wood ducks incubated such nests, perhaps because the mallard hen did not permit it. In 1959 a wood duck hen successfully hatched a nest at the base of a willow tree. In 1960, one clutch of 12 eggs was hatched in an old box (15 by 18 by 12 inches) and another in a nail keg.

Hatching

Eggs were usually gathered at two-day intervals for artificial incubation. Weekly settings were the rule, although some eggs were held for about two weeks. Cost of incubation was five cents per egg. Incubation temperatures were maintained at 99.5 degrees Fahrenheit, and relative humidity at 90 percent. Eggs were sprinkled with water twice a day and were turned every four hours.

Candling of all eggs occurred after two weeks of incubation. Infertile eggs were removed at that time. Unhatched eggs were checked

TABLE 1. INCUBATION PERIODS OF HAND-REARED WOOD DUCK EGGS HATCHED NATURALLY AND IN INCUBATORS, GOOSE ISLAND, MISSISSIPPI RIVER, WISCONSIN, 1958

Days of Incubation	Eggs Hatched by Hen Wood Ducks		Eggs Hatched In Incubator	
	No.	Percent	No.	Percent
28	1	1	0	—
29	0	—	0	—
30	40	60	1	trace
31	6	9	17	6
32	19	28	29	10
33	1	1	60	22
34	0	—	81	30
35	0	—	67	25
36	0	—	16	6
37	0	—	2	1
Total	67	100	273	100

for stage of development. Natural incubation was permitted to compare with artificial hatching. Mechanical incubation often required more than 32 days for hatching an entire setting of eggs (Table 1). As a consequence, it was necessary to remove ducklings on a daily basis when hatching started.

Rearing

Ducklings were placed under brooders for 10 days. No serious problems were encountered in getting the ducklings to eat. Young mallards placed in pens with wood duck ducklings apparently aided in teaching the woodies to eat. Scattering commercial starter pellets around shallow water trays also seemed helpful. At the age of 10 to 21 days, ducklings were moved to a larger room where a brooder was still available. After 21 days ducklings were permitted access to an outdoor pen.

Diseases and Rearing Mortality

No major die-offs of ducklings occurred. However, small day-to-day losses were a constant drain on the rearing program. Most rearing losses occurred in the first two weeks of life. In 1958 a noticeable die-off, due to a respiratory infection, was apparently caused by dust from sphagnum moss used as litter. Changing to wood shavings eliminated the problem. In 1959, 20 ducklings died of infectious sinusitus. No losses to *Salmonella*, as described by Hanson (1951), were detected. Maintaining good sanitary conditions appeared to control and minimize diseases in the rearing stages.

Banding and Release

Almost all of the ducklings banded were color-marked with orange nasal discs and released at 8 weeks of age. Adults released in 1960 were marked with blue bill-markers. All releases occured in refuge areas.

RESULTS

Production Data

A summary of breeding and rearing data are presented in Table 2. A switch failure in the incubator in 1959, causing overheating, destroyed most of the eggs. Of 1,199 eggs only 114 hatched. As a result, no birds were released in the wild that year. Egg fertility ranged from 62 to 86 percent (based on eggs hatching plus fertile eggs that did not hatch). Hatchibility ranged from 65 to 69 percent for mechanical incubation and reached 90 percent for natural incubation. Some fertile but unhatched eggs were examined on the basis of criteria es-

TABLE 2. BREEDING AND REARING DATA ON HAND-REARED WOOD DUCKS AT GOOSE ISLAND, MISSISSIPPI RIVER, WISCONSIN, 1958–60.

Item	1958		1959		1960	
No. breeding females	93		98		160	
	Incubator	Hen Woodie	Incubator	Hen Woodie	Incubator	Hen Woodie
No. eggs incubated	579	98[1]	1,199[2]	180	1,450	450[3]
Percent of eggs						
Hatched	47	67	10	68	40	31
Fertile, not hatched	21	8	76	—	22	—
Infertile	23	12	⊥ 14	—	30	—
Misc. losses	9	11	⊥	—	8	—
Percent hatchability[4]	69	90	—	—	65	—
Ducklings reared						
Number	——216——		——180——		449	16
Percent[5]	—— 63——		—— 81——		80	—

[1] Of these 98 eggs, 55 were incubated by female mallards.
[2] Incubator overheated eggs and only 114 hatched.
[3] Twenty-two incubating hens deserted their nests on the day the first five broods hatched. Fertility of eggs in deserted nests was about the same as in natural incubation in previous years (± 75 percent).
[4] Based on number of fertile eggs only.
[5] Based on number of ducklings hatched and reared to release age of 8 weeks.

tablished by Hanson (1954). Most of the eggs had reached the late stages of development. For example, in a sample of 320 partially developed eggs, embryo deaths occurred in the following pattern: 9 percent in the first week, 14 percent in the second week, 17 percent in the third week and 60 percent in the fourth week. Rearing success ranged from 63 to 80 percent, a respectable level.

Behavior of female wood ducks that incubated clutches in 1960 was considered unusual. Thirty-seven nests containing 450 eggs were established. On the day that hatching started, five broods appeared. By the end of the next day, 22 incubating females had abandoned their nests to accompany the five broods of 57 ducklings. None of these 22 nests hatched. The remaining 10 nests produced 81 ducklings.

Banding Data

In 1958, 139 birds were color-marked and released. Of these, 97 were put in the Goose Island area and 39 were taken inland about 50 miles to the Dike 17 Refuge (1,500 acres) in Jackson County. Only two band recoveries occurred, both in 1958, from the release near Goose Island. One bird was shot locally, despite a closed season on wood ducks, and the other was shot in Texas. Field observations in search of marked birds in the spring of 1959 were without success.

Our best source of recovery data was from 1960 releases of color-marked birds at Goose Island. Table 3 summarizes the reports of color-marked immatures. Total recovery was 9.6 percent. First-year recoveries represented 87 percent. About equal numbers of each sex

TABLE 3. LOCATIONS OF RECOVERIES FOR IMMATURE HAND-REARED WOOD DUCKS RELEASED IN 1960 AT GOOSE ISLAND, MISSISSIPPI RIVER. WISCONSIN[1]

State of Recovery	Number of Direct Recoveries		Number of Indirect Recoveries		Total
	Male	Female	Male	Female	
Wisconsin[2]					
Local	11	9	2	2	24
Other	0	3			3
Minnesota	3	1			4
Iowa	1	2			3
Missouri	1		1		2
Texas	1				1
Arkansas	1				1
Louisiana	1				1
Totals	19	15	3	2	39

[1] Based on 207 immature males and 199 immature females banded and released with orange nasal discs. Another 33 immatures were released in September without being color marked. None of these 33 birds were recovered.
[2] "Local" refers to the Goose Island area. "Other" represents the area south of Goose Island on the Mississippi River.

were reported. High local vulnerability to hunting is suggested. Where dates of recovery were exact, 8 to 15 direct recoveries occurred on the opening week-end of the hunting season. A late September release of 33 immatures without billmarkers produced no recoveries.

In September of 1960, 10 immature males and 10 immature females from Goose Island were released by Dale Hine near Lansing, Iowa as part of a wood duck roost study. These birds were painted yellow on the back and under one wing. None of these birds was observed on near-by roosts. However, four direct recoveries occurred. Two females were shot near Lansing, and one male and one female were shot across the Mississippi River in Wisconsin.

Band recoveries were received from a few adult breeders. One bird was shot in 1958 near Goose Island despite a closed season on wood ducks. Two adults that escaped in 1959 were shot locally in 1961. At the completion of the 1960 breeding season, 57 adult males and 50 adult females were released with blue nasal-discs. Five males and five females were shot in 1960 and one of each sex in 1961. All were local kills.

Sight Observations

A considerable effort was made to locate bill-marked wood ducks each spring. None of the 1958 releases was observed in 1959. However, the 1960 release produced some sight records in 1961. A total of 6 individual immature females with orange bill-markers were found in the LaCrosse area and three others returned to the propa-

tion pen. One brood was observed from these birds in the propagation area. None of the adult females with blue bill-markers was ever observed, and no further sightings were received from the immature females. We know that two bill-marked males returned to the propagation pen in both 1961 and 1962. However, we could not locate our notes to establish the correct color of the bill-markers.

Nest Box Utilization

Frequent inspections of the 100 nest boxes erected by club members showed no use by bill-marked birds. Utilization of the boxes by wood ducks, however, increased in the following manner during the years of study: 1958, none used; 1959 and 1960, three used each year; 1961 and 1962, 20 used each year. We conclude that the increased local use paralleled the improving flyway wood duck population.

EVALUATION

In most respects this wood duck rearing project appears to have been a failure. Potentially, several thousand birds could have been produced. Instead, less than 600 were released. Relatively few sight observations of "homing" birds were obtained, and no evidence was found that stocked birds used nest boxes in the area of release.

A comparison with data in other studies, however, reveals a more optimistic appraisal. Bellrose (1958) summarized the recoveries and sight records of hand-reared wood ducks discussed by Hanson (1951), McCabe (1947) and McKeever (1945) and also from a 90-bird release made near Havana, Illinois in 1953. Band recoveries from these birds totaled about 11 percent, with 76 percent taken the first year. Bellrose concluded that the hand-reared females showed a strong homing response to the area of release. Nelson and Green (1962) tabulated banding data for several thousand wood ducks trapped on the Upper Mississippi River Refuge. These data showed an 11 percent recovery of immatures, with 81 percent occurring in the first year. Through a somewhat higher recovery rate occurred in their studies, the distribution pattern down the flyway for wild and hand-reared birds was similar.

Our band returns, however, were influenced by bill-making. Robert L. Jessen of the Minnesota Conservation Department (pers. comm., Nov. 1965) advised that bill-marking increased recoveries 31 percent in mallards and 20 percent in blue-winged teal (*Anas discors*). Assuming an influence of this magnitude, we still may have had 6 to 7 percent reported, a recovery rate that indicates survival comparable to wild-banded wood ducks. There is, of course, the point of how long bill-markers (silver solder pin and nylon discs) remained intact. We feel the birds were adequately marked into the first breeding

season. At least two males retained the marker into the second season.

Some speculation on the return of birds to the release area is possible from the studies by Bellrose (1958). In his analyses of hand-reared wood duck data, 15 sight observations of females returning to release areas were obtained. This may represent about a 10 percent return of females (assuming half of the 305 birds released were females). In our study, 9 females or 5 percent (of 199 color-marked females) were observed returning the first year from the 1960 Goose Island release. In nesting studies of wood ducks, Bellrose *et al.* (1964) reported that at least 6.5 percent of the yearlings returned to nest in houses.

It is also interesting to note that Bellrose *et al.* (1964) considered the first-year mortality of immature wood ducks banded before flight stage to be about 80 percent. Our birds were banded at a comparable age. On this basis, 40 color-marked females might have been alive to return from the 1960 release. The homing observations of 9 females in 1961 representd 22 percnt of those birds available to return.

SUMMARY

We feel that wood ducks can be reared succesfully for restocking purposes. Banding data suggest that hand-reared birds have similar migratory and mortality characteristics to wild-reared birds. We are in agreement with Bellrose that females show a good "homing" ability to release areas. The negative response to nest boxes in our study may have been influenced by an abundance of natural cavities (an unexplored possibility) and should not detract from the merits of the technique. Further interest in studies of hand-reared wood ducks in Wisconsin seem unlikely in view of the restoration of the species to huntable status in 1959 and currently favorable local and flyway population levels. Nevertheless, more study of wood duck stocking to increase local breeding populations appears justifiable where habitat is relatively unoccupied or if flyway populations again decline seriously.

LITERATURE CITED

Bellrose, F. C.
1958. The orientation of displaced waterfowl in migration. Wilson Bull. 70: 20-40.
Bellrose, F. C., K. L. Johnson, and T. U. Meyers
1964. Relative value of natural cavities and nesting houses for wood ducks. J. Wildl. Mgmt. 28(4): 661-676.
Hanson, H. C.
1951. Notes on the artificial propagation of wood duck. J. Wildl. Mgmt. 151(1): 68-72.
1954. Criteria of age of incubating mallard, wood duck and bobwhite quail eggs. Auk 71: 267-272.
Hunt, R. A., L. R. Jahn, R. C. Hopkins, and G. H. Amelong
1958. An evaluation of artificial mallard propagation in Wisconsin. Wis. Conserv. Dept., Tech Wildl. Bull. No. 16. 79 pp.
Hunt, R. M.
1956. My experience during 38 years of breeding and rearing game birds and wild waterfowl at the Mason State Game Farm. Mich. Dept. Conserv. 28 pp. (mimeo).
McCabe, R. A.
1947. The homing of transplanted young wood ducks. Wilson Bull. 59: 104-109.

McKeever, O. D.
1945. Illinois-Indiana wood duck experiment. P-R Quart. Dept. Proj. 2-R. Oct.
Nelson, H. K., and W. E. Green
1962. Wood duck banding—North Central region 1959-61. Presented at Technical Section, Miss. Flyway Council, July 31, 1962, St. Louis, Mo. (multilith.).
Yeagley, H. L.
1953. Some surprises in research. Audubon Mag. 55: 158-161.

THE ROLE OF ARTIFICIAL PROPAGATION IN WOOD DUCK MANAGEMENT

F. B. LEE AND H. K. NELSON
Northern Prairie Wildlife Research Center, Jamestown, North Dakota

The intent of this paper is (1) to present available information on propagating and releasing wood ducks, (2) to discuss pros and cons of release projects, and (3) to enumerate research needs. Game management of the future will undoubtedly become more challenging and complex, taxing the ingenuity of managers who must ever be seeking and testing new approaches. We are primarily interested in stimulating further thought on the possible role propagation and release of wood ducks have in future management programs.

EARLY INTEREST IN PROPAGATING WOOD DUCKS

The wood duck, with all its charm and beauty, became a favorite with aviculturists at an early date. Precise information on early propagation is fragmentary and our thoroughness in searching the literature for this paper was of necessity incomplete. But limited records show the species apparently became quite popular in Europe before it was raised very extensively in the United States.

Delacour (1959) indicates the wood duck was kept in France as early as 1663. Additional remarks on its early history in Europe are given by Job (1923) and Ripley (1957). Propagation was accomplished primarily in Belgium, Holland, France, and England. In early times American dealers acquired breeding stock in some of these countries for importation into the United States. Ripley (1957) cited one importation made as late as about 1920. Records show the wood duck was a favorite in avicultural collections, both at home and abroad.

The wood duck has been reared artificially in America since the time of Audubon (Phillips, 1928). Apparently a fair amount of interest had developed in breeding wild ducks in captivity by the 1880's. Accounts of attempts to rear the wood duck in captivity are given by Mather (1886, 1887) and Benschoter (1887).

Considerable interest in the wood duck developed at and following

the turn of the century as its population declined. Artificial propagation was frequently included among the proposals for preserving the species (Forbush, 1908). A paper by Fisher (1901) entitled "Two Vanishing Game Birds; the Woodcock and the Wood Duck" attracted considerable attention among conservationists. In 1907 the National Association of Audubon Societies published Special Leaflet No. 10 entitled *The Wood Duck* (Dutcher, 1907). It included a discussion of propagation as one of the methods by which the species might be preserved. This interest in artificial rearing of wood ducks and other wildfowl stimulated two publications on the propagation of waterfowl, including the wood duck, (Job, 1915, 1923).

That the wood duck breeds fairly readily in captivity is illustrated by the extent to which it is kept by aviculturists. This duck is very hardy, adjusts well to confinement, and is tolerant of other ducks—all favorable attributes. It appears, however, that hatching and rearing wood ducks are not nearly as simple as raising mallards or domestic waterfowl.

Literature review indicates that there is a paucity of published information on propagation techniques. Job (1915, 1923) and Phillips (1915) provide some information on the subject. Hanson (1951) provided the most thorough work and gives valuable information on hatching, rearing, feeding and sanitation to control disease. Other papers containing information on propagation of wood ducks are those of Hunt (1956) and Yeagley (1953).

Many past volumes of magazines, such as *Game Breeders Gazette* and *Modern Game Breeding,* contain considerable information on raising wood ducks. But most propagation appears to be on a relatively small scale, and published information on techniques for managing breeding flocks for mass production was not encountered. No doubt such techniques were developed in connection with propagation projects in Ohio, Wisconsin, and Illinois.

Aviculturists undoubtedly have a wealth of valuable information on the propagation of wood ducks. Raymond H. Cunningham of Minnesota has provided us with a detailed written account of some of his rearing methods. Copies of this statement are available upon request. This is only one example of the fine contributions made by aviculturists.

PRESENT STATUS OF PROPAGATION IN THE UNITED STATES

Present status of the wood duck in captivity in the United States is illustrated by examining recent issues of magazines, such as *Modern Game Breeding* and *Game Breeders Gazette.* The wood duck is a popular and commonly kept species. The supply of birds appears to

be good, and they are being offered for sale at $10.00 to $15.00 a pair. Records for 1964 and 1965 indicate that over 8,500 wood ducks are being held in captivity in the United States (Table 1).

PRIVATE PROPAGATION AND RELEASE PROJECTS

Several instances were noted of wood duck propagation and release projects in early years when there was so much concern over the

TABLE 1. WOOD DUCKS REARED OR HELD IN CAPTIVITY IN THE UNITED STATES, 1964–65.*

Region and States	No. of Propagators Having Wood Ducks	No. of Wood Ducks	
		Raised	On Hand At End of Year
Region[1]			
All states**	State listing not available	285	724
Region[2]			
Arizona	8	4	18
Colorado	3	—	12
Kansas	28	51	164
New Mexico	2	—	4
Oklahoma	8	38	96
Texas	39	36	162
Utah	7	19	38
Wyoming	—	—	—
Subtotal	95	148	494
Region 3			
Illinois	81	491	834
Indiana	40	146	459
Iowa	46	44	199
Michigan	37	52	195
Minnesota	59	459	580
Missouri	21	87	226
Nebraska	20	161	240
North Dakota	6	37	34
Ohio	47	169	271
South Dakota	5	24	33
Wisconsin	51	95	229
Subtotal	413	1,765	3,300
Region 4			
All states***	State listing not available	1,754	2,413
Region 5			
Connecticut	23	129	223
Delaware	4	32	60
Maine	6	10	38
Massachusetts	42	117	220
New Hampshire	14	56	66
New Jersey	37	142	216
New York	72	187	371
Pennsylvania	58	112	284
Rhode Island	6	93	54
Vermont	9	55	80
West Virginia	4	20	20
Subtotal	275	953	1,632
TOTAL	—	4,905	8,563

* Data are tabulated by Bureau of Sport Fisheries and Wildlife regions from records of the Division of Management and Enforcement. Data for Regions 1 and 4 are for 1964. Data for Regions, 2, 3 and 5 are for 1965, but may be incomplete due to late reporting.

** Region 1 is comprised of the following states: California, Idaho, Montana, Nevada, Oregon and Washington.

*** Region 4 is comprised of the following states: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, South Carolina, Tennessee and Virginia.

status of the species. Phillips (1928) states that some wood ducks were released by a Mr. Lorillard in New Jersey in 1884-1885. We are attempting to locate further information on this release.

Phillips (1960) tells of his experiences in raising wood ducks from 1909 to 1915 at Wenham, Massachusetts. The size of the free-flying flock is not stated precisely. But comments indicate that the released ducks did not migrate, thus posing somewhat of a problem. The paper contains the following general statement. "There are many places in the United States where the wood duck could be reared and liberated and a local breeding stock easily established."

A more complete account of such a project is described as follows by Job (1923). "On the Walcott estate the wood ducks, raised in confinement and allowed to fly, migrate but return and nest in boxes put up for them along the shores of a lake." "That wood ducks breeding in the wild state are now established in numbers on the Walcott preserve in Norfolk, Connecticut, after only two years of effort is a remarkable demonstration of what the system above described can accomplish. Two years ago Mr. Walcott bought three pairs of pinioned wood ducks from Wallace Evans, probably stock raised on the Evan's Game Farm. The first season, 1913, forty-five young were hatched of which twenty-six were raised. The first clutches laid were hatched under bantams, but the ducks were allowed to hatch their second layings. Only a few of these were pinioned. The rest migrated away for the winter, but mostly returned in the spring, and nested in the woods adjoining the lake where they were reared. In the autumn, 1914, about seventy of them were staying about this lake."

Ripley (1957) describes the propagation and release of wood ducks by Alain White of Litchfield, Connecticut, during a period following World War I to 1939. Most of the original breeding stock was purchased in Belgium and Holland. After a few years, the breeding stock numbered about 400 birds and from 200 to 400 birds were allowed to fly free each autumn. Free-flying wood ducks became very common around Litchfield as a result of these releases. Some of these birds were used to establish other natural breeding colonies in Massachusetts, South Carolina, and possibly other states. These ducks were banded with official U.S. Fish and Wildlife Service bands. More than 9,000 wood ducks had been reared when the program was terminated in 1939. Further study is needed of band recoveries from these birds.

Sharritt (1959) describes a wood duck propagation and release project of Jack Miner in Ontario. First cluthes of eggs collected from free-flying birds nesting in artificial boxes were set under gray call-duck hens. About 50 pairs of wood ducks nested about the sanctuary. But it is not clear how many pairs contributed to the releases.

Grayson and Grayson (1959) describe the propagation and release of 125 wood ducks in Virginia from 1956 through 1958. Some of these birds were known to have returned and bred in the area of release.

Over 1,000 wood ducks have been raised and liberated since 1951 by T. Donald Carter, Boonton, New Jersey (T. Donald Carter, pers. comm.). The birds were banded with Mr. Carter's private bands, and many recoveries were reported from the Carolinas, Virginia, and Georgia. Some of the wood ducks returned, and nest boxes provided in the area of release were used. About 20 or 30 remain throughout the winter in the area of release. We are corresponding with Mr. Carter for further information on his interesting project.

A recent private wood duck propagation and release project not previously reported is that of Raymond H. Cunningham, 3651 Rustic Place, St. Paul, Minnesota. The site of this project is a residential area in the north part of the city just off Rice Street, a main thoroughfare. Lake Vadnais lies about 350 yards to the east across Rice Street, and a small pond is found about 250 yards to the northwest across a railroad track. Table 2 contains pertinent data on Mr. Cunningham's project.

TABLE 2. WOOD DUCK NESTING BOX USE AND DUCKLING RELEASE AT PROJECT OF RAYMOND H. CUNNINGHAM, ST. PAUL, MINNESOTA.

Year	No. Ducks Released in Fall		No. Nest Boxes Available	Boxes Occupied	
	Males	Females		No.	Percent
1957	7	7	0	0	—
1958	0	0	7	5	71
1959	0	0	10	7	70
1960	8	7	10	6	60
1961	0	0	10	7	70
1962	0	0	12	7	58
1963	0	0	12	8	67
1964	5	0	14	11	79
1965	38	20	20	8	40
TOTAL	58	34	95	59	62

In the late summer of 1957 he allowed seven banded female wood ducks to fly free from his pens. These ducks migrated, and the next spring five of the seven available nest boxes were occupied by banded female wood ducks from this release. No birds were released in 1958 or 1959, but seven houses were occupied in the spring of 1959 and six in the spring of 1960. In 1959 two nest boxes were occupied by banded hens from the 1957 release.

The next release was in 1960 when seven unbanded females were allowed to fly free. Nest box use continued at a high level from 1958

through 1964 (Table 2). The highest number of boxes occupied was 11 in 1964. One of the five banded males released in the fall of 1964 returned in the spring of 1965 and mated with a pinioned female in the breeding pen. This past summer (1965) Mr. Cunningham released an additional 20 banded females. It will be interesting to see what degree of nest box use he finds during the spring of 1966.

Over-all results from this propagation and release project are outstanding. The release of seven female wood ducks in 1957 and 1960 apparently resulted in a total of 59 nesting attempts in the immediate vicinity of release during the subsequent eight-year period of 1958 through 1965. Mr. Cunningham believes that at least 400 young wood ducks left the nest boxes as a result of these nesting attempts. He describes the nesting situation as follows: "I have kept these nest boxes under almost constant surveillance during the nesting season and I am sure that all of the nests hatched, although many times hens had to return to boxes while the yard was full of screaming children. This occurred particularly after incubation was underway and hens were off nests for their evening feeding and resting period. This may have delayed hatching somewhat in a few cases but it did not interfere to the extent that any hen ever abandoned her nest. This success occurred in spite of the fact that a few clutches have been directly over (about 15 feet up) a children's swing set, merry-go-round, etc."

PROPAGATION AND RELEASE BY GOVERNMENT AGENCIES

A cooperative wood duck release project of the Illinois Natural History Survey and University of Wisconsin is reported by McCabe (1947). Ninety-seven young wood ducks, hatched and partially reared in Illinois, were raised to about 7 weeks of age and were released in August, 1944 at the University of Wisconsin Arboretum, Madison, Wisconsin. Wood ducks of both sexes returned to the area of release to breed in 1945 and 1946.

Also in 1944, the Illinois Natural History Survey and Indiana Department of Conservation released 95 wood ducks at the Jasper-Pulaski Game Preserve in Indiana (McCabe, 1947; Barnes, 1948). In 1945 at least four females returned to breed in the general area of release.

Bellrose (1958) describes the release of hand-reared wood ducks in Illinois in 1944 and 1953. In July, 1944, 20 ducklings were released at the Tribune Farm near Wheaton, Illinois. One hen returned to the area of release the next spring. In September, 1953, 90 young wood ducks were released on Quiver Creek near Havana, Illinois. At least three hens returned to the Havana area in the spring of 1954.

The wood ducks for both releases were reared at Havana, Illinois.

In Ohio a total of 1,939 hand-reared wood ducks were released in the wild during the four-year period of 1960 through 1963 (Bednarik and Hanson, 1965).

During the years 1963, 1964, and 1965, a total of 1,494 wood ducks were released at Provincial Wildlife Park, Nova Scotia (Eldon Pace, pers. comm.). Of these, 594 were banded and to date recoveries have been reported from eight provinces and states. Of the 110 wood ducks banded and released in 1963, nesting at the park by 3 birds in 1964 and 5 birds in 1965 was noted. In January, 1966 there were approximately 300 full winged-wood ducks at the park that were free to migrate but did not do so. In April and May the population can be expected to build up to approximately 800 wood ducks with the return of birds which have migrated. Pace indicates that, to his knowledge, there were no wood ducks at Provincial Wildlife Park or in the surrounding area 15 years ago.

Another project of this nature is that of the Badger State Sportman's Club at LaCrosse, Wisconsin, which was conducted in cooperation with the Wisconsin Conservation Department. R. A. Hunt has already reported on this project at this syposium.

PROPAGATION IN FUTURE WOOD DUCK MANAGEMENT

What should be the role of propagation and release of wood ducks in future management programs? There is no simple and clear-cut answer. From the standpoint of public agencies it appears that the problem can be narrowed to two facets: (1) propagation and release by private individuals and groups, and (2) progagation and release by public management agencies. Since available data were largely from private release projects, we considered the following aspects: (1) favorable considerations for private release projects, and (2) cautions and dangers in private release projects. Propagation and release by public management agencies are covered largely under research needs. Some points made under a particular topic apply generally to propagating and releasing projects.

Favorable Considerations For Private Release Projects

The wood duck's tolerance of man and compatibility with man's activities are exceptional (Leopold, 1951). Musselman (1948) describes some changes in nesting habits. Through its willingness to accept artificial nest sites, we are able to provide with relative ease an essential part of its breeding requirements. Besides being one of our finest game birds, it seems to be especially adapted for consideration

in land-use planning. Management of farm ponds and woodlots can benefit the wood duck.

Modern philosophies of resource management are placing greater significance on the total recreational attributes of a resource. The "do-it-yourself" idea is frequently expressed by individuals or groups who wish to engage in worthwhile conservation projects. Besides affording considerable recreation in itself, a wood duck release project may lead participants to develop a broad knowledge of conservation matters. Surely private propagation and release programs afford substantial personal recreational and educational benefits to the individuals involved.

Precise biological information on the survival of hand-reared wood ducks released in the wild is limited. But experiences are sufficiently rewarding to be considered worthwhile. Release resulting in the establishment of a small colony of free flying birds which sustains itself from year to year are judged to be satisfactory.

Wood duck release by private individuals may have some commercial aspects. The resort owner who establishes a breeding colony of wood ducks on his property surely has enhanced its value for the tourist trade.

Cautions and Dangers in Private Release Projects

Quality of breeding stock is an important consideration whenever birds are raised for release in the wild. As was previously stated, wood ducks were first raised in captivity many years ago. Whether or not genetic changes have occurred in strains held in captivity is unknown. But wildness and other desirable traits may have been affected. Only by carefully selecting breeders can the best quality offspring be assured.

Disease and its prevention are important considerations whenever fowl are reared in captivity. Hanson (1951) describes how duckling losses were caused by a paratyphoid organism. Whether the rearing program is large or small, a good sanitation program of brooders, rearing pens, and other facilities is essential. It is important that birds released in the wild be free of diseases which could be transmitted to other wild birds or to domestic fowl.

Lack of knowledge by individuals or groups who undertake wood duck propagation and release may contribute to complete failure of the projects. Costs of facilities for rearing wood ducks, and of the project in general, might be so high that funds would be better spent for some other purpose. Specific guidelines, spelled out in practical terms, are needed badly for distribution to interested persons.

Groups or individuals undertaking wood duck release projects

should do so with full knowledge that such projects will not be the solution to dwindling waterfowl populations. They should realize that, in addition to personal benefits, their contribution will benefit the over-all wood duck population only slightly. On the other hand, they should be informed that their contribution can fill a niche in the over-all waterfowl management program.

RESEARCH NEEDS

The Bureau of Sport Fisheries and Wildlife is interested in the potential benefits of wood duck propagation in future management programs. But we believe further study is needed to supply information required to help insure success of propagation projects. Investigations are recommended on the following points.

1. Available banding data on hand-reared wood ducks should be analyzed. This should include recoveries from early bandings, such as the birds released by Mr. White in Connecticut, as well as those from more recent bandings, such as those in Ohio, Illinois, and Wisconsin.
2. A thorough survey should be made of existing information on methods of propagating wood ducks. This should include further literature review, as well as communicating with aviculturists, game farm operators, and others who have raised the bird.
3. Experimental propagation should be conducted under different conditions to help fill voids in propagation methods revealed through literature search and personal contacts. This might include managing small breeding flocks to study fertility and hatchability of eggs, feeding and rearing of young, release procedures, and return of breeding birds during subsequent years.
4. Determine the nature of innate wildness in the wood duck. Decide whether or not genetic changes have made some strains held in captivity less suitable than other strains for survival in the wild.
5. Study the survival and behavior of hand-reared wood ducks released in the wild. This would involve pilot releases in which sufficient numbers of banded, or otherwise marked, wood ducks are liberated. Such experimental releases should be made and be carefully evaluated in a number of different situations where wood ducks are presently absent or are found in limited numbers. For example, we should try releases in typical prairie pothole habitat to see if by providing nest boxes and releasing birds we can establish local breeding populations on such areas. Another example might be to make releases in prairie pothole habitat without the benefit of natural cavities or nest boxes to determine

if the birds imprinted for ground nesting will become ground nesters or use other available elevated sites. If they do use such sites, what is the nesting success, compared with other species nesting in the same area?

6. One or more private wood duck release projects should be carefully followed for a number of years after the planning stage. The purpose of this effort would be to provide knowledge of the special problems and pitfalls experienced by private individuals. Experienees should be published in the form of guidelines for rearing and releasing wood ducks. Appropriate standards for conducting propagation and release projects should be included.

SUMMARY

The wood duck is almost universally admired. Its great beauty, interesting antics, sporting qualities, and the quality of flesh give it a position of great esteem. Its tolerance of man and compatibility with man's activities are remarkable. The willingness of the species to nest and live in close proximity to human habitation is well documented. In certain situations the wood duck is undergoing a period of adjustment to conditions created by man.

Also, unique, in a sense, is the wood duck's willingness to accept artificial nest structures. In effect we are able to provide with relative ease and low expense an integral part of its nesting environment. To accomplish the same thing for some other ducks, it is necessary to go into more intensive habitat preservation and management programs.

We believe many new approaches must be tried and tested to develop new techniques and to improve established procedures that will play an increasingly important role in waterfowl management in the future. We must be alert to emphasize ways by which the public can offer constructive assistance. Propagating and releasing wood ducks is definitely one way in which people can help waterfowl.

LITERATURE CITED

Barnes, W. B.
1948. Unusual behavior of a wood duck. Auk 65(3): 449.

Bednarik, K. E., and C. L. Hanson
1965. Ohio's waterfowl pioneering program. p. 153-171. *In* Game Research in Ohio. Vol. 3. Ohio Dept. Nat. Resources, Columbus. 220 pp.

Bellrose, F. C.
1958. The orientation of displaced waterfowl in migration. Wilson Bull. 70(1): 20-40.

Benschoter, M. M.
1887. Domesticating wood ducks. Forest and Stream 28(17): 367. May 19.

Delacour, J.
1959. Waterfowl of the world. Vol. 3. Country Life Limited, London. 270 pp.

Dutcher, W.
1907. The wood duck. Bird Lore 9(4): 189-193.

Fisher, A. K.
1901. Two vanishing game birds; the woodcock and the wood duck. p. 447-458. *In* Yearbook of Agriculture. U. S. Dept. Agr. 492 pp.

Forbush, E. H.
1908. Useful birds and their protection. Mass. State Board of Agr. 437 pp.

Grayson, J., and W. Grayson
1959. Raising wood ducks in captivity. Atlantic Naturalist 14(2): 86-96.
Hanson, H. C.
1951. Notes on the artificial propagation of wood duck. J. Wildl. Mgmt. 15(1): 68-72.
Hunt, R. M.
1956. My experience during 38 years of breeding and rearing game birds and wild waterfowl at the Mason State Game Farm. Mich Dept. Conserv. 28 pp. (mimeo.).
Job, H. K. *ETAOINSH*
1915. Propagation of wild water-fowl. Bul. No. 3 Nat'l. Assoc. of Audubon Societies, New York, N. Y. 104 pp.
1923. Propagation of wild birds. Doubleday, Page and Co., Garden City, N. Y. 308 pp.
Leopold, F.
1951. A study of nesting wood ducks in Iowa. Condor 53(5): 209-220.
Mather, F.
1886. Domestication of wild fowl. Amer. Naturalist 20(9): 820-821.
1887. Domestication of wild fowl. Amer. Naturalist 21(8): 778.
McCabe, R. A.
1947. The homing of transplanted young wood ducks. Wilson Bull. 59(2): 104-109.
Musselman, T. E.
1948. A changing nesting habitat of the wood duck. Auk 65(2): 197-203.
Phillips, J. C.
1960. My wood-duck pond. Outing. Nov. 1915. (Reprinted in Magazine of Ducks and Geese 11[2]: 26-33.)
1928. Wild birds introduced or transplanted in North America. U. S. Dept. Agr., Bur. of Biological Survey, Tech Bull. No. 61. 63 pp.
Ripley, D.
1957. A paddling of ducks. Harcourt, Brace and Co., N. Y. 256 pp.
Sharritt, G. W. *ETAOINDD*
1959. Jack Miner's raising wood ducks. Nature Magazine. March, 1942. (Reprinted in Magazine of Ducks and Geese 10[2]: 15-16, 36.)
Yeagley, H. L.
1953. Some surprises in research. Audubon Magazine. July-August. p. 158-161.

DISCUSSION

SESSION V

CHAIRMAN VAN DEUSEN: Thank you, Forrest, for a very interesting paper. We will now carry on with the discussion.

A. D. GEIS: I'll direct a question to Frank Bellrose. He indicated that if certain conditions were met, it might be practical to employ nesting structures as a practical management device for wood ducks. Now there's roughly half a million adult female wood ducks in the population. To have any significant impact on this population, we would have to provide nesting structures for perhaps 20 percent of the hens. This means about 10,000 wood duck boxes. If it costs, for instance, $2 per year to construct, erect, and maintain these boxes, all of a sudden we're talking about a $200,000 a year program. I wonder if this is a practical management device?

F. C. BELLROSE: Well I think so, when you consider the fact that our wood duck habitat is being deflated considerably. The wood duck population now has a half million breeding females. I think nesting structures should definitely be included in future management plans.

A. D. GEIS: It seems that this argument takes a rather pessimistic view that habitat is bound to go to pot. I didn't exactly deduce this as far as the Eastern United States is concerned, from this afternoon's comments.

F. C. BELLROSE: Where were you when the paper was being given by Don Hankala? He indicated that in the most important area of wood duck breeding grounds in the United States habitat is going to pot. Based on my trips down the Mississippi Flyway since 1947, bulldozing and burning continue yearly. How can you be optimistic? In view of an increasing human pouplation, there is only one conclusion—wood duck habitat must suffer.

W. A. AULTFATHER: I'm very sorry that in my presentation I didn't clarify the point of optimism that I saw in Region 3 and Region 5, the northern part of the wood duck habitat. I don't see future habitat as the natural type of woodlands that the wood duck originally used. I tried to point out the fact that we're going to have smaller timber, and much more of it will be too small for natural cavities. My optimism stems from the fact that we have opportunities for encouraging wood duck nesting, such as those illustrated in the two films shown this

evening. Trees in fence rows, nesting boxes placed on trees, and other similar types of habitat will replace woodlands as potential nesting habitat. Natural cavities will not be present, except in those areas that the forester and the farmer do not want to manage intensively for timber.

F. B. MCGILVREY: I'd like to add a point that Frank Bellrose made. In this country a great many people, such as sportsmen's groups, bird lovers, etc., are insisting that national organizations do something for wildlife. This is why we got into pheasant propagation in South Carolina, and other activities that aren't very practical. Counting and shooting ducks isn't going to be sufficient. People want to see something done, and if it is not the most practical thing in the world, that's beside the point. They want to see accomplishments. If putting up wood duck boxes is one of the things that'll help, then let's put up wood duck boxes.

CHAIRMAN VAN DEUSEN: Thank you Frank. I think that point was very well taken. This do-it-yourself project that Forrest Lee brought out certainly is very much in evidence in our area. An educational film, similar to the one we saw this evening, can help tremendously to build interest in local projects.

Are there any announcements before we close?

L. R. JAHN: Yes, just one. A 4-minute film on the behavior of day-old wood duck ducklings will be shown by Eugene Hester tomorrow morning at 8:20.

SESSION VI

Thursday, December 9

Chairman: A. O. Haugen

Iowa Cooperative Wildlife Research Unit, Ames

EVALUATING WOOD DUCK POPULATION SHIFTS AND TRENDS: ADVANCES AND LIMITATIONS

DISTRIBUTION AND DENSITY OF WOOD DUCKS IN EASTERN CANADA

M. M. SMITH
U. S. Bureau of Sport Fisheries and Wildlife, Atlanta, Georgia

This paper reviews the range of the wood duck in eastern Canada and provides estimates of the relative density of wood duck populations in the various eastern Provinces. The area discussed includes the Provinces of Ontario, Quebec, New Brunswick, Prince Edward Island, Nova Scotia and Newfoundland and comprises the northern limit of the wood duck range in eastern North America.

The distribution of the wood duck in eastern Canada is well documented in the ornithological literature, and additional reports of its occurrence are available from bird watchers, wildlife workers and others.

Information on the density or size of wood duck populations in eastern Canada is scarce. This is not surprising, since censusing wood ducks is difficult everywhere. It is only from intensive studies, usually on limited areas, that reliable estimates of wood duck numbers and production are available. The material on wood duck densities used here has come from publications, research studies, reports from banders, band recovery data, information solicited from wildlife workers in eastern Canada, and personal observations made in the area during August and September, 1965.

Since most of my information is of a general nature, I cannot provide figures on wood ducks per unit of area in eastern Canada. But it does seem possible with the available material to rank the various eastern Provinces according to the relative size or density of their wood duck populations, and I have done this. Such information may be no worse than the estimates of wood duck numbers we now have for some sections of the United States.

DISTRIBUTION

Most wood ducks in eastern Canada occur in the southern area near the Canadian-United States border. Wood ducks, however, have been recorded north of the tree line in Canada and at places that many of us consider a long way from home.

A few excerpts from the literature on wood duck distribution plus some recent sightings will illustrate the normal range and the wanderings of the wood duck in eastern Canada. Taverner (1934) gives the distribution of the wood duck as "across the continent, north barely into Canada . . . rare or absent through the prairies, occasional in southeastern Manitoba, more common in the east and in southern British Columbia." Macoun and Macoun (1909) describe the woodie as "Rare. A few breed in Nova Scotia (Downs). A rare summer resident. Breeds in New Brunswick (Chamberlain) . . . Breeds in suitable places throughout southern Ontario, but much rarer now than formerly. . . . Murray records it from Moose Factory, James Bay and from Trout Lake. . . .Regularly distributed throughout western Ontario. Breeds along marshes and rivers (Saunders)." Todd (1963) describes the wood duck as essentially a southern bird, but provides a review of some outlying records as follows: "Comeau calls it very rare, have seen a straggler now and then, May 17th 1895. Townsend records a specimen, . . .taken at Long Point on July 1, 1912. And Bruce S. Wright reports a single male bird seen at Bay Johan Beetz, on the North Shore, on August 30, 1947, by E. D. Fowler." Todd lists other records from the Abitibi River and Charlton Island, James Bay.

In recent years, there have been additional sightings at Lake St.

Jean and Lake Abitibi, Baie Beetz and Charlton Islands. Peters and Burleigh (1951) list a wood duck taken near Burin, Newfoundland about 1930 and refer to several others which have been reported shot or observed on the west coast of the island. Leslie Tuck of the Canadian Wildlife Service provided information on a male wood duck sighted at St. John's, Newfoundland in 1952. This duck was later captured there and remained in the vicinity for several years. Tuck reports another male was shot at Ferryland, Newfoundland in November, 1964.

I have two other bits of evidence that the wood duck travels far afield at times. The Bird Banding Office provided recovery data for a wood duck taken on the French Miquelon Islands, which lie about 25 miles off the south coast of Newfoundland. E. B. Chamberlain of the U.S. Bureau of Sport Fisheries and Wildlife advises that "In early August, 1963, we saw two wood ducks, either females or immatures, about 20 miles northwest of the airport at Fort Chimo, Quebec (these birds were observed from the ground. . . .). In August of 1965, one wood duck was seen at the same location. Coordinates for these observations are 58°21' N, 68° 32' W."

This review is not a complete record of all wood duck sightings, but it is enough to show that the species has wandered over much of eastern Canada. These outlying records are interesting, but the usual range of the wood duck in eastern Canada is much more restricted, as evidenced by what follows.

Harry Lumsden of the Ontario Department of Lands and Forests, considers the wood duck a regular breeder in Ontario south of a line from Sault Ste. Marie to North Bay and an occasional breeder for another 100 miles or so north of this line. The woodie also breeds in western Ontario and seems reasonably abundant in the vicinity of Fort Francis. Understand that, in this paper, only the range of the wood duck in eastern Canada is discussed. It is known, for example, that wood ducks occur in southern Manitoba, and some are trapped each year at the Delta Waterfowl Research Station west of Winnipeg.

J. D. Heyland of the Quebec Department of Tourism, Fish and Game, advises that woodies are known to breed along the South River below Montreal and the Ottawa River between Montreal and Ottawa. Breeding woodies also probably occur between Montreal and Quebec, south of the St. Lawrence River, and the species regularly occurs in the kill at Lake St. Peter. Mr. La Perle of the Quebec Department banded wood ducks at Gaspé in 1964 and 1965, but indicates he never heard of this duck breeding in the Gaspé area.

Woodies occur throughout New Brunswick. Studies by H. H.

Prince indicate few are found in the upper half of the Province and those found north and east of the St. John River are thought to be post breeding or moulting males. The wood duck breeds along the St. John River and from there south and west to the Maine border. The greatest numbers occur in the St. John River Valley.

Charles Bartlett, director of Fish and Wildlife Division, Prince Edward Island, states that wood ducks occur on the island and have been recorded each summer during waterfowl surveys. A few male wood ducks were banded annually in 1960-1964 during summer operations, but no females or immatures were ever seen during seven years of field work. There are no records of wood ducks breeding on Prince Edward Island.

Wood ducks occur regularly in the southern and western parts of Nova Scotia, and there is also at least one record from Cape Breton Island. Breeding wood ducks have been found in most of the southern counties of Nova Scotia. Fred Payne, formerly with the Nova Scotia Department of Lands and Forests, considered woodies common but not abundant in the central part of the Province. Payne indicates that a fair number of hand-reared wood ducks have been released near Truro, Nova Scotia each year. How this has affected the distribution of the species in Nova Scotia is unknown. Fair numbers of woodies occur in the New Brunswick-Nova Scotia border area, but most of these seem to be nonbreeders. Wood ducks occur fairly regularly each year in early season bags of hunters in southern Nova Scotia.

In Newfoundland there are few records of wood ducks and the species is only an occasional visitor. I am not aware of any wood duck records for the Labrador section of Newfoundland.

Near the northern limits of the woodies' range, most of the birds are reported to be adult males. These are assumed to be post-breeding or moulting males which seem to scatter widely following breeding. For instance, woodies banded in New England in late summer have been recovered in New Brunswick and Nova Scotia in October of the same year. Therefore, male wood ducks in late summer, even when present in fair numbers, do not necessarily indicate a local breeding population.

As another aid to understanding the distribution of wood ducks in eastern Canada, all wood duck recoveries reported for the period 1960 through August 1965 were examined. There are reasons why the distribution of band recoveries may not be a fair measure of the distribution of wood ducks in Canada. But, for what it is worth, the pattern of band recoveries seems in agreement with the distribution of woodies as presented in this paper.

An interesting question is whether the wood duck range in Canada has expanded and if the woodie population has increased in recent times. H. H. Prince advises that wood ducks have been in the St. John River Valley as far back as local residents can remember. Dr. A. J. Erskine of the Canadian Wildlife Service knows of no evidence that wood duck numbers in the Maritimes have fluctuated very greatly since the first surveys in 1937. He believes the species increased considerably in Ontario with the help of reduced bag limits in the Province during the '30's and '40's. On the other hand, C. E. Addy of the Bureau of Sport Fisheries and Wildlife feels wood ducks are more abundant now in the St. John River Valley than when he first viewed the area some 15 years ago.

DENSITY

So much for distribution. What do we know about the size of the wood duck population in eastern Canada? Quantitive data are scarce and my information on wood duck densities is even more general than that concerning distribution.

Southern Ontario probably has the largest population of wood ducks in eastern Canada. It is also probable that Ontario has the largest number of breeding wood ducks in eastern Canada. Unfortunately, I can offer few figures to substantiate this view. One fragment of information comes from E. B. Chamberlain, who conducts aerial waterfowl surveys each year in eastern Canada. We all know that wood ducks are difficult to see from the air, and Chamberlain advises that only a very few woodies are seen on these flights. But the woodies seen are found only on transects west of Quebec City, and most of these would be in Ontario.

In August and September of 1965, there was a large-scale cooperative banding program in eastern Canada and an examination of the catch provides another clue on wood duck numbers. The cooperative banding effort emphasized the banding of black ducks, although all species trapped were banded. In Ontario, a total of 371 wood ducks were banded among 11,908 ducks trapped. Not a very impressive total, but woodies were trapped at 15 of the 23 stations operated in Ontario and similar numbers were banded in the years 1962 through 1964. I conclude the species is widespread and common in southern Ontario.

The wood duck seems to be most abundant in Quebec along the Ottawa River and south of the St. Lawrence River in the general vicinity of Montreal. When recent wood duck banding recoveries are plotted on a map, there is a cluster along the St. Lawrence River and Richelieau River north of Vermont. These clusters are due in part to a pre-hunting season banding station that has been

operated east of Lake Champlain in Vermont for a number of years. Further, many of these wood ducks move north in late summer before turning south and west in fall. Nonetheless, it seems woodies in southern Quebec are most abundant in the triangle bordered by the United States on the south, the St. Lawrence on the north, and Quebec City on the east.

A few kill figures are available from Canadian Wildlife Service hunter bag checks in Quebec. These are from the opening and/or second weekends of the hunting season. The kill of the wood ducks is reported to decline sharply following the opening of the hunting season. In 1965, along the Ottawa River in southwestern Quebec, of 95 ducks checked 20 were wood ducks. On the Richelieau River in 1954, of 96 ducks examined 15 were woodies. In three years of bag checks on the South River, 277 ducks were examined and 48 of these were wood ducks. At Lake St. Peter in 15 years, 3,301 ducks were checked in hunters' bags and 80 of these were wood ducks.

Again, this is hardly enough information to establish the density of wood ducks in southern Quebec, but early season bags on the Ottawa and Richelieau Rivers contain a fair percentage of wood ducks. North and east down the St. Lawrence, the percentage of wood ducks in the kill decreases. This distribution of kill agrees roughly with my idea of wood duck density in the Province. In Gaspé, which is farther east, 26 wood ducks were banded on the York River in 1965. They were nearly all adult males. As noted earlier, there may be an immigration of post-breeding males that swell the late summer population. Wood ducks are most abundant in the extreme southern part of Quebec. Elsewhere in the Province the wood duck is occasional or rare.

There is more precise information on wood duck densities for the Province of New Brunswick. The Northeast Wildlife Station, under the direction of Bruce Wright, has conducted a mid-summer waterfowl census on a 32,500-acre study area in the St. John River Valley each year since 1947. Waterfowl population figures for the area have fluctuated widely, but the 19-year average has been 1,287 ducks, of which 247 were wood ducks. In the worst year, only 14 wood ducks were tallied out of 317 ducks seen. The highest count was 862 wood ducks in a total of 3,088 ducks observed in 1964. On these ground counts woodies averaged about 20 percent of the summer duck population. It ranked third behind the black duck and blue-winged teal.

Data are also available on the production of wood ducks on this study area. In 1964, 356 waterfowl broods were seen and 60 were identified as wood ducks. Of 205 duck broods observed in 1965, 34

were woodies. Wood ducks made up about 16 percent of the duck broods recorded in the last two years. We cannot expand the study area results to all of New Brunswick, since there is evidence that the St. John estuary is the best waterfowl production habitat in the Province. H. H. Prince describes the main wood duck breeding range as southwestern New Brunswick. He feels that the highest density of nesting wood ducks occurs in the St. John River study area.

Band recoveries for woodies show a cluster in the St. John Valley, but this results in part from pre-season banding on the area and the fact that this part of the Province sustains the highest hunting pressure. Additional information is available from the 1965 banding effort. Fifty wood ducks were trapped at McAdam in southwestern New Brunswick and 53 were banded in the St. John River Valley. The latter number were captured at night with lights by G. E. Cummings of the Bureau of Sport Fisheries and Wildlife and his assistants. The crew was afield nearly every night in August, and I contacted G. E. Cummings for additional information on wood duck numbers in the lower St. John Valley. His reply was that woodies were abundant there, and that quite a number of wood duck broods were seen in the work area. The wood duck is not easy to capture at night but is often observed during banding operations on areas where it occurs.

Three aerial surveys were run over the study area. A few woodies were recorded on each flight. Despite the difficulty of seeing this duck from the air, my impression is that wood ducks are abundant in the lower St. John Valley. But few woodies breed in northern New Brunswick, and the total area of high wood duck production is relative small. Nonetheless, New Brunswick probably ranks second to Ontario as a production area for wood ducks in eastern Canada.

Wood ducks are not uncommon in western and southern Nova Scotia, but specific information on population size is scarce. D. Dodds, associate professor at Acadia University, indicates woodies (1) occur fairly regularly in early season hunter bags in southern Nova Scotia, (2) are fairly common in western Nova Scotia, and (3) are known to breed in most of central and southern Nova Scotia. Fred Payne ventured a guess that something on the order of 100 pairs of woodies are nesting in the wild in Nova Scotia.

About 30 woodies were banded in western Nova Scotia in 1965. All but one were males, with 24 of the males being adults. It appears that Nova Scotia does not contain a very sizable population of wood ducks, but neither is the species rare.

Wood ducks occur regularly on Prince Edward Island, but their numbers are small. C. O. Bartlett advises that during brood surveys in the early 1960's as many as 20 moulting males were observed on a

single pond on the Island. A few wood ducks are taken each fall in the Province, but all seem to be post-breeding males.

A few records exist of wood ducks taken in Newfoundland by hunters or sighted by reliable observers. There is evidence that one brood was produced on the Island, but Leslie Tuck has reason to believe this came from a pen-reared female. The species occurs only occasionally on Newfoundland. Certainly the island is not an important area for woodies.

CONCLUSIONS

Where does all this information lead us regarding the wood duck in eastern Canada? Woodies have been seen over a great area in eastern Canada and occur regularly during late summer, even in areas where they do not breed. The usual range of the species seems restricted to southern Ontario, southern Quebec, New Brunswick, Prince Edward Island, and Nova Scotia. The breeding range is even more restricted, as few woodies breed in Nova Scotia and none is known to breed on Prince Edward Island. Wood ducks regularly occur in the kill in Ontario, Quebec, and New Brunswick, but due to the generally early migration of the species, the harvest is thought to be small.

Parts of southern Ontario, Quebec and New Brunswick have breeding populations of woodies. Wood duck production appears good in some sections, such as the St. John River Valley in New Brunswick. But the total area with such production is relatively small in eastern Canada. In the aggregate, only a small fraction of the continental wood duck population can be produced there.

Despite some harvest, Canada is probably an exporter of woodies. Early migration from Canada in fall probably makes Canadian-reared wood ducks available in both the Mississippi and Atlantic Flyways. Considering the limited size of known breeding areas in Canada, most wood ducks wintering in the United States must be home grown and home harvested. The wood duck is an interesting addition to Canada's waterfowl, but the welfare of the species is necessarily dependent upon regulation of harvest and maintenance of habitat within the United States.

LITERATURE CITED

Macoun, J., and J. M. Macoun
1909. Catalogue of Canadian birds. Canada Dept. of Mines, Govt. Printing Bur. 761 pp.
Peters, H. S., and T. D. Burleight
1951. The birds of Newfoundland. Dept. Nat. Resources Prov. of Nfld. 431 pp.
Taverner, P. A.
1934. Birds of Canada. Bull. No. 72, Biol. Series No. 19, Nat. Mus. of Canada, Ottawa. 445 pp.
Todd, W. E. C.
1963. Birds of the Labrador Peninsula. Univ. of Toronto. 819 pp.

THE VALUE OF ROOST COUNTS AS A POPULATION INDEX FOR WOOD DUCKS

F. EUGENE HESTER[1]

Cooperative Fishery Unit, Bureau of Sport Fisheries and Wildlife and Zoology Department, North Carolina State University, Raleigh

The wood duck (*Aix sponsa*) is a secretive bird of woodland streams and swamps. It feeds and travels in small flocks, usually of less than a dozen birds. Even when actively feeding, wood ducks are difficult to detect, and they are masters at hiding when they suspect danger.

The elusive ways of the wood duck, together with the lack of visibility in wooded bottomlands, almost completely eliminate the possibility of making accurate counts of this bird. There are, however, two brief times each day when the wood duck significantly alters its activities and is easily observed. These brief intervals are at sunset and sunrise, when the ducks make their characteristic roost flight. At sunset they congregate in woodland ponds to spend the night, and at sunrise they disperse from these roosts. Frequently wood ducks can be counted easily as they enter or leave a roost.

Although wood duck roost flights have long been recognized as characteristic of the species (Bent, 1923; Kortright, 1942), only in recent years have biologists intensively studied them. Afternoon roost counts have been made by several investigators throughout the range of this duck. Martin(1957) in Indiana, Martin (1959) and Martin and Haugen (1960) in Iowa, Hester and Quay (1961) in North Carolina, and Smith (1961) in Louisiana have measured time of arrival of the ducks in relation to sunset. They also determined numbers of ducks utilizing various roosts and the time of year at which peak roosting populations were present. Morning counts were also made by Martin (1957) and by Martin and Haugen (1960).

The size of a roosting area may vary from an acre or less to many acres, and the maximum number of birds using a roost may be less than 100 or more than 1,000. Dale Hein (pers. comm., Nov. 1965), in his recent studies in Iowa, Wisconsin, and Minnesota, observed several roosts containing 1,000 or more ducks. His largest roost contained 5,400 ducks. In North Carolina, roosts appear to be more numerous and are used by smaller numbers of wood ducks.

Throughout much of the eastern half of North Carolina there are numerous swamps, many of which are used by the wood ducks as roosting sites. In some areas there are a large number of millponds

[1]Research upon which this paper is based was conducted while I was a graduate student and later a faculty member of North Carolina State University, Department of Zoology.

which were built before the turn of the century. Many of these millponds simply impound sections of small streams and inundate river flood plains, thereby creating shallow swamps. This arrangement of numerous small swamps probably accounts for many roosts in the Piedmont and upper Coastal Plain of North Carolina, each of which contain small numbers of wood ducks.

Peak wood duck populations at roosts in North Carolina usually occur in late October or early November (Hester and Quay, 1961) and frequently contain less than 150 birds. Within five miles of Wendell, a small town located 20 miles east of Raleigh, five wood duck roosts were observed. Some roosts are less than one mile apart. The maximum count on any one of these areas has been 189 wood ducks.

Some roosts in eastern North Carolina contain maximum populations of several hundred birds. Most wood duck roost sites are in permanently flooded areas, and the same sites are generally used year after year.

The number of ducks using a roost would be expected to change from year to year as the flyway population of ducks increases or decreases. If fluctuations in roost counts are correlated with changes in flyway wood duck populations, such counts could be used effectively as a population index.

In evaluating the use of roost counts as a population index, there are several important questions which must be answered:

1. Do the same birds use the roost each night? What is the rate of loss and recruitment? Do ducks intermittently use several roosts, especially small roosts which may be less than a mile apart?
2. Are roosting aggregates composed of local birds congregating prior to migration, of birds actually in the process of migrating, or a combination of the two?
3. If roost counts are used as a population index, should single roosts be counted, or must all roosts in an area be studied?
4. Do peak counts provide the most useful information?
5. To what extent does the amount and distribution of surface water outside a roost site influence utilization of the roost?

In the following discussion, an attempt is made to evaluate present knowledge on these questions.

No research has been conducted to determine whether the same ducks use a particular roost each night. It is commonly believed that the same birds return each night until peak number are reached, after which the birds migrate. Even if this assumption is correct, however, there is very little information to indicate whether the birds

migrate by a series of short flights from one roost to another one nearby, or by longer flights to more distant roosts.

Lack of data on the nightly loss and recruitment of roosting birds obviously leaves unanswered the question of the significance of the peak population. It is entirely possible that by staying shorter periods of time, a greater number of ducks might use a roost than when fewer birds stay longer and thereby build the roosting population to a higher peak. Practically nothing is known about temporary shifts of roosting ducks between roosting sites located adjacent to one another.

Wood duck roosting counts have been interpreted as indicating time of migration, for there is little doubt that many of the birds are migrants. It is probable, however, that in most cases the roosting birds are a combination of local and migrant birds. Near Raleigh we have banded incubating female wood ducks in nest boxes for five years and have marked day-old ducklings in nest boxes by placing Number 1 monel metal tags in the webs of their feet. We have recovered five of these marked ducks during November and December within a few miles of the site at which they were marked in spring of the same year. Since the peak of roosting counts occurs near Raleigh in late October, it is obvious that these five ducks were available to participate in roosting flights throughout the build-up and decline of counts at roost sites. The mid-winter wood duck population near Raleigh is less than 10 percent as great as that of late October (Hester and Quay, 1961).

Some roosts are permanent and have been used annually for long periods of time; others may be used for only a few years and are then abandoned. In the latter category are certain farm ponds, beaver ponds, and other areas undergoing rapid changes. Of the five roost sites studied between 1954 and 1961, only three are still in use. Reduction of water level in one small roost and vegetational changes in the other appear to have been responsible for abandonment by wood ducks. While the old, established roost sites seem to offer the most reliable information about wood duck numbers, the effect of temporary roost areas in diluting or enhancing the counts of primary areas must be recognized and evaluated.

It appears that peak counts could provide the most useful information on wood duck abundance. Certainly this would be the case if the ducks build up to a peak number before any of them move out. Simultaneous counts on several areas appear to be desirable in order to obtain information on the number of ducks in an area. Such counts become more valuable when made at the time of peak numbers. Several counts are obviously necessary if a peak count is to be determined.

Smith (1961) conducted studies in Louisiana from 1954 through 1957 to estimate annual trends in the state's fall population of wood ducks. He concluded that roost counts did not provide a suitable index to change in the wood duck population. He stated that the number of counts needed to provide a suitable index would be great and might need to vary with the amount and distribution of surface water present each year.

Martin (1959) stated that roosting flight counts in fall appeared to be useful in Iowa to inventory wood ducks in areas where roosting concentrations occurred regularly. He recognized, however, that further work was needed in order to evaluate the effects of various environmental factors on use of roosts by wood ducks.

Roosting counts have several inherent problems, yet they are one of the few means of obtaining an index to wood duck numbers. Counts made on one or two areas appear to be of very little value. Only by studying counts from many roosts and the effects of environmental factors on use of roosts can we hope to determine the full significance of roost counts as a population index of wood ducks.

LITERATURE CITED

Bent, A. C.
1923. Life histories of North American wild fowl. U. S. Natl. Mus., Bull 126. 250 p.

Hester, F. E., and T L Quay
1961. A three-year study of the fall migration and roosting-flight habits of the wood duck in East-Central North Carolina. Proc. of the Southeastern Assoc. of Game and Fish Commissioners 15: 55-60.

Kortright, F. H.
1942. The ducks, geese, and swans of North America. The Stackpole Co. and Wild. Mgmt. Inst., Wash., D. C. 476 p.

Martin, D. N.
1957. Wood duck autumn flight activity in relation to sunrise and sunset. Ind. Div. of Fish and Game, Indianapolis. 8 p. (multilith). Paper presented at 19th Midwest Wildl. Conf., Mil., Wis.

Martin, E. M.
1959. River float and roosting flight counts as indices to numbers of wood ducks. M.S. Thesis, Iowa State Univ., Ames. 114 p.

Martin E. M., and A. O. Haugen
1960. Seasonal changes in wood duck roosting flight habits. Wilson Bull. 72(3): 238-243.

Smith, M. M.
1961. Louisiana wood duck studies. Final P-R Report July 1950-June 1961. La. Wildl. and Fisheries Comm., New Orleans. 26 p.

INFLUENCE OF HUNTING REGULATIONS ON WOOD DUCK POPULATION LEVELS

H. M. REEVES

Division of Management and Enforcement, Bureau of Sport Fisheries and Wildlife, Minneapolis, Minnesota

The history of the wood duck during the past century is one of the most exciting success stories in the annals of wildlife management. Some species, skidding ever downward in numbers, vanished from the American scene. But it is our good fortune that the Beau Brummell of the waterfowl was snatched from the brink of oblivion.

Federal waterfowl regulations reflect the remarkable recovery of the species. In 1929 no wood ducks could be included in the nationwide daily hunter bag limit of 25 ducks. But only thirty-two years later, both of the two permitted ducks in the Atlantic Flyway daily bag could be wood ducks. In recent years, the wood duck has consistently ranked second or third among the waterfowl harvested in the Atlantic and Mississippi Flyways.

This report is a review of eastern wood duck populations and their response to regulations and other factors. Hawkins (1956) compiled references on the subject but did not evaluate it. Four eras are used here to categorize population trends from time of settlement to the present: (1) pristine numbers, (2) excessive exploitation, (3) population recovery, and (4) regulated harvests.

I am indebted to a number of individuals for assistance in preparing this paper. Personnel of the Bureau of Sport Fisheries and Wildlife include: A. S. Hawkins, Mississippi Flyway Representative; R. K. Martinson and A. D. Geis, both of the Migratory Bird Populations Station; F. H. Davis, Regional Supervisor of Management and Enforcement; and R. D. Purinton, U. S. Game Management Agent Trainee. Mrs. Evelyn Gish, librarian at the University of Minnesota was very helpful. Special appreciation is due L. R. Jahn of the Wildlife Management Institute for critically reviewing the manuscript.

ERA OF PRISTINE NUMBERS

Indigenous to the watered deciduous forest of temperate eastern North America, the wood duck was present in high numbers prior to the 1870's and 1880's. According to Phillips (1925:65): "Older writers, notably Audubon, testify to the extreme abundance of this species in all the eastern part of the United States. . . .In general, this species was exceedingly abundant all over the eastern United State until the early eighties."

Forbush (1929:227-228) wrote: "Once this beautiful bird was common to abundant throughout New England, wherever there were wooded river valleys and swamps, along all the water-courses, about the margins of lakes and ponds and all over our well-watered terrain. In heavily timbered regions they were even more abundant than the Black Duck." Baird, Brewer, and Ridgway (1884:13) stated: "It breeds abundantly from Texas to the British Provinces."

During this early period the wood duck seemed capable of sustaining itself against localized overhunting and deleterious land use. Certainly there was little evidence that a population decline had begun.

ERA OF EXCESSIVE EXPLOITATION

Early writers attributed the rapid decline of wood ducks at the end of the 19th century to overharvesting and habitat destruction or change. These influences caused a progressive and prolonged population reduction. Widespread fear was expressed that the species would be exterminated from the wild. Emphasizing this point, Forbush (1929:228) declared: "Spring shooting which went on merrily even after the ducks had laid their eggs brought the species nearly to extinction in the early part of the twentieth century. At that time there were said to be more Wood Ducks in Belgium than in the United States. The Belgian pigeon and poultry fanciers, recognizing the value of the Wood Duck's peerless beauty and the danger of its extinction, imported them and reared them artificially in large numbers, and the time came when Americans who desired live Wood Ducks were forced to buy them from the Belgians at exorbitant prices."

In commenting upon importations of game birds and eggs into the United States, Palmer and Oldys (1904:14) declared: "It is interesting to note that the wood duck, although a native species, figured in the importations to a greater extent than any other duck except teal and mandarins, most of the birds coming from Antwerp, where they are raised for the trade." Elliot (1898:90) commented: "The beauty of the male makes him a desirable specimen for collectors, and the flank feathers are eagerly sought by the makers of artificial flies, while its flesh is always acceptable to gourmands. Altogether, with so many suitors of various kinds, each desiring the bird for his own special purpose, the Wood Duck's chance for becoming extinct is a very good one."

Grinnell (1901:141, 596) succinctly stated: "Being shot at all seasons of the year they are becoming very scarce and are likely to be exterminated before long. . . .It is greatly to be desired that all States may enact laws something like those of North Dakota, where the num-

ber of ducks that may be killed in a day is limited to twenty-five. If such a law could be put into operation, and the shooting season could be shortened so that it would last for three of four months, instead of eight, the effect on our waterfowl would soon be seen." Trautman (1940:189), in writing of the Buckeye Lake area of Ohio, said: "Between 1890 and 1900 the numbers of Wood Ducks began to decrease sharply; this continued until 1914, when the legislature of Ohio passed an act prohibiting the shooting of Wood Ducks for sport."

Cooke (1906:8) said of the wood duck: "It is a sad commentary on our present system of game protection that wood duck, one of the handsomest of our native birds and one whose breeding range is almost entirely within our boundaries, is the species that has suffered most. So persistently has this duck been pursued that in some sections it has been practically exterminated. Even in states where it still breeds commonly . . . public sentiment fails to recognize the importance of adequately protecting this bird, and the laws still permit it to be destroyed late in the spring. As a result the wood duck is consistently diminishing in numbers, and soon is likely to be known only from books or by tradition."

These limited reports and countless others, place most of the blame for the wood duck population decline on spring shooting, market hunting and commercialization, unrestricted or excessively long seasons, unlimited or unrealistic bag limits, and unrestricted or wasteful harvest methods. All occurred at the same time that habitat was being destroyed. If large harvests and habitat destruction had continued unabated, they would almost certainly have resulted in extinction of the species in the wild. Of possible corrective actions, regulation of the harvest offered the most apparent and practical means of benefiting the population.

ERA OF POPULATION RECOVERY

Sporadic attempts to give added protection to the wood duck date back to 1846 when Rhode Island locally restricted spring shooting of it and the black duck (Palmer, 1912:23). This effort evidently marks the theoretical beginning of waterfowl species management in the United States. But unfortunately, enforcement of this and other early laws was frequently ineffective. In 1904 Louisiana closed the season on wood ducks for five years. This was the first of many closed seasons enacted by states.

In discussing why early efforts at regulating game populations were chiefly directed towards resident species, Leopold (1933:215) said: "The fact that seasons and bag limits on migratory birds have remained so much more liberal than seasons on resident game strong-

ly substantiates the assertion made elsewhere . . . that people can be induced to conserve what stays on their own land, but only the exceptional individual will voluntarily conserve what he shares with the community at large."

Generally, attempts at providing needed protection for waterfowl were late in coming. As of 1870, 36 states provided no protection whatever to waterfowl, and as late as 1900, 10 states still had not acted (Lawyer, 1919:304).

National concern for waterfowl did not materialize until 1913 when the Weeks-McLean Bill became law as an amendment to the Agricultural Appropriations Act (Phillips, 1934:4). The Act placed custody of migratory birds in the Federal Government, and authorized regulations prescribing closed seasons for the wood duck. An estimated 75 to 90 percent of the usual spring hunting ceased, and public interest in the waterfowl dilemma was finally aroused. However, the Weeks-McLean Act had certain weaknesses, major ones being its possible unconstitutionality and its limited authority and enforceability.

It was not until the Migratory Bird Treaty Act was signed on August 16, 1916 by the United States and Great Britain, acting in Canada's behalf, that a firm basis for waterfowl protection and management was provided. This act, formally ratified by both countries, effective July 3, 1918 (40 Stat. 755), and subsequently amended (16 U.S.C. 703-711), has become the basis for present federal responsibilities in ascertaining the status of migratory game bird populations and for setting regulations. The initial act provided special protection for the wood duck and eider duck.

Passage of the Migratory Bird Treaty Act did not result in an immediate and obvious response in the then very low wood duck population. In discussing the effect of federal protection Phillips (1925:65-67) wrote: "Suitable nesting areas are being reduced in size and the all-the-year close time as decreed by Federal Law is not always effective, where at the beginning of the shooting season thousands of ignorant shooters take the field. Even among educated sportsmen mistakes are common, and the scattering remnant continue to fall a prey to the all too eager hunter. Without doubt, a very scarcity of the species is now, in itself, a factor towards its inability to gain in numbers. . . .In the New England States there has been some increase, but the more populated areas show either a very slow gain or none at all. . . .If real protection could be afforded to this duck in the northern states until October 1, some would migrate before they were killed, for killed many will always be in spite of there being a 'close' time upon them."

Roberts (1932:247-248), in writing of the wood duck's recovery in Minnesota, noted: "As it seemed probable that extinction was threatening, it has for some time been unlawful, by both federal and state laws, to kill this bird at any season of the year, in any part of the United States, and under such protection it has apparently increased somewhat and may now be found in fair numbers throughout Minnesota. . . .During recent years the numbers have been steadily increasing throughout the state."

Phillips and Lincoln (1930:296) stated: "Once greatly reduced by summer shooting, especially in our northern states, this fine duck has recovered everywhere with protection. Its early departure from our northeastern states and Canada renders it fairly safe from overshooting. Increasing greatly in the Mississippi Valley." A. S. Hawkins (pers. comm., Nov. 1965) stated that traditional August shooting of flapper wood ducks persisted in the Illinois River Valley long after season restrictions were imposed.

It appears that even under theoretical full protection numbers of wood ducks continued to be taken by ignorant, careless, or intentional hunters. Generally, it seemed that the population experienced

TABLE 1. SYNOPSIS OF FEDERAL DUCK HUNTING REGULATIONS FOR THE ATLANTIC AND MISSISSIPPI FLYWAYS, 1920–47

Year(s)	Days in Season	Duck Daily Bag	Wood Duck		Span of Season	Shooting Hours
			Daily Bag	Poss. Limit		
1920–29	92–108	25	no season		Sept. 15–Jan. 15	½BS-S[1]
1930	92–108	15	no season		Sept. 15–Jan. 15	½BS-S
1931	30–31	15	no season		Oct.1–Dec. 19	½BS-S
1932	56–61	15	no season		Oct. 1–Dec. 19	½BS-S
1933	56–61	12	no season		Oct. 1–Dec. 19	½BS-S
1934	30	12	no season		Oct. 3–Jan. 13	S-S
1935	30	10	no season		Oct. 21–Dec. 19	7:00–4:00
1936	30	10	no season		Oct. 10–Dec. 25	7:00–4:00
1937	30	10	no season		Oct. 9–Dec. 26	7:00–4:00
1938	45	10	no season		Oct. 1–Dec. 29	7:00–4:00
1939	45	10	no season		Oct. 1–Dec. 29	7:00–4:00
1940	60	10	no season		Oct. 1–Dec. 31	S-4:00
1941	60	10	1[2]	1	Oct. 1–Dec. 31	S-4:00
1942	70	10	1	1	Sept. 26–Jan. 10	S-S
1943	70	10	1	1	Sept. 25–Jan. 10	½BS-S
1944	80	10	1[3]	1	Sept. 20–Jan. 20	½BS-S
1945	80	10	1[3]	1	Sept. 20–Jan. 20	½BS-S
1946	45	7	1[4]	1	Oct. 5–Jan. 6	½BS-½BS
1947	24–30[5]	4	1[4]	1	Oct. 7–Jan. 6	S-1BS[6]

[1] ½BS-S = ½-hr. before sunrise to sunset, etc.
[2] Permitted in 14 Atlantic and Mississippi Flyway States (Alabama, Arkansas, Delaware, Georgia, Kentucky, Louisiana, Maryland, Mississippi, Missouri, North Carolina, Pennsylvania, South Carolina Tennessee and Virginia.)
[3] Closed season in Massachusetts.
[4] Closed season in Massachusetts, New Jersey and West Virginia.
[5] States were given a choice of different season lengths with continuous and split seasons.
[6] First noon opening on first day of season.

a very slow rate of recovery in the initial years of full protection. Then gradually the rate accelerated as the breeding population increased beyond a certain "threshold" level, and perhaps also as a result of growing hunter awareness of the plight of wood ducks.

ERA OF REGULATED HARVESTS

An expanding wood duck population, and the realization that some of the birds were being shot accidentally along with other waterfowl, prompted federal regulations in 1941 for 15 states to permit one wood duck in the daily bag and possession limit (Table 1). All but one (Texas) of these states were later incorporated into either the Atlantic or Mississippi Flyways. Continued, but not always consistent, improvement in the population resulted in two-bird bag and possession limits for the two eastern flyways in 1962 (Tables 2 and 3). No open seasons were declared for wood ducks in the Mississippi Flyway in 1954 and 1956, but some Atlantic Flyway states have had seasons each year since 1941.

TABLE 2. SYNOPSIS OF FEDERAL DUCK HUNTING REGULATIONS FOR THE ATLANTIC FLYWAY, 1948–65.

Year	Days in Season	Duck Daily Bag	Wood Duck		Span of Season	Shooting Hours[1]
			Daily Bag	Poss. Limit		
1948	24–30[2]	4	1[4]	1[3]	Oct. 8–Jan. 8	½BS–1BS[4]
1949	32–40[2]	4	1[5]	1[5]	Oct. 7–Jan. 7	½BS–1BS[4]
1950	32–40[2]	4	1[5]	1[5]	Oct. 7–Jan. 7	½BS–1BS[4]
1951	36–45[2]	4	1[6]	1[6]	Oct. 5–Jan. 5	½BS–1BS[4]
1952	44–55[2]	4	1[6]	1[6]	Oct. 1–Jan. 10	½BS–1BS[4]
1953	60	4	1[6]	1[6]	Oct. 1–Jan. 10	½BS–S
1954	54–60[2]	4	1	2[7]	Oct. 4–Jan. 19	½BS–S
1955	70	4	1	2	Oct. 7–Jan. 15	½BS–S
1956	70	4	1	2	Oct. 5–Jan. 15	½BS–S
1957	70	4	1	2	Oct. 5–Jan. 15	½BS–S
1958	54–60[2]	4	1	2	Oct. 10–Jan. 15	½BS–S
1959	40–50[2]	3–4[8]	1	2	Oct. 9–Jan. 8	½BS–S
1960	38–50[2]	3–4[8]	2[9]	2[9]	Oct. 7–Jan. 7	½BS–S
1961	36–50[2]	2–3(2)[8,10]	2[9]	2[9]	Oct. 13–Dec. 30	S–S
1962	40–50[2]	2–3(2)[8,10]	2	2	Oct. 12–Dec. 30	S–S
1963	40–50[2]	3–4(2)[8,10]	2	2	Oct. 5–Jan. 5	S–S
1964	40–50[2]	3–4(2)[8,11]	2	2	Oct. 3–Jan. 3	S–S
1965	36–50[2]	3–4(2)[8,11]	2	2	Oct. 9–Jan. 9	S–S

[2] States were given a choice of different season lengths, continuous or split seasons and bag limits.
[3] Closed season in Massachusetts, New Jersey, and West Virginia.
[4] ½BS–1BS = ½-hr. before sunrise to 1 hr. before sunset, etc.
[5] Closed season in Massachusetts and West Virginia.
[6] Closed season in West Virginia.
[7] Except possession limit of only 1 in New Hampshire.
[8] Daily bag limit depended upon length of season selected.
[9] Except in Massachusetts where the daily bag limit could not contain more than 1 wood duck and in Pennsylvania the daily bag or possession limit could not contain more than 1 wood duck.
[10] Mallard and/or black duck limits shown in parentheses for states selecting the higher daily bag limit.
[11] Mallard limits shown in parentheses.

TABLE 3. SYNOPSIS OF FEDERAL DUCK HUNTING REGULATIONS FOR THE MISSISSIPPI FLYWAY, 1948–65.

Year	Days in Season	Duck Daily Bag	Wood Duck		Span of Season	Shooting Hours[1]
			Daily Bag	Poss. Limit		
1948	30	4	1	1	Oct. 8–Jan. 8	1/2BS–1BS[2]
1949	40	4	1	1	Oct. 7–Jan. 7	1/2BS–1BS[2]
1950	35	4	1	1	Oct. 6–Jan. 5	1/2BS–1BS[2]
1951	45	4	1	1	Oct. 5–Jan. 5	1/2BS–1BS[2]
1952	55	4	1	1	Oct. 1–Jan. 10	1/2BS–1BS[2]
1953	55	4	1	1	Oct. 8–Jan. 10	1/2BS–S
1954	55	4	No season		Oct. 1–Jan. 10	1/2BS–S
1955	70	4	1	1	Oct. 1–Jan. 15	1/2BS–S
1956	70	4	no season		Oct. 1–Jan. 15	1/2BS–1/2BS
1957	70	4	1[5]	1[5]	Oct. 1–Jan. 15	1/2BS–S[4]
1958	70	4	1[5]	1[5]	Oct. 1–Jan. 15	1/2BS–S[6]
1959	40–50[7]	3–4[8]	1	1	Oct. 7–Jan. 8	1/2BS–S
1960	40–50[7]	3–4[8]	1	1	Oct. 7–Jan. 8	1/2BS–S
1961	20–30[7]	2–3[8]	1	1	Oct. 13–Dec. 30	S–S
1962	25	2(1)[9]	2	2	Oct. 12–Dec. 30	S–S
1963	32–35[7]	4(2)[9]	2	2	Oct. 5–Jan. 5	S–S
1964	36–40[7]	4(2)[10]	2	2	Oct. 3–Jan. 3	S–S
1965	36–40[7]	4(1)[10]	2	2	Oct. 9–Jan. 9	S–S

[1] Shooting began at noon on opening days during 1948–1954 and 1959–1963.
[2] 1/2BS–1BS = 1/2 hr. before sunrise to 1 hr. before sunset, etc.
[3] Closed seasons in Kentucky, Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri and Wisconsin.
[4] Shooting hours were 1/2 hour before sunrise to 1/2 hour before sunset in Alabama, Arkansas, Louisiana, Mississippi, Ohio and Tennessee.
[5] Closed seasons in Arkansas, Kentucky, Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri and Wisconsin.
[6] Shooting hours were 1/2 hour before sunrise to 1/2 hour before sunset in Alabama, Louisiana, Mississippi, Ohio and Tennessee.
[7] States were given a choice of different season lengths and continuous or split seasons.
[8] Daily bag limit depended upon length of season selected.
[9] Mallard and/or black duck limit shown in parentheses.
[10] Mallard limit shown in parentheses.

General Relationships Between Hunting Regulations and Game Populations

For decades, waterfowl management has proceeded on the supposition that season lengths, daily bag and possession limits, and purposes, methods, places, and times of taking affect the rate of harvest and population size. Only in recent years has evidence accumulated to permit some measure of the effects of these restrictions on waterfowl. Geis (1963) and Crissey (1964 and 1965) have clearly described why hunting regulations have differential effects on resident and migratory game birds. The principles involved may be summarized as follows:

1. Hunting pressure on resident species is largely self-limiting regardless of season length, while migratory game birds are subjected to a series of decimating opening day and lengthy season hunting pressures. A mallard produced in Minnesota in 1965 could conceivably be subjected to at least seven opening days and partial seasons before reaching its winter destination in Louisi-

ana. Enroute it could be exposed to a total of 92½ days of continuous hunting, far exceeding that sustained by most resident game species.

2. Studies have shown that non-hunting mortality factors for resident species tend to decrease as shooting mortality increases. However, it appears that about the same proportion of a migratory game bird population will die annually of non-hunting causes, regardless of hunting pressure. A number of studies indicate that hunting mortality is largely added to non-hunting mortality (Hickey, 1952:156; Smith and Geis, 1962; Geis, 1963:166; Crissey, 1964:116).
3. The resultant higher mortality caused by hunting of a species is important only if it is not compensated for by increased production. The keys to waterfowl production, assuming that breeding stock is adequate, are quantity and quality of habitat. There is little evidence that low density waterfowl breeding populations are more productive than high density populations; if anything, the reverse may be true.

While these conclusions have not yet been demonstrated for all species of ducks, particularly those inadequately banded, the implications are sufficiently strong to suggest that they apply, at least in degree, to a number of species, including the wood duck. Already, there is evidence of the direct relationship between shooting pressure and the survival of immature wood ducks (Smith, Goddard, and Geis, 1963:3). Thus, regulations which tend to reduce hunting pressure on wood ducks also reduce the rate of mortality, thereby permitting increased survival to the following year.

Effect of Regulations Designed Specifically for the Wood Duck

Regulations provided specifically in behalf of wood ducks include closed seasons, limited daily bag and possession limits, delayed season opening dates, and restricted shooting hours. An array of similar and other regulations have been directed towards the aggregate of waterfowl species.

Any discussion of special regulations should consider whether or not characteristics of the species favor more intensive management. Although the wood duck has brilliant plumage, characteristic flight silhouette and behavior, and distinctive habitat preferences, these advantages are offset to a considerable degree by its high vulnerability to the gun. Green (1963:38) compared hunting vulnerability of wood ducks on the Mississippi River with that for other ducks. The wood duck was more vulnerable than all except the green-winged teal and shoveler, and was about three times more vulnerable than

the mallard. He concluded that it ranked third in vulnerability among 17 species.

Jessen (1964:1), in writing of waterfowl species management, stated that there are two general methods by which it may be accomplished. The first, selective shooting, requires that hunters be able to identify ducks in flight, and that none or only limited numbers of certain species be shot. One potentially useful fact favoring this approach is that a relatively low proportion of all waterfowl hunters bag a majority of the waterfowl. However, Jessen (1963:2), in discussing species identification by hunters, noted that redheads in 1957 and 1958 comprised about 7.3 and 6.2 percent, respectively, of the Minnesota bag, even though the species was fully protected. He concluded that redheads were harvested nearly in proportion to their availability.

The second method allows hunting only at certain places and times, taking advantage of known species behavior and migration. The species needing protection should not be present in significant numbers when hunting of other species is permitted. Although this method is imperfect, it does provide substantial protection, and in Jessen's opinion, may be more workable than relying upon species identification by hunters.

In reviewing the effects of protective regulations for certain ducks at Bear River, Van den Akker and Wilson (1951:376) concluded, even earlier than Jessen, that the setting of seasons at a time when the subject species would not be abundant would be more useful than relying upon the hunting public to distinguish protected from non-protected species in flight.

Several studies indicate the hunters' willingness and ability to identify wood ducks from other species. Bellrose (1944:363) stated that a significant proportion of the wood duck population was killed by hunters during years of complete protection, but that when one wood duck was permitted in all 48 states the rate of band recovery rose to 5.4 percent, a level two-thirds greater than during years of complete protection. These data suggest that wood ducks are protected to a considerable extent in closed seasons, but not completely.

Floyd H. Davis (pers. comm. Nov. 1965) reports one reason for the restrictive daily bag and possession of hooded mergansers, first effective during the 1953-54 season. Some hunters were misidentifying wood ducks as hooded mergansers, thus sometimes exceeding the daily bag of wood ducks.

After examining the diary of a Lake Winnebago, Wisconsin hunter, Bartonek, Hickey and Keith (1964:106) concluded that regulations did not effectively limit the number of canvasback, redhead, buffle-

head, and ruddy ducks bagged, but did appear effective for the wood duck.

In Wisconsin during 1956 and 1957, 122 Horicon Marsh hunters were asked to identify a dead hen wood duck (Hunt, 1963:5). Only 59 named the bird correctly, even though they had it in hand. Many of the hunters guessed that it was a teal, hen mallard, or bluebill. The wood duck season was closed those years. Presumably these same hunters would have found the identification of flying wood ducks even more difficult.

One percent of the wings collected in western Minnesota during a 1958 duck-wing study were from wood ducks, even though the season was closed. The following year, when one wood duck was permitted in the bag, 2.3 percent of the sample were wood ducks (Smith, Goddard, and Geis, 1963:3).

Crissey (1965:242) concluded that hunters' ability to identify birds in the hand is not good, and that it is very poor for birds in flight. Hopefully, added emphasis on species management in recent years has encouraged hunters to improve their abilities to identify waterfowl. However, wings from wood ducks comprised about three-fourths of those from protected species received in the wing collection during the 1965 experimental teal season. I conclude that hunter ability or willingness to identify wood ducks in flight is at best only fair.

There is some evidence that differential daily bag limits have been effective in regulating harvests. In commenting upon the results of regulations permitting two wood ducks in the daily bag, Smart and Carney (1964:1) stated: "In the Atlantic Flyway, the increase in the wood duck kill due to second wood ducks in the bag was greater in 1963 (37.2%) than in 1962 (26.4%). Some of this increase was due to a change from 1 to 2 in the wood duck limit in Pennsylvania in 1963. Massachusetts, however, maintained a one-wood duck limit during both years, yet showed an increase. The greatest rise in the kill due to second wood ducks in the bag occurred in the three states at the extreme southern end of the flyway. However, a number of northeastern states closed much of their wood duck habitat to hunting early in the season in order to reduce the danger of forest fires, and this may have depressed hunting success in 1963.

"During the 1963-64 season in the Mississippi Flyway, there was a much greater increase in the kill due to second wood duck (32.9%) than had occurred during the 1962-63 season (22.4%). Much of this increase may have been due to the more liberal bag limits on other species. Under the basic bag limit of 2 in 1962, a hunter who had

bagged a duck other than a wood duck could not legally kill 2 wood ducks. In 1963, under the basic bag limit of 4 (3 in Minnesota), the same hunter could shoot 1 or 2 mallards or other ducks and still legally bag 2 wood ducks."

These observations and others indicate that closed seasons and restricted daily bag limits save a proportion of the population from overharvesting. But it seems evident that hunters' indentification of species in flight must improve considerably if management is to reap full benefits from relatively simple species regulations.

The strong crepuscular flight habits of wood ducks suggest that we may be able to design shooting hours to provide them added protection. One such attempt was made in the Mississippi Flyway in 1957 and 1958. States not hunting wood ducks ended shooting at sunset, while those allowing one wood duck terminated shooting one-half hour before sunset. Although this regulation may have reduced the wood duck kill, its effectiveness was never evaluated.

Effect of Other Regulations

A factor sometimes overlooked is the effect restrictive regulations have upon harvest by discouraging hunter participation. "Duck Stamp" sales in recent years have declined in response to restrictive regulations, especially those governing season length and daily bag limits. When general waterfowl regulations are curtailed, fewer hunters, including those that would otherwise hunt wood ducks incidentally or intentionally, take to the field.

Conversely, in years of restricted bag limits on other key species, such as the mallard and black duck, hunting pressure is shifted to the wood duck. It may then assume a greater importance in the harvest. This happened in 1960 to 1964 in the Mississippi Flyway. Wood ducks increased from fifth to second in the harvest (Table 4). Contributing factors could have been relative population levels, availability of wood ducks and other species, and hunting season dates. Note in Table 4 that the wood duck ranked fifth in the Mississippi Flyway in 1960 with a calculated kill of 142,200, but fourth in 1961 with a lesser kill of 108,000.

Season dates and lengths play important roles in regulating the wood duck harvest by states. Longer hunting seasons are usually offered when fall flight forecasts are optimistic. States then commonly select seasons better bracketing the period of the expected fall flight of major species. This generally means extending the season both earlier and later than in years of shorter seasons. In this manner, longer seasons usually lead to earlier opening dates, and in the north-

TABLE 4. IMPORTANCE OF THE WOOD DUCK AND OTHER MAJOR SPECIES IN THE ATLANTIC AND MISSISSIPPI FLYWAY DUCK HARVEST, 1960-64. BASED ON WEIGHTED PERCENTAGES OF DUCK WINGS SUBMITTED BY HUNTER (SMART, 1964 AND 1965).

Year	Atlantic Flyway					Mississippi Flyway				
	Mallard	Black Duck	Wood Duck	Rank of Wood Duck	Calculated Kill[1]	Mallard	G. W. Teal	Wood Duck	Rank of Wood Duck	Calcul Kil
1960	14.3	30.7	12.5	3rd	98,800	53.0	5.9	4.8	5th	142,
1961	14.6	27.1	17.1	2nd	126,600	48.9	8.2	6.1	4th	108,
1962	15.6	28.9	15.8	2nd	116,600	40.0	6.2	15.3	2nd	163,
1963	16.3	24.7	14.0	3rd	124,800	37.1	6.6	14.0	2nd	371,
1964	16.1	24.5	10.6	3rd	99,600	36.8	8.1	9.0	2nd	313,

[1] Estimate of wood duck kill only; data furnished by R. K. Martinson (pers. comm., Nov. 1965).

TABLE 5. PERCENTAGE OF WOOD DUCKS IN THE DUCK HARVEST DURING DIFFERENT PERIODS OF HUNTING SEASONS IN SELECTED MISSISSIPPI FLYWAY STATES. BASED ON WINGS SUBMITTED BY HUNTERS IN 1959 (GEIS AND CARNEY, 1961).

State	Oct. 7–10	Oct. 11–20	Oct. 21–31	Nov. 1–10	Nov. 11–20	Nov. 21–30	Dec. 1–10	Dec. 11–20
Minnesota	3.8	1.0	0.5	1.2				
Wisconsin	8.4	7.1	3.4	←	0.7	→		
Michigan	3.5	7.1		1.4				
Ohio	37.4	25.6	3.6		←	9.2 →		
Iowa		1.6	4.6	←		1.5	→	
Illinois			10.5	3.5	1.1	←	1.1 →	
Missouri				3.1	2.0	1.7		
Arkansas						4.8	1.2	
Louisiana						10.1	7.5	5.6

ern states, heavier pressure on local wood ducks. Table 5 demonstrates the importance of wood ducks during the early part of hunting seasons in several states.

Many investigators have commented on the effects of early seasons on wood duck populations (Bellrose, 1944:364; Green, 1963:58; Jahn and Hunt, 1964:27; Kaczynski and Geis, 1961:8; Lee *et al.*, 1964: 140; McCann, 1964:1; and Stewart, 1958:166). Generally, earlier seasons tend to increase mortality rates and lower survival rates. This is probably why northern wood ducks are subjected to higher hunting losses than southern wood ducks. Delayed seasons, especially in key northern states, permit a portion of the wood ducks, which are characteristically early migrants, to move south prior to the hunting season. Those remaining in the north are diluted by migrants of various species. Simply delaying the season one year gives considerable protection to local breeding populations and may enhance production the following year.

The importance of adequately protecting local populations is emphasized by the findings of Bellrose, Johnson, and Meyers (1964: 671-2). From 55 to 60 percent of the surviving adult hens tended to home to the area of their previous successful nesting. Immature females also returned to their natal area, but at a lower rate. The consequences of overharvesting local breeding populations were clearly described by Hochbaum (1947). One possible alternative to opening seasons early would be to eliminate waterfowl hunting locally at particularly important wood duck concentration and feeding areas. Usefulness of this concept must be examined in the field in many states.

CONCLUSIONS

Hunting regulations contributed to sparing the wood duck from extermination throughout its eastern range. Moreover, regulations are

playing an ever-increasing role in wood duck management as knowledge accumulates from bandings, wing collections, hunter surveys, fall population surveys, and other studies. Additional investigations are needed to establish the annual population status. Special emphasis should be directed towards banding adequately all important segments of the population. More population censuses are needed for specific times and places.

Wood duck populations may be managed by specific regulations aimed directly at the species, and by regulations developed for waterfowl in general. Species regulations theoretically hold great promise, but are presently limited by the inability or unwillingness of most hunters to identify waterfowl species under hunting conditions. Our understanding of the effects of general hunting regulations on wood ducks is imperfect. But results from gross appraisals of the effects of season dates and bag limits on the wood duck population permit predictions with some accuracy. Until a high proportion of wildfowlers are able and willing to identify ducks in flight, hunting regulations for times and places must be used to better control wood duck harvests. Biologists and hunters need more knowledge to make greater use of the concept of species management for wood ducks.

LITERATURE CITED

Baird, S. F., T. M. Brewer, and R. Ridgway
1884. The water birds of North America. 2 Vols. Mem. Mus. Comp. Zool., Harvard Coll., Boston, Mass.

Bartonek, J. C., J. J. Hickey, and L. B. Keith
1964. An evaluation of waterfowl regulations and local harvests in Wisconsin. Wis. Acad. Sci., Arts and Letters 53: 83-107.

Bellrose, F. C., Jr.
1944. Duck populations and kill, an evaluation of some waterfowl regulations in Illinois. Ill. Nat. Hist. Survey Bull. 23 (Art. 2): 327-372.

Bellrose, F. C., K. L. Johnson, and T. U. Meyers
1964. Relative value of natural cavities and nesting houses for wood ducks. J. Wildl. Mgmt. 28(4): 661-676.

Cooke, W. W.
1906. Distribution and migration of North American ducks, geese and swans. U. S. Dept. Agr., Biol. Survey Bull. No. 26. 90 p.

Crissey, W. F.
1964. Exploitation of migratory waterfowl populations in North America. p. 105-120. *In* first European meeting on wildfowl conservation: proceedings. Nature Conservancy, London. 289 p.

1965. Waterfowl species management: problems and progress. Trans. N. Amer. Wildl. and Nat. Resources Conf. 30: 229-246.

Elliot, D. C.
1898. The wild fowl of the United States and British possessions, or the swans, geese, ducks and mergansers of North America. F. P. Harper. 316 p.

Forbush, E. H.
1929. Birds of Massachusetts and other New England states. 3 Vols. Mass. Dept. of Agr., Norwood, Mass.

Geis, A. D.
1963. Role of hunting regulations in migratory bird management. Trans. N. Amer. Wildl. & Nat. Resources Conf. 28: 164-172.

———, and S. M. Carney
1961. Results of duck-wing collection in the Mississippi Flyway, 1959-60. U. S. Fish and Wildl. Serv., Spec. Sci. Rept.-Wildl. No. 54. 120 p.

Green, W. E.
1963. Waterfowl utilization and hunting kill, 1964 through 1960, Upper Mississippi River Wildlife and Fish Refuge and Mark Twain National Wildlife Refuge. U. S. Fish and Wildl. Serv., Spec. Sci. Rept.-Wildl. No. 71. 62 p.

Grinnell, G. B.
1901. American duck shooting. Forest and Stream Publ. Co., New York, N. Y. 627 p.
Hawkins, A. S.
1956. Wood ducks and men. Unpublished manuscript filed with U. S. Fish and Wildl. Serv., Bur. Sport Fisheries and Wildl., Minneapolis, Minn. 15 p.
Hickey, J. J.
1952. Survival studies of banded birds. U. S. Fish and Wildl. Serv., Sci. Rept.-Wildl. No. 15. 177 p.
Hochbaum, H. A.
1947. The effect of concentrated hunting pressure on waterfowl breeding stock. Trans. N. Amer. Wildl. Conf. 12: 53-64.
Hunt, R. A.
1963. Comments on the ability of hunters to identify ducks. *In* Waterfowl Mgmt. Notes, Tech. Sect., Miss. Flyway council. No. 103 8 p. (multilith).
Jessen, R.
1963. Comments on the ability of hunters to identify ducks. *In* Waterfowl Mgmt. Notes, Tech. Sect., Miss. Flyway Council. No. 103. 8 p. (multilith).
———
1964. The species management need. Unpublished manuscript filed with the Div. of Game Research, Minn. Dept. of Conserv., St. Paul, Minn. 2 p.
Jahn, L. R., and R. A. Hunt
1964. Duck and coot ecology and management in Wisconsin. Wis. Conserv. Dept., Tech. Bull. No. 33. 212 p.
Kaczynski, C. F., and A. D. Geis
1961. Wood duck banding program progress report, 1959 and 1960. U. S. Fish and Wildl. Serv., Spec. Sci. Rept.-Wildl. No. 59. 41 p.
Lawyer, G. A.
1919. Federal protection of migratory birds. p. 303-316. *In* U. S. Dept. Agr. Yearbook, Wash., D. C.
Lee, F. B., R. L. Jessen, N. J. Ordal, R. I. Benson, J. P. Lindmeier, and L. L Johnson
1964. Waterfowl in Minnesota. Minn. Dept. of Conserv., Tech. Bull. No. 7. 210 p.
Leopold, A.
1933. Game management. Charles Scribner's Sons, New York, N. Y. 481 p.
McCann, J. A.
1964. Wood duck banding program, 1963. U. S. Fish and Wildl. Serv., Bur. Sport Fisheries and Wildl., Admin. Rept. No. 51. 33 p. (multilith).
Palmer, T. S.
1912. Chronology and index of the more important events in American game protection, 1776-1911. U. S. Dept. Agr. Biol. Surv. Bull. No. 41. 62 p.
———, and H. Oldys
1904. Importation of game birds and eggs for propagation. U. S. Dept. Agr., Farmers Bull. No. 197. 28 p.
Phillips, J. C.
1925. A natural history of the ducks. Vol. 3. Houghton Mifflin Co., Boston, Mass. and New York, N. Y. 383 p.
———
1934. Migratory bird protection in North America. Spec. Publ. Amer. Comm. for Int. Wildl. Protection. Cambridge, Mass. 38 p.
———, and F. C. Lincoln
1930. American waterfowl, their present situation and the outlook for their future. Houghton Mifflin Co., Boston, Mass. 312 p.
Roberts, T. S.
1932. The birds of Minnesota. 2 Vols. The Univ. of Minn. Press, Minneapolis. 821 p.
Smart, G.
1964. Species composition of the duck kill during the 1963-64 hunting season compared with prior years. U. S. Fish and Wildl. Serv., Bur. Sport Fisheries and Wildl., Admin. Rept. No. 52. 4 p. (multilith).
———
1965. Species composition of the duck kill within states for the 1963-64 and 1964-65 hunting season. U. S. Fish and Wildl. Serv., Bur. Sport Fisheries and Wildl., Admin. Rept. No. 82. 13 p. (multilith).
———, and S. M. Carney
1964. The increased wood duck kill due to second wood ducks in the bag, 1962-63 and 1963-64 seasons compared. U. S. Fish and Wildl. Serv., Bur. Sport Fisheries and Wildl. Admin. Rept. No. 53. 3 p. (multilith).
Smith, R. I., and A. D. Geis
1962. Comparison of black duck recovery and annual mortality rates. U. S. Fish and Wildl. Serv., Bur. Sport Fisheries and Wildl., Admin. Rept. No. 1. 15 p. (multilith).
———, S. V. Goddard, and A. D. Geis
1963. Analysis of some wood duck bandings and report on the 1962 wood duck banding program. U. S. Fish and Wildl. Serv., Bur. Sport Fisheries and Wildl., Admin. Rept. No. 21. 25 p. (multilith).
Stewart, P. A.
1958. Local movements of wood ducks (*Aix sponsa*). Auk 75(2): 157-168.

Trautman, M. B.
1940. The birds of Buckeye Lake, Ohio. Museum of Zool., Univ. of Mich., Misc. Publ. No. 44, Ann Arbor. 466 p.
Van den Akker, J. B., and V. T. Wilson
1951. Public hunting on the Bear River Migratory Bird Refuge, Utah. J. Wildl. Mgmt. 15(4): 367-381.

DISCUSSION

SESSION VI

CHAIRMAN HAUGEN: I think a few comments are appropriate here on the work of one of my students. Dale Hein just finished his Ph.D. at Iowa State. He finished his Ph.D. thesis on the wood duck, and three publications have already been written. They will appear in print shortly. It's very unusual, by the way, to have a student not only finish his thesis but to write three articles for publication, as well, before he leaves the campus. Two articles will be in the Journal of Wildlife Management and one in the Wilson Bulletin. I want to read you a few sentences from his abstracts that may fit in here. He, by the way, had 768 morning and evening flight counts at 52 roosts over the five years of his study, first for his MS and then for his Ph.D on this same topic. A few sentences then from his summary and abstract. Under management he stated that fall flight counts can provide an index to the trend in year to year changes in abundance of wood ducks. In Iowa and adjacent parts of the Upper Mississippi River Valley counts should be made September 15 to 25, with September 20 as the preferred target date. Counts should include all birds arriving at the roost from 20 minutes before sunset to 40 minutes after sunset. He said spring flight counts at mouths of tributary streams can furnish an index to population trends and numbers of nesting wood ducks associated with the Mississippi River Refuge.

There's something that's a little different than in many other places. You know the Mississippi River in that area lies below the surrounding upland. There are deep cuts where the tributary rivers emptying into the Mississippi come down through those blufflike areas. The ducks go up these rivers and stay there during the day. In the evening they come out of the mouths of these rivers into the Mississippi. So the wood ducks are very easy to count in that area. Counts should be made April 15 to 25, with April 20 as preferred target date. The counting period is from 40 minutes before sunrise to 20 minutes after sunrise, or from 20 minutes before sunset to 40 minutes after sunset. Dale says flight counts at mouths of tributaries were superior to river float counts as an index to trends in abundance in wood ducks.

In another place he says shooting hours affect the wood duck kill. Wood ducks are most vulnerable before sunrise and after sunset, that is during the roosting flight period. If hunting is allowed before sunrise or after sunset, as it was in 1960, it might be wise to ban the hunting at known roosts. This, of course, would be a difficult task for administrative and enforcement personnel.

These are just a few points from the thesis that I thought might be interesting. In case your library tries to get an inter-library loan of the thesis, call for "Wood Duck Roosting Flight Phenomenon" by Dale Arthur Hein. It is filed at the Iowa State Library.

G. K. BRAKHAGE (*Missouri Department of Conservation*): I'd like to address a question to Dr. Hester. Do you pursue any spring counts of wood ducks to obtain a population index?

F. E. HESTER (*North Carolina State University*): I have made some spring counts and have also made morning counts at wood duck roosts. We sometimes get a buildup of migrant ducks, at least in the year I counted them, in March. But this was before I got into the nesting study and I am more confused by this than enlightened at the present time. Our nesting season in North Carolina begins in February and some of the ducks are actually seeking out nest sites in January. Although I recorded a buildup of wood ducks in March for one year, this problem of resident birds versus migrant birds is something which I am not in the position to resolve. So I don't know whether these were migrant birds or whether it was just a buildup of the local nesting birds at the time.

F. J. JESSEN (*Minnesota Department of Conservation*): I'd like to ask Dr.

Hester if people have documented very well, or described, the roost areas from a habitat standpoint. Are there any particular characteristics that they have in common?

F. E. HESTER: I think Dale Hein and some of the other people working under Dr. Haugen have described the habitat at some sites. The roosts are not uniform. Some of them vary quite a bit from others. I can give you a description of two of the roosts I've studied, which I think will serve as examples. One of them was a temporary water area of about one acre, caused simply by road scrapers digging out sand from the ditch as it washed down a little hillside. The scraper would come along and push the sand to the outside instead of pushing it up into the road. This in itself was apparently sufficient to dam a little stream, probably over a period of several years. It caused a little dam, a couple of feet high, to flood a little swamp which had alder and buttonbush. At the new water level it was invaded almost exclusively with some burreed. At this roost of one acre I counted 189 wood ducks.

There's another roost at the head of one of these old mill ponds, in which the swamp is about 100 acres. The ducks apparently don't use the pond uniformly, but they use a rare restricted part of about 100 acres. In this case it is a long standing swamp composed primarily of black gum and other entirely mature trees. Another roost is dominated primarily by the eastern Carolina water ash.

These examples show the variation in habitat at roosts. The vegetation type is not the same. Things like water depth are not the same. Some of them have much more open water than others. It is a little hard for me to characterize them in general. It's sort of the same type of place that many wood ducks feed during the day. People who have counted a roost have often recorded that ducks will leave the roost and come back in the middle of the day to loaf or feed there—in the same area they roost in. So I think everybody who's counted these roosts has made some description of them, but they're not of a uniform type. You may be able to get a pretty good idea by knowing different types of swamps. But they're not all identical.

CHAIRMAN HAUGEN: I will add just a couple of points to that. Dale Hein says in his thesis that there is no way to identify a roost except by finding wood ducks in it. He says in large blocks of wood duck habitat a detailed description of a particular roost would usually fit the surrounding area just as accurately. Roosts were always located in emergent vegetation, most often with open water constituting 10 to 80 percent of the roosting area. If the water level dropped, he found that the birds moved over a little way, but not necessarily a great distance, to a nearby area that was somewhat similar.

P. SPRINGER (*South Dakota Cooperative Wildlife Research Unit*): I see Al Geis is anticipating my question, I believe. Is anything known on the sex and age composition of wood ducks in the roost? I think Al has made some night drives in these roosts. If anyone else has some information, I'd like to know about it.

A. D. GEIS (*Bureau of Sport Fisheries and Wildlife*): I really don't know whether roost trapping presents an unbiased sampling of the birds present in an area, but most certainly all ages and sexes are represented. This is the case in the few roosts that we've dealt with. And remember, all our roosts are in the same general area. We've seen no dramatic differences in sexes and ages.

Roost trapping provides an excellent opportunity to examine the conditions that Dr. Hester mentioned should be met to understand the reliability of roost counts. The limited roost trapping that we've done in Maryland suggests, for example, that migrants are obviously present at the time of peak numbers. Despite wandering tendencies of the wood duck, we get far too many recoveries from Ontario-banded birds in traps at Horicon, and things of that sort, for local birds to be the only ones present. Also we find evidence of shifts among roosts and turnover in the roost population. Of course, in regard to these last two points, we don't know the effect that handling the birds has on their behavior. We may prompt some of the turnover that occurs in these roosts. But certainly evaluations based on subsequent recoveries and the fact that we clearly have migrants present provide us

with leads on this problem. So I would urge that roost trapping be incorporated in the program to evaluate this technique of roost counts. It can be done relatively easily if the conditions are right.

F. B. MCGILVREY (*Patuxent Wildlife Research Center*): I'd like to make a few comments on roost counts. I've been doing roost counts at Patuxent in both spring and fall for the last three years, and I am beginning to see a pattern in results. It is not always so good in the spring, but I think it's real good in late summer. Roost counts are compared with data from brood surveys, nesting success, and this sort of thing. Spring counts show a definite spring flight every spring, just after the ice goes out, usually in March. There is a short period before nesting begins, when apparently all these birds, as far as I can tell, are resident birds. All these birds are in pairs. Then as nesting begins you start seeing a lot of singles come in. If they are flying early enough in the day, you can easily identify the drakes.

Our wood duck population at Patuxent is so stable that I can't be sure whether or not spring counts are a good index. But there is a good comparison between the spring flight and the number of nesting birds that we have. Then in late summer we get a build up of birds, mostly immatures I believe. The males pull out, but our adult hens molt right in our roost area. I verify this because I've trapped and banded an awful lot of flightless molting hens right in the roost. But you get a build up in the late summer that compares very nicely with my brood count on the center. Then we get an abrupt peak, usually in October, which is an indication of migrants moving in.

J. M. ANDERSON (*Winous Point Shooting Club*): I'd like to ask Al Geis or Bellrose, or anyone else who will offer an opinion, whether he thinks the recovery of the wood duck from the point of near extinction is due more to protection or to habitat manipulation. Which in your opinion is the more important factor?

F. C. BELLROSE (*Illinois Natural History Survey*): Obviously, in the comeback from the early 1900's to the 1930's it was protection, because there was very little habitat manipulation in those days. The refuge program of the Fish and Wildlife Service was just getting underway and state refuges were relatively uncommon. Therefore, I think we must say that protection brought the wood duck back at that time.

CHAIRMAN HAUGEN: I think this conclusion must be reached if we review the literature. It appeared that the concern for habitat or the mention of habitat in those years of exploitation are relatively few and far between. A few people were aware of habitat destruction and management. However, I'll have to agree with Frank on this point. Of the two courses of action to be followed, improvement of the habitat or regulations, obviously manipulation of regulations was the easy way to help the wood duck population.

I wonder if I may ask Al Geis a question? I wonder if you might have any comments regarding the effectiveness of regulations by species for time and place of hunting?

A. D. GEIS: First, the best type of species management in regard to regulations would be those instances where a particular species would have shooting pressure directed against it in a situation where it would be the only species present. However, we've looked long and hard for situations in which it would be possible to apply a regulation in this way, and in the overall picture they're pretty rare. It is extremely difficult to find an area in which you have any one species that you wish to protect, or direct shooting pressure against. Some years ago we evaluated data for redheads and canvasbacks in an attempt to identify areas in which the kill was very strongly concentrated. When we examined band recoveries, we found that they just weren't as nicely concentrated as people hoped they were. Our efforts for species management, I'm afraid, are going to have to be quite limited, unless through natural evolution the animal called the hunter can improve his behavior. The opportunity to apply species management through areas and dates is, unfortunately, rather limited.

Now let's take this matter of the importance of regulations in regard to the status of wood duck one step further. I can't help but look to the future when

conditions are good in prairie Canada and we get back to very good and liberal regulations in the United States. I am very much concerned about this. I think we've had pretty good wood duck regulations in recent years, thanks to the sorry plight of ducks in general. It's indeed going to be interesting to see what happens when conditions improve and the general waterfowl regulations become more liberal.

To shift subjects slightly, I'd like to comment a little further on this matter of roost counts. I think Frank's very fortunate that his roost counts at Patuxent are so stable. We've been counting some other roosts in Maryland and we've noticed fluctuations from 1,500 one year down to 200 or 300 the next. This supports Dr. Hester's comments that counts on individual roosts, as a generality, are somewhat suspect. We would hate to deduce much of anything from the highly variable brood counts that we've obtained along the Potomac River.

L. R. JAHN (*Wildlife Management Institute*): I'd just like to comment on the second part of the original question involving the habitat. There are two good sources of information on the plant community that furnishes breeding cavities. Curtis, a fine ecologist in Wisconsin, studied the flood plain forest, as one type of many plant communities in that state. Very interestingly enough this is the only plant community that has not been disturbed significantly by man. This is the same type of flood plain forest that was studied very intensively in the St. John River Valley in New Brunswick. The average age of the trees furnishing cavities is 215 years. The cavities have been there since the trees were 12 inches d.b.h. or larger in size. When you are cruising a woodlot and want to judge whether or not there might be cavities, remember there must be trees which are 12 inches d.b.h. or larger in size.

The stability of the flood plain forest is really rather surprising when you start digging into it. The only threat on the part of man is to the elm at the present time. The wood is used to correct faulty sewers. In some sewers the large volume and mixture of materials are causing leaks. These wastes are causing a breakdown of soil structure and the sewers are caving in. This has caused a demand for cutting old elms to use as slats to support sewers. How widespread this is in the Midwest, I can't say for certain, but I know I've seen woodlots that were absolutely raped of their elms.

J. B. DAWSON (*Ontario Department Lands and Forests*): I'd like to make several comments concerning Mort Smith's remarks on breeding wood duck densities in Ontario. I don't think there is any question that in the last ten years habitat has improved for the wood duck. We have had a tremendous increase in our beaver population. At the present time we have beaver in almost every conceivable place where we could have beaver. But it is difficult to know how many wood ducks are involved. We find that ducks on these small beaver ponds are hard to band. They do not show up in our dike checks. There are a great many small beaver ponds across eastern Ontario, and I suggest that perhaps we have 30,000 square miles of reasonably good wood duck habitat. I suggest that we are contributing a fair number of wood ducks to the Flyway. Mort Smith remarked that wood ducks were a fairly early migrant. This is true, but we do have considerable numbers of wood ducks in southern Ontario. The wood duck is fairly important for the hunter, perhaps more important than the black duck.

SESSION VII

Thursday, December 9

Chairman: K. E. BEDNARIK
Ohio Division of Wildlife, Columbus

ESTABLISHING THE STATUS OF WOOD DUCK POPULATIONS—SUCCESSES AND PROBLEMS

A. D. GEIS
Bureau of Sport Fisheries and Wildlife, Laurel, Md.

Hawkins and Addy (1965) have already described the wood duck's unique habitat and habits which cause it to have quite different population survey problems than most other waterfowl species. Annual waterfowl population surveys which provide information on most species do not yield useful information on the wood duck because (1) the range of the wood duck is not included and/or (2) most of the birds present are not seen.

To obtain information on the approximate size of the wood duck population, it has been necessary to depend on an indirect method. This procedure was first used to estimate the wood duck population prior to the 1959 and 1960 hunting seasons (Kaczynski and Geis, 1961) and provided the first real insight concerning the size of the wood duck population. The approach followed has been applied in other wildlife studies for a long time. It simply requires data on (1) the size of the hunting kill and (2) the rate of kill. For example, if we know the kill is 100,000 birds, and this represents one-tenth of the pre-season population, there must have been 1 million birds prior to the hunting season. Much of this paper will relate to the data-gathering procedures required to make such estimates.

Information on population size, however, is not enough for effective management. Also needed is information on:

(1) Annual mortality rates (the proportion of the pre-season population dying each year).
(2) Production rates (proportion of each year's pre-season population consisting of young-of-the-year.).
(3) Importance of hunting as a mortality factor.
(4) Regional differences in the characteristics of populations.

For management purposes, this additional information is essential. For example, if the population declines we should know whether it is due to abnormally low production or unusually high mortality rates. Furthermore, hunting regulations are the one management tool that can be applied effectively throughout the range of this species. Therefore, we must understand the influence of hunting regulations on the status of wood ducks. This subject has already been discussed by Mr. Reeves at this meeting, so I will merely mention it here.

If the management program is dedicated to obtaining the maximum amount of recreation from the resource, it seems likely that a uniform set of regulations throughout an entire flyway will not suffice in the future. Some population units may be harvested to a lesser extent with liberal regulations than others could be with very restrictive regulations. Therefore, information on the characteristics of population units should be obtained. Director Gottschalk of the Bureau of Sport Fisheries and Wildlife, in his talk to the Waterfowl Advisory Committee in August 1965, cited management by population units within a species as a technique for securing additional recreation from a resource. As examples he mentioned the mallard regulations in the Columbia basin in Washington, Oregon and Idaho, and the early season in the San Luis Valley in Colorado.

PROGRAM TO OBTAIN THE DATA NECESSARY TO DETERMINE AND UNDERSTAND THE STATUS OF WOOD DUCKS

Kill Survey

A mail questionnaire survey of waterfowl hunters provides estimates of the size of the hunting kill in the United States. Prior to the wing collection survey, hunters reported the species composition of their kill on a questionnaire. Wing collection survey results (Geis and Carney, 1961) indicate that the importance of wood ducks in the kill was accurately reported by the questionnaire survey. The kill survey also provides the basis for estimating band-reporting rates; *i.e.*, the proportion of band recoveries that is reported to the Bird Banding Laboratory.

Wing Collection Survey

This survey secures a wide variety of data from wings sent through the mail by a representative sample of hunters. From its initiation in the Mississippi Flyway (1959) and in the Atlantic Flyway (1960), it was evident that wood ducks made up a very substantial part of the total kill. In recent years in the Mississippi Flyway, the wood duck has regularly been second only to the mallard

in importance, while in the Atlantic Flyway the wood duck ranks third. The wing collection survey provides vital data on the proportion of total kill consisting of wood ducks, the age and sex composition of the wood duck kill, a wide variety of other information on the geographic and chronologic distribution of the kill, and other characteristics of the harvest.

Banding Program

The banding program provides data on (1) rate of kill of each age and (2) annual rates of mortality. Information on rate of kill is required to make indirect population estimates and to translate the age composition in the kill into the age composition in the population to measure the production rates.

Population estimates, theoretically, could be obtained for several different periods within the year, since they relate to the time the banding was done. Currently, only pre-season banding is of sufficient scale to permit such estimates. A representative sample of wood ducks banded in the winter is needed so that a winter population estimate also can be secured. This estimate would yield information on the time when non-hunting mortality occurs. Wood duck population estimates for recent years are shown in Table 1. It illustrates how data from a variety of sources are brought together to obtain estimates of population size.

ADEQUACY OF THE DATA GATHERING PROGRAM

Kill Survey

Sampling error and representativeness of the sample used are not problems in the survey due to its size (60,000 questionnaires received in 1964) and finely divided stratification. However, a better understanding of the relation between the actual kill and the kill that hunters report on a questionnaire at the end of the season is still needed. The work done by Atwood (1956) serves as the basis for evaluating reporting bias. A downward adjustment in the reported kill is routinely made, but more work on this subject is needed.

Accurate estimates of band-reporting rates depend upon making reliable estimates of the total number of banded birds taken of each species and comparing them with the number actually reported to the Bird Banding Laboratory. It is a procedure in which one estimate is based on another and, consequently, the sampling error is hard to evaluate. However, when this approach was applied and compared with the available information based on reward bands, the agreement was striking (Geis and Atwood, 1961), suggesting that this is a useful technique for obtaining this vital information.

TABLE 1. WOOD DUCK KILL INFORMATION AND ESTIMATES OF THE PRE-HUNTING SEASON POPULATION IN THE ATLANTIC AND MISSISSIPPI FLYWAYS, 1963–65.

		1963	1964	1965	
Retrieved kill	Atlantic Flyway	124,800	105,600	154,600	Weighted estimates of the retrieved kill, based on the questionnaire survey results adjusted for response bias.
	Mississippi Flyway	371,100	320,500	337,600	
	Total	495,900	426,100	492,200	
Age ratio in kill	Atlantic Flyway	1.52	1.59	1.88	From wing survey, expressed as immatures per adult.
	Mississippi Flyway	1.77	1.90	2.26	
	Weighted Average	1.71	1.78	2.13	
Band recovery	Adult	0.058	0.044	0.042	Proportion of wood ducks banded in the summer and pre-hunting season period that were recovered in the first hunting season, expressed as a fraction. Weights equally the recovery rate from each State of banding.
	Immature	0.068	0.053	0.054	
Relative recovery rates		1.17	1.20	1.28	Extent to which immatures are more likely to be shot than adults. Immature recovery rate / adult recovery rate.)
Harvest rates	Adult	0.193	0.147	0.140	Observed recovery rates adjusted for non-report of bands, using 0.30 reporting rate.
	Immature	0.227	0.177	0.180	
Retrieved kill by age	Adult	182,990	153,270	157,200	Applying wing survey age ratio to questionnaire survey results.
	Immature	312,910	272,830	335,000	
Pre-season population estimates	Adult	948,135	1,042,653	1,122,357	Retrieved kill divided by rate of harvest.
	Immature	1,378,458	1,541,412	1,861,111	
	Total	2,326,593	2,584,065	2,983,968	
Immature/adult in pre-hunting season population		1.45	1.48	1.66	

Concern has been expressed about the size of the kill by "unlicensed" hunters, since the questionnaire survey does not include them and uses duck stamp sales as a basis for its kill estimates. Because of the habitat utilized by wood ducks, hunters afield for upland game no doubt encounter wood ducks more often than other species of ducks. The size of kill of wood ducks by unlicensed hunters is unknown; however, in a practical sense, this kill can probably best be evaluated by combining it with non-hunting mortality.

Wing Collection Survey

Representativeness of the wing collection survey should pose no problem, since it is a very large sample, well distributed geographically, and in analysis is subject to further weighting to iron out any disproportionate sampling that occurs. A potential problem associated with this survey may exist because the accuracy with which age determinations are made for wood ducks taken in late November, December and January has not been verified. Limited studies with penned birds indicate that age criteria known to be valid in October persist throughout the hunting season; however, additional verification would be highly desirable.

Both wing collection and mail questionnaire survey data would be more complete if this information were available for Canada as well as the United States. Lack of information from Canada would

TABLE 2. SUMMARY OF PRE-HUNTING SEASON WOOD DUCK BANDINGS, 1959–64 (MAY–OCTOBER)*

State or Province	Age	Years						Total
		1959	1960	1961	1962	1963	1964	
Ontario	Adult				128	232		360
	Immature				126	168	146	440
	Locals					41	14	55
Other Provinces	Adult	102	61	130	4	85	141	523
	Immatures	55	36	67	6	12	10	186
	Locals					28	41	69
Canada	Adult	102	61	130	132	317	141	883
	Immatures	55	36	67	132	180	368	838
	Locals					69	55	124
Total		157	97	197	264	566	564	1,845
Maine	Adult			191	369	413	201	1,174
	Immatures			131	187	179	181	678
	Locals					108		108
Vermont	Adult	123	252	321	161	290	212	1,359
	Immatures	183	574	344	239	522	485	2,347
Massachusetts	Adult					124		124
	Immatures					132		132
	Locals					291		291
Connecticut	Locals				188			188
New York	Adult	213	194	245	190	129	235	1,206
	Immatures	358	520	613	447	384	619	2,941
West Virginia	Adult					132		132
	Immatures	142		129	207		165	643
	Locals						165	165
Maryland	Adult				246	284	324	854
	Immatures				496	656	436	1,588
North Carolina	Immatures				187	130		317
South Carolina	Adult		293	259	963	650		2,165
	Immatures			451	827	469	131	1,878
Other States	Adult	117	170	246	496	294	366	1,689
	Immatures	114	249	279	228	245	282	1,397
	Locals	173	157	267	85	310	172	1,164
Atlantic Flyway	Adult	453	909	1,262	2,425	2,316	1,338	8,703
	Immatures	797	1,343	1,947	2,818	2,717	2,299	11,921
	Locals	173	157	267	273	418	628	1,916
Total		1,423	2,409	3,476	5,516	5,451	4,265	22,540

Minnesota	Adult	190	106	228	398	689	860	2,471
	Immatures	391	147	496	346	447	297	2,124
	Locals						162	162
Wisconsin	Adult	259	565	917	1,370	1,829	626	5,566
	Immatures	638	1,549	1,054	590	1,408	1,528	6,767
	Locals		123	131	250	121		625
Michigan	Adult	197	134	162	260	172	259	2,184
Michigan	Immatures	190	215		122	100	165	792
	Locals	126			134	337	398	995
Iowa	Adult			136	156	901	378	1,571
	Immatures	178	463	684	1,301	1,753	1,545	5,924
	Locals		110	221	380	380	613	1,704
Illinois	Adult		157		190	829	972	1,148
	Immatures	276	1,149	149	964	2,144	2,534	7,216
	Locals			120	511	453	233	1,317
Indiana	Adult	147	453	306	240	330	273	1,749
	Immatures	118	297	438	428	497	566	2,344
Ohio	Adult	155	236	276	454	560	434	2,115
	Immatures			434	778	867	638	2,717
	Locals	262	414	128	234	282	403	1,723
Missouri	Adult	203	207	149	336	1,143	782	2,820
	Immatures	419	196	178	270	686	1,065	2,814
	Locals			138			312	450
Kentucky	Immatures					201		201
	Locals				214	320		534
Arkansas	Adult					392	226	618
	Immatures						149	149
Tennessee	Adult				226	457	382	1,065
	Immatures			162	446	1,887	1,800	4,295
	Locals				154			154
Louisiana	Adult		121					121
	Immatures	394	184	164	481			1,223
	Locals				197			197
Mississippi	Immatures						299	299
	Locals			101	281	140		522
Alabama	Immatures						130	130
Other States	Adult	320	64	270	223	231	177	1,285
	Immatures	165	90	88	8	93	85	529
	Locals	360	318	280		295	97	1,350
Mississippi Flyway	Adult	1,471	2,043	2,444	3,853	7,533	5,369	22,713
	Immatures	2,769	4,290	3,847	5,374	10,083	10,801	37,524
	Locals	748	965	1,119	2,355	2,328	2,218	9,733
Total		4,988	7,298	7,410	11,942	19,944	18,388	69,970
Central Flyway	Adult	7				6	61	74
	Immatures	1				10		11
Total		8				16	61	85
Oregon	Immatures		175	315	191	237	148	1,068
Other States	Immatures	71	5					76
Pacific Flyway	Adult	22	41	39	24	51	54	231
	Immatures	71	180	317	191	237	148	1,144
	Locals	3	2	3				8
Total		96	223	359	215	288	202	1,383
U. S. and Canada	Adults	2,055	3,054	3,875	6,434	10,223	6,963	32,604
	Immatures	3,693	5,849	6,178	8,875	13,227	13,616	51,438
	Locals	924	1,124	1,389	2,628	2,815	2,901	11,781
Total		6,672	10,027	11,442	17,937	26,265	23,480	95,823

* Bandings for individual States and Provinces are shown only when they exceed 100 birds. All bandings are included in Flyway totals.

be particularly vexing were it not for the fact that, unlike most other species of waterfowl, the breeding wood duck population and hunting kill in Canada are relatively small compared to those in the United States.

Banding Program

Although the summer and/or pre-season banding program of flying adult and immature wood ducks has been an outstanding success (Table 2), some gaps in coverage are evident. All significant portions of the breeding range should be represented. However, this is not the case, particularly in the southern states.

The winter banding program has been inadequate and hardly begins to sample the winter population (Table 3). But there is evidence indicating that this seasonal effort is improving.

TABLE 3. SUMMARY OF WINTER (JANUARY–FEBRUARY) WOOD DUCK BANDINGS IN 1959–64.

Area	Years						Total
	1959	1960	1961	1962	1963	1964	
South Carolina						445	445
Georgia						167	167
Florida			243		102		345
Other States		43	73		79	25	220
Atlantic Flyway		43	316		181	637	1,177
Arkansas					499	247	746
Louisiana					219		219
Mississippi						225	225
Other States	1		65		83	125	274
Mississippi Flyway	1		65		801	597	1,464
Central Flyway						14	14
Pacific Flyway	2						2
All Flyways	3	43	381		982	1,248	2,657

Since funds and manpower are limited, it is well to consider which types of banding provide the most useful information. The best recovery and mortality rate information comes from banding flying immature and adult wood ducks prior to the hunting season (pre-season banding). Since this is the basis for most of the needed information outlined earlier, this type of banding should be of highest priority. The banding of locals (flightless young) is appealing. It relates, with precision, production areas to harvest areas. Its value for other uses, however, is limited. A study is now in progress at the Migratory Bird Populations Station which compares the distribution of recoveries and band recovery rates from wood ducks banded as locals and immatures. The distribution of recoveries from

the two age categories is generally similar. This study is scheduled for discussion in a forthcoming Administrative Report.

It should be emphasized that the reliability of the population, kill rate, and mortality rate estimates depends on the accuracy with which the birds are aged and sexed when banded. Determining the age of wood ducks is difficult compared to other species. Since immatures have been observed to have different first-hunting-season recovery rates than adults, it is evident that there is a substantial degree of accuracy in the age determinations that have been made. How much greater the difference between immatures and adults would be if age and sex determinations were perfect is unknown. Persons associated with the wood duck banding program must fully appreciate the vital importance of accurate age and sex determinations.

NEED FOR INFORMATION ON A REGIONAL OR SUB-POPULATION UNIT BASIS

According to available data, various banded wood duck populations show marked differences in shooting pressures and mortality rates in the United States. There is a strong suggestion that northern populations encounter higher shooting pressures and higher annual rates of mortality than those in the South. An analysis of banding data through 1961 indicated that wood ducks banded in the northern states of Maine, Vermont and Wisconsin had the highest recovery and mortality rates, while West Virginia birds (the only "southern" state with sufficient data) had the lowest recovery and mortality rates. Better data, particularly from the southern part of the wood duck's range, are required to understand the differences that exist between population units. If it develops that southern populations have low harvest and high survival rates, there may some day be justification for a liberal wood duck season in southern areas in September, prior to the arrival of migrants from the north.

In many respects, the population size and production rate estimates obtained by the indirect method tend to "paint with too broad a brush." The indirect population estimates produced in recent years are crude expressions of the size of the populations inhabiting an area as vast as the combined Atlantic and Mississippi Flyways.

A factor contributing to a lack of precision in these estimates is the questionable kill rates used in making the estimates. These unweighted recovery rates combine data from a variety of banding stations without recognizing that some stations reflect the characteristics of much larger numbers of wood ducks than do other stations.

Furthermore, as I pointed out before, despite the sterling qualities of the wood duck banding program, there are still large populations not represented by banded birds. Therefore, it must be assumed that the banding that has been done reflects the characteristics of the entire population. If the populations in the South are of substantial size, I suspect that the actual rate of kill of the continental wood duck population is less than that which has been used in recent years to make the population estimates. This is because the banding program has been concentrated in the northern edge of the wood duck's range where shooting pressure is relatively high. If this is true, the continental wood duck population is larger than prevailing estimates indicate.

No attempt has been made to weight the banding data from different areas because the necessary information to do this is lacking. This does not mean that this information cannot be obtained. Theoretically, it should be possible to estimate the size of the population reflected by each banded sample through an indirect means, if the following conditions are met:

(1) The distribution of the kill from each banding area is not the same, *i.e.*, birds banded in different areas tend to be killed in different areas.
(2) All wood duck populations of significant size are represented by a banded sample of sufficient size to reflect the distribution of the kill.
(3) The size of the kill in various harvest areas is known.
(4) Band-reporting rates are the same or of known magnitude in all harvest areas.

These conditions should permit calculating the size of the population represented by bandings in each area by solving a series of simultaneous equations having as many equations as there are harvest areas and as many unknowns as there are banding areas. The "calculations" associated with this approach should be no problem in this era of high speed computers.

SUMMARY

To summarize the status of our current knowledge about the wood duck population, it can be said that we have a rough measure of annual population size. It is difficult to evaluate the accuracy of these estimates. But in my opinion they should detect changes in population size in the order of ±33 percent. The mortality rate and production rate information being obtained should be of sufficient precision to help explain changes in over-all population levels. Our understanding of the status and characteristics of wood duck popu-

lations, however, is seriously weakened because we may have substantial populations that are not represented by banded birds. The conclusions I stated relative to the adequacy of the population, production and mortality information may be wrong, if very large populations with unique characteristics are not being included in the present banding program. In this regard, we obtain estimates of the size of the kill and its age and sex composition for all significant harvest areas in the United States. However, kill rate information is not available for most southern populations. Lacking this information, we must base conclusions largely on data from populations of wood ducks in the northern part of their range.

Despite these difficulties associated with the wood duck data-gathering program, the known information about this important and elusive species represents an outstanding achievement in waterfowl management. Our knowledge about this species' status, population trends, and population dynamics considerably exceeds that for the mourning dove, despite the fact that roughly 50 doves are harvested annually for every wood duck. This is a testimonial to the efforts of many people, a considerable number of whom are represented at this meeting.

LITERATURE CITED

Atwood, E. L.
1965. Validity of mail survey data on bagged waterfowl. J. Wildl. Mgmt. 20(1): 1-16.
Geis, A. D., and E. L. Atwood
1961. Proportion of recovered waterfowl bands reported. J. Wildl. Mgmt. 25(2): 154-159.
———, and S. M. Carney
1961. Results of duck-wing collection in the Mississippi Flyway, 1959-60. Bur. of Sport Fisheries and Wildl., Spec. Sci. Rept. Wildl. No. 54. 120 p.
Hawkins, A. S., and C. E. Addy
1965. Problems in flyway-wide appraisgal of wood duck habitat. *In* Proc. Wood Duck Symposium, Wildl. Mgmt. Inst., Washington, D. C.
Kaczynski, C. F., and A. D. Geis
1961. Wood duck banding program progress report, 1959 and 1960. Bur. of Sport Fisheries and Wildl., Spec. Sci. Rept. Wildl. No. 59. 41 p.

SUCCESSES AND PROBLEMS IN SUPPLYING DUCK WOOD POPULATION STATUS INFORMATION—MISSISSIPPI FLYWAY

R. BARRATT
Chairman, Wood Duck Committee, Technical Section, Mississippi Flyway Council; Iowa Conservation Commission, Des Moines

Dr. Geis has outlined the various needs for data to effectively establish wood duck population estimates by indirect methods. He has pointed out many other needs essential to proper management of this species. With the information and methods presently available, it is apparent that the harvest of wood ducks is regulated on a "trial and error" basis.

We currently establish regulations for the harvest of wood ducks without accurate estimates of annual production. Reliable data are now largely available only after regulations for the hunting seasons have been established. Therefore, we face these facts: (1) at present we are setting seasons based on last year's population estimates, (2) we are harvesting birds from a population of unknown magnitude, and (3) we are evaluating post-hunting season data to determine survival.

One fact should be obvious, managing a resource by these methods is courting disaster. Had certain other waterfowl been managed accordingly during the last 10 years, it is likely that we would not have had a duck population presently capable of withstanding a hunting season.

It is of paramount importance to devise a method of accurately estimating wood duck populations prior to the establishment of annual hunting regulations. Dame Fortune has been kind in recent years and wood duck populations have flourished. But with current management procedures, we need but one "crop failure" to decimate our wood duck populations to the point where they would take many years to recover.

With the wood duck, we are dealing with a species that is largely contained within the respective flyways. They are not seriously affected by adverse habitat conditions in the prairies. Here is a chance to manage a species, which, for the most part, spends its entire life within the continental United States. Yet we apparently know less about the population dynamics of this species than any other common duck.

The purpose of this paper is to discuss the successes and problems of obtaining wood duck population information in the Mississippi Flyway. From previous comments, it should be apparent that

problems greatly outnumber accomplishments. Some progress has been made within the flyway in the last few years in banding and inventorying wood ducks.

BANDING ACCOMPLISHMENTS AND NEEDS

Banding has proved to be the most significant management tool available for this species. In 1959 the Technical Section of the Mississippi Flyway Council initiated an intensive wood duck banding program. A quota of 500 birds was established for each of the 14 states within the flyway. This quota was later raised to 750 birds per state, and was increased to 1,000 birds per state in 1964. Banding of wood ducks in the flyway increased annually from a few thousand birds to more than 23,000 in 1963.

Presently, the greatest needs for wood duck banding in the Mississippi Flyway are to improve distribution of the banded sample and to apply greater effort in banding significant numbers of birds at wintering areas after the hunting season closes. In the last several years, banding of local and immature wood ducks in the northern portion of the flyway has been excellent. Fine efforts were contributed by both federal and state agencies. There is still a great need in the lower reaches of the flyway for pre-hunting season banding. Cooperation is needed particularly from the national wildlife refuges in Alabama, Mississippi, and Louisiana. Dr. Geis has already pointed out the need for winter banding.

One of the critical problems in the wood duck banding program in earlier years was the inability of banders to correctly age and sex birds. Since differential vulnerability to hunting pressure and preseason population estimates are based largely on banding data, it is imperative that banded birds be accurately aged and sexed.

BREEDING POPULATION INVENTORIES

As pointed out previously, the major problem in managing wood ducks is the inability to measure accurately production on the breeding areas. The habitat of breeding wood ducks is such that conventional survey methods are nearly worthless. Stream float counts, natural nest cavity checks, nest box checks, and other similar methods have been used by various agencies for a number of years. Opinions regarding the value of data collected by these methods vary greatly.

A study of the files of the Wood Duck Committee, Technical Section, Mississippi Flyway Council, shows that a great deal of data on population dynamics of the wood duck have been collected. The collection of these data, however, has not been systematic and is not

comparable from year to year. States have not always used the same methods, and, in some cases, have changed methods from one year to the next. Therefore, it is extremely difficult to establish production trends.

Dr. Dale Hein, while a graduate student at Iowa State University, made a statistical analysis of the data collected by the Wood Duck Committee. He concluded that most of the data were not statistically sound. Nevertheless, wood duck populations in individual states tended to follow the same general trend in a given year. But there was no sound basis for measuring the degree of increase or decrease in the population.

Although current survey methods are far from satisfactory, it is desirable that they be employed in a systematic manner from one year to the next. This approach is essential to provide continuity in the wood duck population status information.

It is imperative that better techniques for surveying annual wood duck production on the breeding grounds be devised. In 1964 and 1965 Iowa experimented with a method of determining total waterfowl production on a given marsh. Our method employs two or more types of banding operations run at close intervals. In this case, blue-winged teal populations were sampled by the night-lighting method and, secondly, by using conventional drive-trap techniques. Both efforts are a regular part of the breeding grounds banding program carried on in prairie marshes. This scheme of marking a sample of a given population and estimating total populations from the percentage of marked individuals in subsequent captures is, of course, nearly as old as the science of game management. It is quite probable that this method might be applied to the wood duck by using a combination of night-lighting and bait-trapping procedures to capture flightless young. Although this technique may be expensive, if carried out on the magnitude necessary to make it statistically sound, it could be used at little additional expense where banding operations are being conducted. Certainly, any program which might give us a better estimate of wood duck production merits further exploration.

PROBLEMS OF DATA GATHERING

Though much of this paper deals with inadequacies in our efforts to gather accurate information on wood duck populations, it must be pointed out that any technique is only as good as we make it. The most accurate census procedure imaginable would be largely worthless unless the data were properly collected and reported.

In the past, the task of compiling data from the flyway has been

seriously hampered by a lack of response on the part of technicians responsible for waterfowl research. For example, in 1965 only six of 14 states in the Mississippi Flyway responded to a letter from the Wood Duck Committee asking for data prior to the summer meeting of the Technical Section. In order to supply population status information for the formulation of hunting regulations, it is necessary that everyone involved cooperate.

Reasons for failing to supply the requested information are varied. Some states reported they had no data and could only furnish opinions. Opinions coming from qualified observers are useful, and, in fact, often prove to be quite reliable.

Other states plead a lack of time. Unforunately this is often true, since administrators sometimes do not allow their technicians time enough from their regular duties to cooperate fully in the flyway programs. Chairman Bednarik of the Technical Section of the Mississippi Flyway Council pointed this out to administrators at the Council meeting in St. Louis in 1965. Several administrators expressed their desire to cooperate fully and assured the Technical Section that the technicians from their respective states would be given time to carry out their responsibilities.

Still other states admit to procrastination. Everyone has a responsibility to his profession to cooperate to the best of his ability. Probably no where today is this responsibility greater to the professional in the wildlife field than in waterfowl management. Without cooperation from the various agencies, waterfowl will be doomed.

SUMMARY

Although the task of securing wood duck population status information is fraught with problems, it need not be an impossible task. Problems can be resolved by increasing banding efforts, improving census techniques, expanding understanding of population dynamics, and increasing cooperation of personnel responsible for data collections. When these activities are achieved, wood duck management will be improved greatly in the Mississippi Flyway.

SUCCESSES AND PROBLEMS IN SUPPLYING WOOD DUCK POPULATION STATUS INFORMATION—ATLANTIC FLYWAY

G. F. PUSHEE, JR.

Chairman, Wood Duck Committee, Technical Section, Atlantic Waterfowl Council; Massachusetts Division of Fisheries and Game, Westboro

The Technical Section of the Atlantic Waterfowl Council was formally established in May, 1960. Committee assignments were made, and I was asked to be chairman of the Wood Duck Committee. As many of you know, we have been concerned with the wood duck in Massachusetts since the late 40's. I was tremendously pleased that a separate committee was named for this species. It had appeared to us in Massachusetts that there was very little concern for the wood duck in the Atlantic Flyway, although since about 1956, we have noted and reported a continual decline in the breeding population.

Committee action started during the summer of 1960 with a questionnaire sent to the states and regional offices of the Fish and Wildlife Service. Response was fairly good to this request for information on past wood duck banding and plans for the future. The results of this questionnaire were summarized and presented at the first meeting of the Technical Section in February 1961. Again, there was no particular concern expressed for the welfare of this species. In the southern part of the flyway especially, the feeling was that wood ducks were abundant.

It was noted, however, that no reliable population figure was available from the winter inventory, nor was there any idea what proportion of these birds were raised in the South. It was gratifying, therefore, to have a representative from Georgia propose that there be a Flyway banding program for an initial three-year period. There was an immediate increase in the number of ducks banded, from 2,561 in 1960 to 3,615 in 1961. In 1962 the number doubled to 6,908. In the next two years, however, the numbers decreased, to 6,677 in 1963 and to 5,960 in 1964 (Table 1).

Banding goals were set in a joint effort by the Banding Committee and the Wood Duck Committee. The goal (state and federal) combined) has been exceeded in only one state and has come close in two others. The specific reason why goals have not been met is not known because in discussions and in answers to questionnaires, there has been considerable interest shown throughout the Flyway. It can hardly be blamed on a lack of knowledge of how to trap. Proven

TABLE 1. WOOD DUCK BANDING GOALS AND ACCOMPLISHMENTS IN THE ATLANTIC FLYWAY, 1962–64.

State or Province	Annual Banding Goal	No. Banded in Specific Years			
		1962	1963	1964	All Years
New Brunswick	** 250	0	98	99	197
Nova Scotia	** 500	0	0	212	212
Ontario	*1,000	334	442	247	1,023
CANADA TOTAL	1,750	334	540	558	1,432
Maine	*1,300	655	700	436	1,791
New Hampshire	* 100	0	0	0	0
Vermont	*1,350	401	824	780	2,005
Massachusetts	* 550	140	313	461	914
Rhode Island	** 500	66	43	19	128
Connecticut	** 500	297	0	0	297
New York	*2,100	708	575	873	2,156
Pennsylvania	**1,000	39	90	6	135
New Jersey	** 500	0	67	51	118
Maryland	*1,000	841	1,045	1,169	3,055
Delaware	** 500	88	27	0	115
West Virginia	** 500	378	368	468	1,214
Virginia	*1,500	227	165	47	439
North Carolina	*2,000	465	288	181	934
South Carolina	*3,000	1,889	1,160	679	3,728
Georgia	*2,000	38	219	201	458
Florida	*3,000	342	253	31	626
U. S. TOTAL	21,400	6,574	6,137	5,402	18,113
FLYWAY TOTAL	23,150	6,908	6,677	5,960	19,545

* As recommended by the Banding Committee in 1963.
** As recommended by the Wood Duck Committee in 1965.

techniques from bait-trapping to drive-trapping have been described and discussed. My personal opinion is that most of the members of the Flyway have not been able to give the wood duck the proper priority. Massachusetts is one of the few states which is giving this species more than passing interest. During the past five years, reports from the Bureau have indicated an expanding population with a healthy age ratio. This may be true, but it is contrary to findings in Massachusetts during the same period. I think many states are lulled into apathy with a false impression. Massachusetts has been so concerned that it has never taken the two-bird option.

At this point, the Committee has no idea what the banding effort has been in 1965. We were encouraged by the response to a memorandum which we sent out this past May. Of the 16 states answering, only two reported no plans for trapping this year and one of those will give it consideration another year. The one Canadian province which did reply expected to exceed last year's effort, which was good. The Fish and Wildlife Service reported plans to increase

their efforts. They have, incidentally, banded the larger share of birds each year in the past.

More and more interest is being shown in drive-trapping and night-lighting. Several states indicated they had started special studies on nesting and production. In some cases, this included banding the nesting females and web-tagging the ducklings. More of these basic data are needed to determine such things as brood survival and the amount of recruitment of young females to the breeding population.

In 1961 the Bureau provided the Committee with a draft of its proposed project to determine distribution, migration, hunting kill and survival of the wood duck. This draft was distributed throughout the Atlantic Flyway and comments on it were solicited. Our comments were forwarded to the Migratory Bird Station. The Committee is aware that the final analysis of all wood duck bandings will not be made by the Bureau until after the mallard and Canada goose records are analyzed.

The Bureau has been cooperative in presenting data in special scientific and administrative reports. We would like to suggest that more interest might be generated in the states and provinces if, in addition to calculating the age ratios and pre-season populations, the Bureau would report each year the relative mortality rate by states or regions. Also, an annual figure on mortality from all causes would be helpful.

The deadline for the original analysis of wood duck banding data has come and gone. Interest by states in banding woodies has run the full cycle from high to low and is high again. We hope that within the next five years enough well-distributed banding records can be assembled to make the proposed analysis of the wood duck data a reality.

DISCUSSION

SESSION VII

CHAIRMAN K. E. BEDNARIK (*Ohio Division of Wildlife*): This discussion will relate to establishing the status of wood duck populations. I have been a member of the Wood Duck Committee of the Technical Section of the Mississippi Flyway Council for the past seven or eight years. We find that progress in establishing the wood duck population status has been a slow and painful evolution. The floor is now open for discussion.

R. J. JESSEN (*Minnesota Department of Conservation*): I was very much impressed by the information that Al Geis presented. To me it indicates, as he pointed out, a very high reproductive rate in the wood duck and a harvest rate that isn't particularly high. The harvest rate may be 20 percent or less, which is almost comparable to the rate in big game. I think this might suggest that the mortality of the wood duck is one of natural mortality due to causes other than habitat deficiencies, such as lack of nesting cavities. I wonder if Al would carry this thought a little further.

A. D. GEIS: Bob, I think your interpretation of the situation is quite right. The wood duck doesn't have an extremely high shooting mortality. It is obvious

that most of the wood ducks that die each year are victims of some other form of mortality. It is also correct that their production rate is real fine. I think it behooves people studying wood ducks to focus attention on what these other sources of mortality might be. So I'm just agreeing with you wholeheartedly.

G. F. PUSHEE (*Massachusetts Division of Fisheries and Game*): It seems that whenever I go to a flyway meeting, I'm the only one that shows concern about the wood duck population. I don't know whether we're that far off in Massachusetts, or if somebody else is, but we know definitely from our studies that our breeding population has declined. We are not now getting recruitment of young birds as we were when our population was in a healthy condition. I just wonder if there are other areas within the Mississippi Flyway where there's any concern of this sort. I haven't been able to run into it as yet. I assume Massachusetts is a good example of an area where the population is overharvested or something peculiar is involved that makes the state wood duck population trend inconsistent with changes in the flyway as a whole.

H. J. MILLER (*Michigan Department of Conservation*): I'd like to attempt a reply and I'd like to add a couple of other remarks regarding the status of the wood duck in the upper part of the Mississippi Flyway. Our Canadian neighbors to the east of us made a comment about the beaver population and its effect on the wood duck population. My comments are hinged around the effects of the beaver management program in the northern fringe area.

In Michigan, as well as in parts of Ontario, and I suspect in parts of Wisconsin too, even during the low periods of the wood duck population in 1940 through the 1950's, we were having considerable difficulty convincing sportsmen that wood duck populations were real low. We had fair populations of wood duck, and I suspect that the type of habitat that we have in the northern fringe area has carried a very stable population of wood duck over many years. We have never seen the real scarcity of wood ducks nor been frightened over the idea that the species was going to become extinct, at least in the past 15 years in this northern range. We appreciate that the wood duck population was very low in other parts of the flyway, according to all information submitted. My point is that we think that the management of the beaver is a very important management tool in keeping a fair wood duck population in the northern end of the range. And we have had very little discussion about the importance of beaver in wood duck management. Numerous beaver ponds are providing roosting areas, feeding areas, and nesting habitat. In other words, the price of beaver pelts I think would influence the population of wood ducks in this northern fringe country. In the past ten years, the price of beaver pelts has been pretty low. We've had a pretty high beaver population, with a consequence that we've had quite a lot of wood duck habitat and pretty good production.

J. M. ANDERSON (*Winous Point Shooting Club, Ohio*): I have often wondered what limiting factors are operating in populations of other tree-nesting species, such as the goldeneye and the hooded merganser. Might not some studies of these species throw some light on mortality factors other than hunting? If so, are there some good reasons why we aren't making studies of these two species?

A. D. GEIS: I don't really know. But I'm very much concerned that the characteristics and behavior of mergansers and goldeneyes are so utterly different than for wood ducks. It would be a little far-fetched to apply any conclusions drawn with regard to these two species to the wood duck. Also remember that their breeding ranges are quite different. So I'm a little concerned about reaching meaningful conclusions.

I'd like to discuss this matter of consistently operating a year late to establish the status of wood ducks populations. Bob Barratt pointed out that we lack current information on production rates when we set waterfowl hunting regulations. You'll also remember that over half the wood ducks shot each year are young birds, suggesting that there is some virtue in his argument. I agree he has a point. But I can't help think that if we should make a mistake, we have an opportunity to correct it. I think that if we should find that we depressed the wod duck population, due to a combination of poor production and overliberal

regulations, we're in a position to correct the matter through restrictive regulations the following years. So I don't think the situation might be quite as devastating as the tone of Bob's discussion may have suggested.

J. H. STOUDT (*Bureau of Sport Fisheries and Wildlife*): You may think I'm a little out of order in commenting here, having lived on a prairie for the last many years. But I was born on the Mississippi River and worked on the Upper Mississippi Refuge for three years. I'm a little worried about getting enthusiastic about the low kill and high production of wood ducks, and, therefore, maybe you're going to increase the kill. Every time you cut the limit on a species of duck down to one, like you've done on the wood duck for a good many years, you're apt to have a lot of birds shot that are not retrieved and reduced to the bag. I'd like to ask how you measure the number of wood ducks that are stomped in the mud each year.

A. D. GEIS: Well you really do have to measure this, the same as you have to measure the annual mortality rate. You have measures of total mortality during the year and the legal kill, or the kill that people are willing to admit to. Many times when we have a one-bird limit the person takes a banded bird and reports it, but we have no way of knowing if he takes a gunny sack full. So I'm convinced that when there's at least one legal bird in the bag we get the band report. So perhaps our kill-rate information, when there is at least one bird in the bag, may not be too bad. And even above and beyond that, we should be able to get estimates of total rates of mortality. One thing that kind of puts us out of business is a complete closure on hunting. But still all is not lost if we have a season every so often. I think this was demonstrated not long ago with the redhead and canvasback band recovery data, which I think show very conclusively that the closed seasons we had on these two species increased their survival. There are still ways of getting at natural losses. I guess we have to hope that we don't completely miss the real values with our estimates. Certainly we get estimates of the total mortality rate.

CHAIRMAN BEDNARIK: Thank you, Al. We recognize you as a veritable walking Encyclopedia Britannica in terms of waterfowl information. In fact, you have so much information that one of the biggest problems is keeping within the time limits for meetings. But these remarks are a compliment. I'm glad that you are able to attend all our meetings because you provide a great deal of information for our people.

J. P. ROGERS: I'd like to refer to an earlier exchange by Geis and Jensen about the importance of investigating other mortality factors. I think their conversation left the implication that we shouldn't be too concerned about nesting habitat, or that other factors are more important. I agree that we should certainly investigate other mortality factors. But I'd like to point out that the good wood duck production and relatively low shooting mortality are facts referring to the population that we have right now. We certainly should be concerned about habitat in an effort to increase our population base. I think these two concepts are very different and that one should not rate higher than the other.

A. O. HAUGEN (*Iowa Cooperative Wildlife Research Unit*): Are we apt to have a particularly disastrous year in the production of the wood duck, a species that nests in hollow trees all over the United States along creeks, ponds, swamps, etc.? Are we as apt to have a year of poor production, as we have in some prairie nesting species of ducks when a drought hits?

R. BARRATT (*Iowa Department of Conservation*): Actually I don't think that it's as apt to happen with wood ducks as with some other ducks, but we could have factors such as late storms, freezing weather, or some things of that sort that could reduce production substantially. I don't think drought conditions are too important to the wood duck.

P. SPRINGER (*South Dakota Cooperative Wildlife Research Unit*): An important part of Al's program relies on the correct measure of the band recovery rate. I'll admit that this has been changing, and I wondered how accurate his current figure is and how much this would vary in different parts of the country. I'm sure

the recovery rate varies. To me it is quite important to know these variations in calculating production and population figures.

A. D. GEIS: I agree, Paul; you're quite right. This is an important point. I'll say this though; if we are far off in our estimate of band reporting rates, we get far-fetched results. These sets of data have to maintain a reasonable relationship to one another, or the fact that this condition doesn't exist is revealed by the fact that we begin to have absurdities generated. The fact that we get consistent results that seem to hold together, suggests that we're not too far off. For example, if we found that our population estimate soared dramatically during a period when production rates were declining, it would suggest that something wasn't right. So as a generality, I think we do have a reasonable approximation of the band reporting rate.

As far as the local situation is concerned, I don't know. I suspect there are local differences in band reporting rates. It's far more difficult, with the extensive type of survey that we have, to measure band reporting rates on a local basis. For this reason we are very much opposed to these local publicity programs to increase band reporting rates. It further complicates this matter, and as I mentioned before and as George Pushee emphasized, we really need to understand the characteristics of some local populations. But the variable band reporting rates make local estimates very difficult. So to summarize the situation, I think we are measuring band reporting rates in a general sense on a vast area. I don't know how well we're doing on a local basis.

R. A. HUNT (*Wisconsin Conservation Department*): We have gone from one wood duck to two in our flyway and the Atlantic Flyway, and there appears to be a continuing favorable trend in wood ducks. I wonder if you'd speculate on how far we could go in liberalizing regulations. Could we go to a bag limit of four? What effect do you think this would have.

A. D. GEIS: First, I think it is a mistake to look at the wood duck regulations alone. We have had the change in wood duck regulations at a time when there have been dramatic changes in the general waterfowl situation. So I think we must always consider the wood duck regulations in relation to those on other ducks. There have been some very dramatic things happening. Perhaps some of these haven't been adequately emphasized thus far. For example, in Arkansas, when they got down to a one and two-bird limit, instead of the wood duck making up 1 or 2 percent of the kill, it suddenly made up 12 percent of the kill. So we've had some inter-action between the regulations between different species. I think it is unsafe to generalize about the situation in regard to the wood duck by itself. Now perhaps a four-bird limit might be justified under a situation in which general waterfowl regulations were very restrictive. I'm inclined to feel apprehensive if we're entering into an era of more liberal regulations. In short, I don't really know what the answer is, but I'd feel very dubious about a four-bird limit on the wood duck when we're dealing with 70-day seasons and an overall four-bird limit.

W. E. GREEN (*Bureau of Sport Fisheries and Wildlife*): Along that line, Al, it is sometimes misleading to look at the wood duck harvest in terms of percentage of total kill unless you relate the percentage to the overall kill. On the Upper Mississippi River last fall (1964), for the first time, the wood duck was the most widely taken species of any on the river. Our information is not completely worked up yet, but there is pretty good evidence that the total kill of wood ducks is not any higher this year than it has been in the past, even though it is in first place. A lot of this is due to the fact that our mallard kill on the river is way down. We've noticed surprisingly little increase in the wood duck kill even though regulations on the wood duck were liberalized. I'm talking now about the total kill, not percentage kill. As a matter of fact, the first year that we went to the two-bird limit on the river, we were quite concerned about what might happen to our population. On the basis of over 5,000 field bag checks that we made that season, we found that there were only 45 additional wood ducks taken by these hunters because they were permitted two birds in the bag rather

than one. So no substantial increase in harvest occurred on the Upper Mississippi River due to the more liberal regulations.

CHAIRMAN BEDNARIK: We'll have to terminate this discussion now. At this time, I'd like to introduce Harvey Nelson. Harvey would like to make some comments about distribution records for wood ducks.

H. K. NELSON (*Jamestown Wildlife Research Center, Bureau of Sport Fisheries and Wildlife*): We have some questions concerning the distribution maps presented in your program and also on preparation of a map that would indicate the current distribution of the wood duck. On the back of your program is the so-called "historical" distribution map that was prepared by Chan Robbins. You will note the caption indicates that it was based on information available through 1938. Information available in their distribution files was used. I'd like to ask if there are any comments concerning possible corrections or additions to this map? If so, we'd like to have them. For example, there may be some changes in order for southern Canada or the Appalachian region. There seem to be some big gaps involved. It may merely be a gap because available information was incomplete. We have the original map at Jamestown. Before preparing the final map for publication we would welcome any corrections. Just send any corrections or additions to us. This will simplify the whole matter. We want to be sure that the information presented is reported properly and accurately. We want to include this map in the proceedings of the meeting, so send me any comments within two weeks. This would permit construction of a map showing the status of wood duck distribution up through 1938.

We had also contemplated including a current distribution map for the program, as well as the proceedings. But it was not possible to compile this material before the meeting. We still feel it would be desirable to pull together all the known data at this time and prepare such a map. In discussions with Al, he indicated that he'd be glad to have Chan Robbins and one of his staff work on this, if we can set up some procedures for getting the information to them. There are two or three ways we could do this. From my point of view, I think it would be best if we would systematically solicit this information through the Flyway Technical Committees, as we've done for other projects. We would attempt to get an up-to-date coverage. The information in turn could be made available to Al and Chan and a current distribution map would be forthcoming. Of course, this would not permit the map to be included in the transactions of the meeting. But it could be sent out in some other form at a later date.

CHAIRMAN BEDNARIK: Now we'll have closing remarks of the Wood Duck Symposium by Bill Crawford, who is the President of the North Central Section of the Wildlife Society, one of the organizations sponsoring this symposium.

SYMPOSIUM SUMMARY

R. A. McCABE
Chairman of Department of Wildlife Ecology, University of Wisconsin, Madison.

The subject of our gathering these last two days is a duck of rare plumage, limited geographical range, and particular ecological requirements. The impact of man's land-use activities on the welfare of the wood duck can, as a whole, be regarded as detrimental. You have here sharpened your pens and your wits to appraise the situation, to analyze limiting factors, and to ponder courses of action. To say that we have scored in each area would be a self-indulging overstatement. The wealth of insight and understanding of this species of waterfowl, and the conservation problems associated with it that came from these discussions exceeded all expectations.

I was aware that the current status of the wood duck would be covered adequately by the symposium just completed—and it was. As an exercise to my contribution, I looked up some of the old classics in the ornithological and hunting literature. I found that the wood duck was classified as *Anas sponsa* in Linnaeus' *Systema Naturae*, volume one, 1758, on page 128. Later, in 1828, the generic name *Aix* replaced *Anas*. The "*Aix*" came from the Greek meaning a kind of waterfowl (in Aristotle), while "*sponsa*" came from the Latin, meaning betrothed, alluding to the wedding dress of the bird. Hence, one of the early references refers to the wood duck as "the bride" or bridal duck.

I found also, as Mrs. Nice (1954) had for incubation periods among birds, that an early error duly recorded is often repeated and even compounded by intelligent author and hack writer alike. For example, I checked a series of references on two points: (1) the North American range of the wood duck, and (2) the way in which downy young leave the nesting cavity. On the first point, the ranges were ascribed as "in every quarter of the United States" and "as equally well known in Mexico and many of the West India Islands" (Wilson and Bonaparte: 1876); in all fresh water of North America (Hallock: 1879); North America at large to the West India islands and north to the British possessions (Canada) (Yorke: 1899); Florida to Hudson Bay and winters southward to southern Mexico, Cuba and Jamaica (Chapman: 1912). Many references parrot Coues (1903) who states: "Temperate North America to southern Cuba." Others refer to Mexico generally, but Blake (1953) in his *Birds of Mexico* says that it "winters casually in northern Mexico (Sonora) and south at least to Distrito Federal." Unanimity on

the basic point of range even now is not clear-cut, as the map in the back of your program booklet testifies.

On the natural-history point concerning the evacuation of ducklings from the nest cavity, Thomas Nuttall (1834), John J. Audubon (1835), and Alexander Wilson and Bonaparte (1876) state that there are times and conditions which when evaluated by the female cause her to carry the young in her bill from the nest cavity to the water. One author (Yorke: 1899) states that they are carried between the thighs of the female and when not carried are "pushed" from the nest. Elliott (1898), Grinnell (1901) and Coues (1903) agree that they either drop or are carried from the nest. Bent (1923) has recorded two first-hand accounts, one where the young were carried to the water on the back of the female and the other where the young were carried in the bill. Even the scholarly and meticulous Forbush (1925) leaves room for this kind of nonsense. Bellrose (1953), however, states that ". . . in dozens of observations we have made of the departure of the young, we have never seen such an episode," referring here to the various physical means by which females carried young from the nest.

If, on points such as these, our revered naturalists of the past have failed either to confirm or deny accuracy of observation, how then shall we regard their other statements of fact? While such a casual attitude toward truth is said to cause a boy to lose faith in his father, it also forced a scientific attitude onto those field workers interested in wildlife conservation.

It is that scientific attitude which prompted the papers presented here to deal objectively with one species of our natural-resource complex.

Larry Jahn put this symposium in perspective and in focus with his opening remarks. I trust that some of his provocative questions were answered, in part at least, by the sessions just concluded. It was indeed a program in which the knowledge of distinct disciplines and experience were brought to bear on the question of species management.

The wood duck habitat is comprised largely of those plant communities found in the lowland forests. The tree species composition varies and becomes more diversified south to north. As a plant community the lowland forest is relatively stable, so that a sound management program once developed would have wide application.

Forest management is the chief management activity to affect this riverine plant community. We were reminded that foresters are businessmen. We hope that they will be ecologists and humanitarians as well. Although the prediction for the future is stumpage at a

smaller d.b.h., the forester is willing to do what he can to preserve habitat as he satisfied stockholders. In order to give maximum help, the wildlife biologist is asked on occasion to provide guidelines in the form of answers to questions he has been trying unsuccessfully to ascertain for quite some time. In this respect he is like the medical researcher who must tell his patient that although he has worked as hard as is humanly possible, he cannot cure cancer. From a resource point of view it may be wise to put vitally needed habitat into public ownership where noneconomic factors become part of value judgments.

Although two speakers point to the possibility of an increase in bottomland timber in some areas, another pointed to the serious loss caused by drainage and the conversion of such lands to agriculture and soft-wood silviculture . . . both detrimental to wood duck welfare. Such drainage and alleged land improvement are supported by P.L. 566. The North Carolina Wildlife Resources Commission report condemns this law as threatening extensive and serious damage to the recreation and economy of the southeast region. The effect of this program in the wood duck's northern range was not considered detrimental.

The U.S. Corps of Engineers is engaged in long-range planning which recognizes wildlife resources. Such planning, it was said, was not arbitrary since council with local county and state agencies was involved. "Textbooks" were admittedly not consulted on matters of plant communities. (It is not to be assumed that the planning is the better for it.)

Flyway-wide appraisal of wood duck habitat is difficult, expensive, and even prohibitive on budgets provided for waterfowl investigations. Thus it may be difficult to supply the forest manager with the data he needs to guide his program, unless a uniform system of monitoring gains and losses in wood duck habitat can be worked out adapted to machine processing.

On one area, the Chippewa National Forest in Minnesota, an inventory was made and a management plan developed. The cost would be about 1⅓ million dollars or $27.00 per acre, but the minimum annual worth of this improvement was calculated at between $358,000 and $632,000. Even a wildlife manager could justify the economics of this investment with all its "iffy" aspects.

Habitat management to be understood must define which of the wood duck habitats is under consideration: (1) nesting, (2) brooding, (3) feeding, (4) molting, (5) wintering. On most areas patchy emergent vegetation with a network of passages is ideal brood cover, while a tangle of downed timber and brush is good year-round

cover. These two definitions met with no objections. In the Midwest, at least, it was alleged that nest sites are decreasing, particularly in proportion to human population increase and intensified land-use. It was pointed out also that wood ducks could be raised artificially, and that they could be used for introducing wood ducks into habitats that were devoid of a breeding nucleus. In addition, propagating programs have been used for educational and recreational purposes. In one paper, an outstanding return of propagated wood ducks to a pin-point homing site indicated that this species has an extraordinary adaptation for homing. Of seven females reared in one area, and, I presume, subject to shooting pressure during migration and wintering, five returned to breed in the rearing locality—a truly outstanding performance.

One writer said that "there is no way of accurately assessing the impact of forest management and other human activities on wood duck habitat." And further, in order to convince land managers that wood duck habitat is worth saving, a monetary value must be put on the wood duck as a wildlife species. If these observations are correct, we and the wood duck are indeed in trouble. It may be as difficult to ascribe a monetary value to a wood duck population as it is to determine land-use impacts on its well-being.

Trees can be managed for mast crops which are the prime food of wood ducks. Thinning oak stands to increase crown size and encourage an open-grown condition is conducive to mast production. Bottomlands of thinned oaks can also be seeded to millet in the event of an anticipated mast failure. Controlled or natural flooding then brings duck and food together.

Decay of heartwood in certain tree species is an ecological factor affecting habitat quality by increasing the potential for nesting cavities. Wood duck nest boxes, however, play an important role by increasing available nesting sites. A translucent fiberglass nest box has been developed which allows sufficient light to enter, thus discouraging box use by competing starlings.

Although populations are not large in eastern Canada, parts of southern Ontario, Quebec, and New Brunswick have breeding wood ducks. Some of these birds, as indicated by banding research, have been taken in the Mississippi and Atlantic flyways.

Two points of view were expressed on the use of wood duck roosts as a census technique. One worker felt that counts were usable for a given area; another field man thought that there were a considerable number of variables that need to be assessed before such counts can be relied on as accurate.

Shooting pressure affects the survival of young wood ducks par-

ticularly, and legislation on season lengths, bag limits and shooting hours are important to the protection of wood ducks.

Regulations are relatively easy to formulate but before signatures can be put on paper making them law, there are expensive and extremely difficult field and administrative data that must be accumulated. These data give meaning to and scientific backing for our game laws. Much of this field information comes from banding programs. We were told that some of our southern states need to be encouraged to participate on a larger scale in this vitally needed banding scheme. In addition, field technicians who sex and age banded birds inaccurately impair the end products of their field labor. Year-to-year changes in methods for collecting data also prevent adequate comparisons. Failure to share whatever is gathered further limits team efforts to appraise a wildlife resource on a large geographic area. Population trends are evident among the states, but the degree of change between states and among the various states is not always precisely known.

Although there was general optimism concerning the present status of the wood duck, Massachusetts studies indicate that the wood duck is still in a precarious position in parts of the Northeast.

An important statement made in a discussion period was that (paraphrased) from a population point of view we know more about the wood duck than any other species. I hope that this conference has added even more.

As I heard and read the papers at this meeting, the gaps in our knowledge of the wood duck as a wildlife resource may be summed up as follows:

(1) We need more data on population status and productivity from specific areas. These data must come largely from banding programs.

(2) We need to reconcile habitat preservation with government-supported land-use programs that under some circumstances are habitat destroying.

(3) We need to reconcile certain government—and private—forestry practices with the effect they have on wood duck populations. Wildlife biologists must furnish any and all data which will allow foresters to engage in multiple-use programs that can benefit wood ducks.

(4) We need to appraise changes in wood duck habitat rapidly and accurately. Such appraisal will help initiate remedial practices immediately, as they are needed.

(5) We need to assess decimating factors on wood duck ducklings that operate in the various brood-rearing habitats. This is

essential to wood duck management and habitat evaluation.

(6) We need to assess nonhunting mortality on wood ducks (other than ducklings).

A very dear friend of mine, whom I respected as an intellectual ecologist and loved as I would flesh and blood kin, once said this of falling wildlife numbers: "Any change in population level must arise from one of three causes: (1) something died, (2) something was never born, or (3) environment changed." The fourth dimension we have added is that these forces can and do act in combination. More particularly, however, has come the encouraging attitude of willingness on the part of diverse agencies and individuals to pool their knowledge and efforts to find solutions to ecological problems at a species level.

I commend each participant in this symposium for helping to set a precedent in teamwork which should find repetition and ramifications in all phases of wildlife conservation.

LITERATURE CITED

Audubon, J. J.
1835. Ornithological biography. 5 Vols. Adam and Chas. Black, Edinburgh. Vol. 3. 638 p.

Bellrose, F. C.
1953. Housing for wood ducks. Ill. Nat. Hist. Survey, Circ. No. 45. 47 p.

Bent, A. C.
1923. Life histories of North American wild fowl. Order Anseres (part). U. S. Natl. Mus., Washington. 250 p.

Blake, E. R.
1953. Birds of Mexico. Univ. of Chicago Press, Chicago. 644 p.

Chapman, F. M.
1912. Handbook of birds of eastern North America. D. Appleton and Co., New York. 530 p.

Coues, E.
1903. Key to North American birds. 2 Vols. Dana Estes and Co., Boston. Vol. 1. 535 p.

Elliot, D. G.
1898. The wild fowl of the United States and British possessions. Francis P. Harper, New York. 316 p.

Forbush, E. H.
1925. Birds of Massachusetts. 3 Vols. Comonwealth of Massachusetts. Vol. 1. 481 p.

Grinnell, G. B.
1901. American duck shooting. Forest and Stream Publ. Co., New York. 623 p.

Hallock, C.
1879. The sportsman's gazetteer. Forest and Stream Publ. Co., New York. 5th Ed. 908 p.

Linnaeus, C.
1758. Systema Naturae. Vol. 1. Photographic facsimile of the first volume of the tenth edition (1956). British Mus., London. 824 p.

Nice, M. M.
1954. Problems of incubation periods in North American birds. Condor 56(4): 173-197.

Nuttall, T.
1834. A manual of the ornithology of the United States and Canada. (The water birds). Hilliard, Gray and Co., Boston. 627 p.

Wilson, A., and Prince C. L. Bonaparte
1876. American ornithology. Chatto and Windus, Picadilly, London. 3 Vols. Vol. 3. 540 p.

Yorke, F. H.
1899. Our ducks. The Amer. Field Publ. Co., Chicago. 131 p.

CLOSING REMARKS

B. T. CRAWFORD
President (1965), North Central Section of The Wildlife Society, Columbia, Missouri

I am very pleased to have the opportunity to present the closing remarks for this symposium. Dr. McCabe has done an excellent job of summarizing, and I do not want to appear redundant. Basically, I will attempt to put this meeting in perspective and will offer some thoughts for the future.

Symposia do not necessarily constitute a new approach for studying a particular problem, however, a symposium on the wood duck is a relatively new dimension. We might call it the "in depth look." Nationwide, I can recall only a few important symposia conducted on wildlife subjects. Today we are pioneering on an important and timely wildlife resource.

The need for directing a strong communicative effort toward the wood duck has been long overdue. In reviewing the literature, we see much isolated research taking many directions. There has never been an attempt at bringing the subject material on the wood duck under a comprehensive and thorough review. As it has been said many times during our discussions here, we have a considerable body of technical information on wood ducks, but it is scattered all over the landscape.

Personally I have been pleased, and I think this is exactly what McCabe has said, to see the accomplishments in wood duck research and management despite the unplanned and isolated approach to problems by individual researchers. There have been a few notable exceptions, where continuous effort has been applied for many years. The long-term Illinois research by Bellrose and associates, and the current flyway banding programs, as described by Geis, are outstanding contributions. But work on the wood duck has been, for the most part, a generally disjointed effort. Of course, each separate research project or program, when added to the over-all effort, contributes its part to the larger picture.

I see this symposium as a catalyzer, and as a tool for developing some central thrust that will give us the knowledge, the strength, and perhaps a plan to do the job needed for the wood duck. With the personal contacts and enthusiasm generated here, along with the impact that the printed proceedings of the symposium will carry nationally, I would predict that this very successful meeting will generate future accomplishments.

As President of the North Central Section of The Wildlife Society,

I would very much like to thank the Wildlife Management Institute, and Larry Jahn in particular, for the excellent work in preparing for this meeting. Also, thanks for their part in developing the opportunity for our professional organization, the North Central Section of the Wildlife Society, to co-sponsor this meeting. I would also like to express our many thanks to the agencies and individuals who have contributed unselfishly toward making this meeting possible, particularly the Michigan Department of Conservation.

In this day and age, when tabs for most affairs are being picked up by the employing organizations or non-profit groups, it is refreshing, I believe, to see the money of the individual professional worker, through his dues and society, being funneled into a symposium of this type. It puts you and your dollars in a position of supporting worthy projects, not just waiting for somebody else to do the job for you.

The North Central Section is currently every interested in supporting other meetings of this type. We are soliciting cooperation of professional wildlife groups for producing similar symposia. If you are interested and have thoughts for additional sessions, please contact the North Central Section of The Wildlife Society. We will be glad to plan with you.

I thank all of you for the opportunity of participating in this symposium. I congratulate you on a very fine meeting.

SYMPOSIUM PARTICIPANTS

CONNECTICUT
Philip Barske

DISTRICT OF COLUMBIA
Clark G. Webster

GEORGIA
Verlon E. Carter, Don J. Hankla, Morton M. Smith

ILLINOIS
Frank C. Bellrose, E. Carl Brown, Frank W. Collins, H. Gordon Hanson, James D. McCali

IOWA
R. Barratt, L. M. Frederickson, H. J. Harris, Arnold O. Haugen, Eugene Klonglan, Frederic Leopold, David L. Trauger, P. A. Vohs, M. W. Weller

MARYLAND
C. E. Addy, Aelred D. Geis, Frank B. McGilvrey

MASSACHUSETTS
George F. Pushee, Jr., Dale Sutherland

MICHIGAN
W. Bartells, W. Batch, Bruce L. Baetly, Carl Bennett, Jr., C. T. Black, G. J. Bober, Marvin Cooley, J. Foote, Charles E. Friley, Jr., Jack Frye, Earl Gordinier, Ed Green, John B. Hakala, Roland Hoffman, Thomas Howard, Robert Huff, George L. Hunt, G. W. Irvine, Joe Johnson, E. J. Mikula, Herbert Miller, Lee Mowbray, Dave Osborne, M. D. Pirnie, Merle Raber, Charles M. Smith, R. D. VanDeusen, Charles W. VanKirk, Gary Went

MINNESOTA
William Aultfather, John Bedish, Herbert H. Dill, Arthur Eustis, William E. Green, R. C. Hanson, Arthur S. Hawkins, Robert L. Jessen, John E. Mathisen, H. M. Reeves

MISSOURI
George Brakhage, Harold H. Burgess, Bill T. Crawford, Max Hamilton, John P. Rogers, Ralph W. Weier, Jim Wofford

NEBRASKA
Wade H. Hamor

NORTH CAROLINA
F. Eugene Hester

NORTH DAKOTA
Forrest B. Lee, Harvey K. Nelson, Glen Sherwood

OHIO
John M. Anderson, Karl Bednarik, Mrs. Robert W. Murphy, Mrs. Rosalie North, H. Granville Smith

ONTARIO, CANADA
W. H. Carrick, Blair Dawson, A. G. Loughrey, N. G. Perret
J. D. Heyland

SOUTH DAKOTA
Ray Linder, Paul F. Springer, Jerry Stoudy

WISCONSIN
R. A. Hunt, L. R. Jahn, Gerald F. Martz, Robert A. McCabe, Robert Radtke, C. F. Smith, F. Stearns