DERIVATION OF NORTHERN WOOD DUCKS HARVESTED IN SOUTHERN STATES OF THE MISSISSIPPI FLYWAY

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Abstract: Over 2,400 first-year band recoveries of 144,800 northern banded wood ducks (*Aix sponsa*) were examined to identify the source of northern migrants harvested during 1950 through 1968 hunting seasons in Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Tennessee, and Texas. Harvest trends for the seven-state area revealed that 20 percent of the northern migrants was derived from Eastern Canada and Atlantic Flyway production areas. However, 80 percent of the northern birds was obtained from two Mississippi Flyway production areas. Individual state derivation patterns of northern adults and immatures are discussed in detail.

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Because its breeding range involves every state in the eastern United States, the wood duck is often judged our most important resident waterfowl species. It consistently ranks third or fourth in the total United States waterfowl harvest and second in the Atlantic and Mississippi Flyway harvests. However, most studies of the wood duck have been local in nature and concentrated on life history events or techniques of estimating abundance. The dynamics of state and regional populations have not been adequately assessed due to the wood duck's forest environment, which precludes the use of conventional waterfowl survey methods to estimate population densities and production. Consequently, hunting regulations for this species have remained essentially unchanged since the early 1960's. A better knowledge of regional and population similarities or differences in harvest characteristics is needed to encourage more progressive management of this natural resource.

Approximately 60 percent of the wood duck harvest occurring in the combined states of Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Tennessee, and Texas is composed of birds produced north of a line connecting the upper state boundaries of Arkansas, Kentucky, and Virginia (Bowers and Martin 1975). In this paper we categorize and describe the derivation of such northern, adult and immature wood ducks harvested in the above seven southern states during 1950 through 1968 hunting seasons.

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DATA SOURCE AND METHODS

Banding and recovery data (1950 through 1968) filed on magnetic tapes at the Migratory Bird and Habitat Research Laboratory, Laurel, Maryland, were utilized throughout this study. Emphasis was on first-year recovery records (2,400 direct recoveries) of 144,804 banded wood ducks captured in northern production areas and recovered (shot or found dead) in 7 southern states. Recovery records of adults (birds in their second or later year of life) and immatures (birds of the year capable of flight) were restricted by the status (normal, experimental, wild, etc.) and banding period of captured birds. Only wild wood ducks caught, banded, and released in a normal manner during May through September 1950 through 1968, and harvested during a hunting season September through January 1950 through 1969, were tabulated.

Because banding efforts and numbers banded varied in relation to actual wood duck densities present, it was necessary to compute a "weighting factor" that would estimate the relative number of wood ducks represented by each banded sample. Weighting factors were obtained by dividing the number of birds banded in each state or province into an estimated population value for that area (Geis 1972).

Population values or indices of abundance were obtained from the forest index, simultaneous equation, and waterfowl population model approaches described by Bowers (1977) and Sutherland (1971). The forest-index technique assumed a correlaiton existed between the distribution and abundance of suitable forest habitats and wood duck numbers. A wood duck, population-density index was estimated by subjective assignments of wood duck importance values to each of six forest types (Bowers 1977). The second approach, Flyway Habitat Management Unit Project (FHMUP), utilized estimates of wood duck abundance described in a 1965 waterfowl population-density model developed jointly by state conservation departments and the U.S. Fish and Wildlife Service (Sutherland 1971). The third technique involved solutions to a set of simultaneous linear equations by means of computer. Matrices of all areas of banding and harvest, harvest rates, and numbers harvested were utilized in the calculations (Bowers and Martin 1975; Bowers 1977). Other general descriptions of this mathematical approach to population estimates are given by Geis (1966), Overton and Davis (1969), and Chapman and Junge (1965).

The origins of northern birds harvested in selected southern states were determined from weighted direct recoveries. Geis (1972) and Steward et al. (1958) gave an in-depth explanation of derivation procedures. Briefly, such procedures involve a study of the distribution of recoveries from breeding areas to show what proportion of the kill in a harvest area was derived from each breeding site. Table 1 is an example of the procedure used. Contingency tables (Chi square test, Siegel 1956: 104-111) were used to test the null hypothesis that derivations of northern banded birds did not differ with respect to two time periods of banding. Chi square tests were also utilized to discern age differences in the proportion of wood ducks derived from various production areas.

Table 1. Utilization of weighted band recoveries to indicate wood duck derivation of harvest (hypothetical data).

	Birds Recovered in LA. (Derivation of Harvest)				
Source of Recovered Birds	*No. of Recoveries (A)*	*Weighting Factor (B)*	*Weighted Recoveries[a] (A x B)*	*State Origin of Harvest[b] (in %)*	*Reference Area Origin of Harvest[c]*
Lake States Area	13	—	295	—	21.6
Michigan	5	20	100	7.3	—
Ohio	5	30	150	11.0	—
Indiana	3	15	45	3.3	—
North Central Area	36	—	1,070	—	78.4
Minnesota	10	40	400	29.3	—
Wisconsin	9	35	315	23.1	—
Iowa	3	15	45	3.3	—
Illinois	8	20	160	11.7	—
Missouri	6	25	150	11.0	—
Total	49		1,365	100.0	100.0

[a]Reference—area weighted recoveries were obtained by summing the weighted recoveries of component states.

[b]Th product of (A x B) divided by 1,365.

[c]Reference—area weighted recovery value divided by 1,365.

RESULTS AND DISCUSSION

Banding Data and Population Indices

Derivation characteristics did not differ between the May through August and May through September banding periods ($P > 0.10$); therefore, we used the larger May through September banded sample (32,009 adult males, 20,096 adult females, 49,832 imma-

ture males, and 42,867 immature females). Approximately 2,400 of the 144,804 northern banded birds were harvested in 7 southern states during the first hunting season after banding. A minimum of 4,800 wood ducks was banded in each northern state of the Mississippi Flyway; however, banding efforts in many northern sections of the Atlantic Flyway and Canada were insufficient and not representative of the populations sampled. Conseqently, recovery derivations from these areas were analyzed on a reference-area basis. Reference areas were defined as adjacent banding sites or states from which wood ducks displayed similar recovery distributions. We used reference areas described by Bowers and Martin (1975) (Fig. 1).

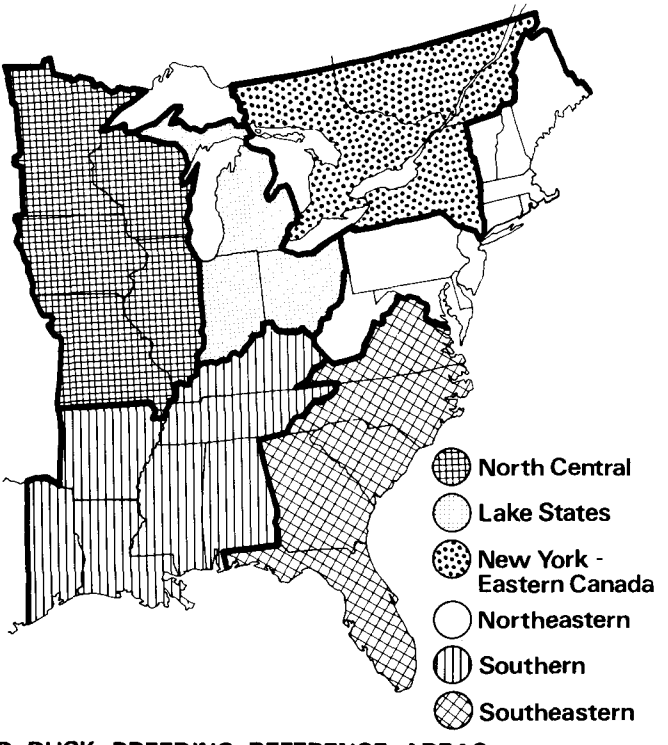

Fig. 1. WOOD DUCK BREEDING REFERENCE AREAS

Summarized in Table 2 are preseason population indices obtained by summing population estimates of the simultaneous equation, forest value, and FHMUP techniques. These combined estimates produce a set of values we believe to best represent the relative abundance of northern wood ducks in eastern North America. The simultaneous equation estimates used in obtaining population sums depended upon precise information on size and rates of harvest, in addition to the assumption that all major populations of wood ducks were adequately represented by bandings and recoveries. Because it was impossible to judge how well these and other conditions were fulfilled, the northern population figures in Table 2 should be considered indices of comparative abundance and not actual numbers of wood ducks present.

Once corrections for disproportionate banding efforts had been made, the harvest derivation characteristics for adults and immatures were discernible.

Adult Derivation

Calculations in Table 3 show the first-year recoveries of northern adults occurring in each of the 7 southern states in addition to "unweighted" derivation patterns. The weighted values and weighted derivation of harvest trends are given in Table 4. Based on weighted data, an average of 8.9 percent of the northern adults harvested in the 7

Table 2. Preseason population indices of wood ducks.[a]

State or Province	*Adults*	*Immatures*
Mississippi Flyway		
Illinois	95,596	177,274
Indiana	93,337	126,833
Iowa	68,690	81,111
Michigan	174,810	227,158
Minnesota	312,788	439,162
Missouri	128,237	134,032
Ohio	84,309	109,709
Wisconsin	296,615	348,758
Atlantic Flyway		
Connecticut	15,136	19,281
Delaware	12,919	9,812
Maine	95,961	125,704
Maryland	20,806	17,229
Massachusetts	52,659	76,739
New Hampshire	52,844	85,331
New Jersey	42,775	53,401
New York	136,637	182,095
Pennsylvania	109,076	134,758
Rhode Island	4,891	9,796
Vermont	45,654	76,621
West Virginia	44,201	73,955
Canada		
Ontario	306,606	413,261
Quebec	71,485	62,508
Total	2,266,032	2,984,528

[a]Obtained by combining totals of three population estimates described by Bowers (1977) and Sutherland (1971).

Table 3. Number of direct recoveries and unweighted derivation of northern banded (May-September, 1950-68) adult wood ducks harvested in 7 southern states[a].

Source of	*Recovered in*														
	Alabama		*Arkansas*		*Kentucky*		*Louisiana*		*Mississippi*		*Tennessee*		*Texas*		*Total*
Recoveries	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*Recoveries*
Illinois	12	(12.0)	18	(13.0)	2	(28.6)	50	(16.0)	17	(10.6)	4	(12.9)	20	(17.1)	125
Iowa	1	(1.0)	16	(11.6)	0	(0.0)	25	(8.0)	6	(3.7)	1	(3.2)	13	(11.1)	62
Indiana	9	(9.0)	5	(3.6)	1	(14.3)	26	(8.3)	19	(11.8)	2	(6.4)	4	(3.4)	66
Michigan	6	(6.0)	4	(2.9)	1	(14.3)	23	(7.4)	10	(6.2)	4	(12.9)	2	(1.7)	50
Minnesota	10	(10.0)	26	(18.8)	1	(14.3)	61	(19.6)	24	(14.9)	2	(6.5)	34	(29.1)	158
Missouri	1	(1.0)	14	(10.1)	0	(0.0)	31	(9.9)	22	(13.7)	2	(6.5)	17	(14.5)	87
Ohio	16	(16.0)	3	(2.2)	1	(14.3)	7	(2.2)	11	(6.8)	2	(6.5)	1	(0.8)	41
Wisconsin	20	(20.0)	47	(34.1)	0	(0.0)	79	(25.3)	41	(25.5)	9	(29.0)	23	(19.6)	219
New York-E. Canada	7	(7.0)	3	(2.2)	0	(0.0)	3	(1.0)	9	(5.6)	1	(3.2)	3	(2.6)	26
Northeastern	18	(18.0)	2	(1.4)	1	(14.3)	7	(2.2)	2	(1.2)	4	(12.9)	0	(0.0)	34
Total	100	(100.0)	138	(99.9)	7	(100.1)	312	(99.9)	161	(100.0)	31	(100.0)	117	(99.9)	866

[a]Parenthesized numbers represent the percent of harvest derived from a northern source.

Table 4. Weighted derivation-of-harvest patterns of northern adult wood ducks banded May-September, 1950-68, and harvested in 7 southern states.[a]

Source of Recoveries	Weighted Values for Wood Ducks Recovered in: Alabama Wt.	%	Arkansas Wt.	%	Kentucky Wt.	%	Louisiana Wt.	%	Mississippi Wt.	%	Tennessee Wt.	%	Texas Wt.	%
Illinois (6.112)[b]	73.3	(5.4)[c]	110.0	(6.6)	12.2	(13.8)	305.6	(8.0)	103.9	(4.6)	24.4	(6.8)	122.2	(8.4)
Iowa (8.840)	8.8	(0.6)	141.4	(8.5)	0.0	(0.0)	221.0	(5.8)	53.0	(2.4)	8.8	(2.5)	114.9	(8.0)
Indiana (10.644)	95.8	(7.0)	53.2	(3.2)	10.6	(12.0)	276.7	(7.3)	202.2	(9.0)	21.3	(6.0)	42.6	(2.9)
Michigan (20.424)	122.5	(9.0)	81.7	(4.9)	20.4	(23.0)	469.8	(12.3)	204.2	(9.1)	81.7	(22.8)	40.8	(2.8)
Minnesota (17.717)	177.2	(13.0)	460.6	(27.6)	17.7	(20.0)	1,080.7	(28.4)	425.2	(19.0)	35.4	(9.9)	602.4	(41.7)
Missouri (10.308)	10.3	(0.8)	144.3	(8.6)	0.0	(0.0)	319.5	(8.4)	226.8	(10.1)	20.6	(5.8)	175.2	(12.1)
Ohio (7.789)	124.6	(9.2)	23.4	(1.4)	7.8	(8.8)	54.5	(1.4)	85.7	(3.8)	15.6	(4.4)	7.8	(0.5)
Wisconsin (10.158)	203.2	(14.9)	477.4	(28.6)	0.0	(0.0)	802.5	(21.1)	416.5	(18.6)	91.4	(25.6)	233.6	(16.2)
New York-E. Canada (15.187 to 63.205)	286.6	(21.1)	105.1	(6.3)	0.0	(0.0)	167.1	(4.4)	501.4	(22.4)	14.4	(4.0)	105.1	(7.3)
Northeastern (2.845 to 70.463)	257.8	(19.0)	73.3	(4.4)	20.0	(22.5)	112.3	(2.9)	23.3	(1.0)	44.0	(12.3)	0.0	(0.0)
Total	1,360.1	(100.0)	1,670.0	(100.1)	88.7	(100.1)	3,809.7	(100.0)	2,242.2	(100.0)	357.6	(100.1)	1,444.6	(99.9)

[a]Based on weighted values of direct recoveries in Table 3.
[b]Parenthesized numbers under northern states and provinces are "weights" showing the number of wood ducks represented by each direct recovery.
[c]Parenthesized numbers adjacent to southern states reveal what percentage of the harvest is attributable to a northern source.

southern states (Southern reference area) was derived from Atlantic Flyway production areas; 9.4 percent originated from the New York-Eastern Canada reference area (eastern Ontario, New York, and Quebec); and over 81 percent was acquired from 8 northern states of the Mississippi Flyway. The origin of northern adults harvested in individual states of the Southern reference area often deviated from reference-area patterns.

Alabama. Forty percent of the northern adults harvested in Alabama originated from birds produced in the combined Northeastern (Maine to West Virginia) and New York-Eastern Canada reference areas (Table 5). This is an unique feature; because, most of the other 6 deep-south states derived only a small percentage of their northern migrants from such eastern production areas. A substantial number of northern adults harvested in Alabama (34.7 percent) was also procured from the North Central reference area (Minnesota, Wisconsin, Iowa, Illinois, and Missouri) of the Mississippi Flyway (Table 5). The materialization of Alabama as a melting pot of northern banded wood ducks becomes more evident with the realization that 25 percent of the adult harvest was derived from the Lake States area (Michigan, Indiana, Ohio) (Table 5). The 4 most important sources of northern adults were the New York-Eastern Canada and Northeastern reference areas, Wisconsin and Minnesota. These 4 areas were responsible for approximately 68 percent of the northern, adult wood ducks harvested in Alabama (Table 4).

Mississippi. Similar to Alabama, 21.9 and 22.4 percent of northern adults harvested in Mississippi originated from the Lake States and New York-Eastern Canada reference areas (Table 5). Unlike Alabama, only 1.0 percent of the harvest was derived from production areas of the Northeastern reference area. The 4 most important sources of adult birds were the New York-Eastern Canada area, Minnesota, Wisconsin, and Missouri. These combined areas accounted for 70 percent of the northern harvest (Table 4).

Louisiana, Arkansas, Texas. The most notable similarity among these 3 states was a large harvest percentage derived from the North Central reference area (72-86 percent), and a minor importance of northern birds banded in the Northeastern and New York-Eastern Canada reference areas (0-7%) (Table 5). An obvious dissimilarity was the proportion of wood ducks originating from the Lake States area. This reference area supplied 21 percent of the northern adults harvested in Louisiana but less than 10 percent of the adults harvested in Arkansas or Texas (Table 5). Minnesota, Wisconsin, and Missouri were responsible for 59 to 70 percent of the northern migrants harvested in Louisiana, Arkansas, or Texas (Table 4).

Tennessee and Kentucky. The 7 direct recoveries in Kentucky and 31 direct recoveries in Tennessee were insufficient to describe derivation characteristics. These reduced rates of recovery were related to low waterfowl-hunter numbers, the subsequent reduced hunting pressures, and waterfowl regulations that allowed the major influx and efflux of migrants to occur before hunting was permitted.

Immature Derivation

Recoveries and unweighted sources of northern immatures harvested in 7 southern states are shown in Table 6. Weighted data and derivation of harvests are summarized in Tables 5 and 7. Based on averages for weighted direct recoveries, approximately

Table 5. Reference-area source of northern wood ducks harvested in 7 southern states during 1950 through 1968 hunting season.

	Reference Area Source (%)									
	North Central		Lake States		NY-E. Canada		Northeastern		Total Percent	
Harvested In	Adult	Immature	Adult	Immature	Adult	Immature	Adult	Immature	Adult	Immature
Alabama	34.7	19.7	25.2	29.6	21.1	17.7	19.0	32.9	100.0	99.9
Mississippi	54.7	44.6	21.9	36.6	22.4	11.6	1.0	7.2	100.0	100.0
Arkansas	79.9	71.3	9.5	19.2	6.3	5.8	4.4	0.6	100.1	99.9
Texas	86.4	90.9	6.2	8.5	7.3	0.0	0.0	0.5	99.9	99.9
Louisiana	71.7	67.0	21.0	19.9	4.4	8.7	2.9	4.3	100.0	99.9
Kentucky	33.8	26.9	43.8	52.6	0.0	0.0	22.5	20.4	100.1	99.9
Tennessee	50.6	47.9	33.2	7.6	4.0	8.2	12.3	36.2	100.1	99.9

Table 6. Number of direct recoveries and unweighted derivation of northern banded (May-September, 1950-68) immature wood ducks harvested in 7 southern states.[a]

	Recovered in														
Source of	Alabama		Arkansas		Kentucky		Louisiana		Mississippi		Tennessee		Texas		Total
Recoveries	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	Recoveries
Illinois	27	(18.4)	88	(36.4)	4	(40.0)	162	(29.9)	41	(19.5)	11	(16.7)	81	(27.3)	414
Iowa	10	(6.8)	38	(15.7)	1	(10.0)	86	(15.9)	40	(19.0)	13	(19.7)	67	(22.6)	255
Indiana	15	(10.2)	9	(3.7)	2	(20.0)	29	(5.4)	14	(6.7)	2	(3.0)	10	(3.4)	81
Michigan	8	(5.4)	7	(2.9)	0	(0.0)	13	(2.4)	11	(5.2)	0	(0.0)	1	(0.3)	40
Minnesota	7	(4.8)	15	(6.2)	0	(0.0)	50	(9.2)	6	(2.9)	3	(4.5)	30	(10.1)	111
Missouri	3	(2.0)	26	(10.7)	0	(0.0)	49	(9.1)	15	(7.1)	4	(6.1)	26	(8.8)	123
Ohio	20	(13.6)	1	(0.4)	2	(20.0)	30	(5.5)	20	(9.5)	5	(7.6)	8	(2.7)	86
Wisconsin	8	(5.4)	53	(21.9)	0	(0.0)	100	(18.5)	38	(18.1)	16	(24.2)	72	(24.2)	287
New York-E. Canada	14	(9.5)	4	(1.6)	0	(0.0)	12	(2.2)	10	(4.8)	4	(6.1)	0	(0.0)	44
Northeastern	35	(25.8)	1	(0.4)	1	(10.0)	10	(1.8)	15	(7.1)	8	(12.1)	2	(.07)	72
Total	147	(99.9)	242	(99.9)	10	(100.0)	541	(99.8)	210	(99.9)	66	(100.0)	297	(100.1)	1,515

[a]Parenthesized numbers represent the percent of harvest derived from a northern source.

14 percent of the northern migrants harvested in the Southern reference area was derived from the Northeastern reference area of the Atlantic Flyway; 7 percent of the northern birds was supplied by the New York-Eastern Canada reference area; 25 percent of the harvest originated from the Lake States reference area; and a majority of the northern immatures (54%) was procured from the North Central reference area (Table 5).

Alabama. Nearly 50 percent of the northern immatures harvested in Alabama was obtained from the more eastern situated production areas of Canada and the Atlantic Flyway (Tables 5 and 7). Again, Alabama becomes recognizable as an attractive wintering site for northern birds from all eastern North American production areas. Only Tennessee approached Alabama in the magnitude of harvest diversity. The four most important sources of northern immatures harvested in Alabama were as follows: (1) the Northeastern reference area (32.9%), (2) New York-Eastern Canada reference area (17.7%), (3) Michigan (15.7%), and (4) Minnesota (8.9%) for a total of 75.2 percent.

Mississippi. Unlike Alabama, few immature wood ducks (7.2%) were obtained from the Northeastern reference area of the Atlantic Flyway (Table 5). The most prevalent northern sources of harvested immatures were 8 states comprising the North Central and Lake States reference areas of the Mississippi Flyway. When combined, these two reference areas accounted for 81 percent of the northern immatures harvested in Mississippi. Individually, the most influential sources of northern wood ducks were Michigan (22.6%), Wisconsin (16.6%), New York-Eastern Canada (11.6%) and Indiana (8.0%), for a total of 58.8 percent (Table 7).

Table 7. Weighted derivation-of-harvest patterns of northern immature wood ducks banded May-September, 1950-68 and harvested in 7 southern states.[a]

Source of Recoveries	Weighted Values for Wood Ducks Recovered in:													
	Alabama		Arkansas		Kentucky		Louisiana		Mississippi		Tennessee		Texas	
	Wt.	%	Wt.	%	Wt.	%	Wt.	%	Wt.	%	Wt.	%	Wt.	%
Illinois (3.506)[b]	94.7	(4.9)[c]	308.6	(16.2)	14.0	(23.0)	568.0	(11.8)	143.8	(7.8)	38.6	(6.1)	284.0	(13.1)
Iowa (2.379)	23.8	(1.2)	90.4	(4.7)	2.4	(3.9)	204.6	(4.3)	95.2	(5.2)	30.9	(4.8)	159.4	(7.3)
Indiana (10.493)	157.4	(8.2)	94.4	(5.0)	21.0	(34.5)	304.3	(6.3)	146.9	(8.0)	21.0	(3.3)	104.9	(4.8)
Michigan (37.765)	302.1	(15.7)	264.4	(13.9)	0.0	(0.0)	491.0	(10.2)	415.4	(22.6)	0.0	(0.0)	37.8	(1.7)
Minnesota (24.313)	170.2	(8.9)	364.7	(19.2)	0.0	(0.0)	1,215.6	(25.3)	145.9	(7.9)	72.9	(11.4)	729.4	(33.5)
Missouri (8.726)	26.2	(1.4)	226.9	(11.9)	0.0	(0.0)	427.6	(8.9)	130.9	(7.1)	34.9	(5.5)	226.9	(10.4)
Ohio (5.495)	109.9	(5.7)	5.5	(0.3)	11.0	(18.1)	164.8	(3.4)	109.9	(6.0)	27.5	(4.3)	44.0	(2.0)
Wisconsin (8.015)	64.1	(3.3)	424.8	(22.3)	0.0	(0.0)	801.5	(16.7)	304.6	(16.6)	128.2	(20.1)	577.1	(26.5)
New York-E. Canada (7.183 to 77.827)	341.1	(17.7)	111.3	(5.8)	0.0	(0.0)	416.4	(8.7)	213.1	(11.6)	52.6	(8.2)	0.0	(0.0)
Northeastern (3.069 to 135.299)	632.8	(32.9)	12.4	(0.6)	12.4	(20.4)	206.6	(4.3)	132.4	(7.2)	230.7	(36.2)	11.3	(0.5)
Total	1,922.3	(99.9)	1,903.4	(99.9)	60.8	(99.9)	4,800.4	(99.9)	1,858.1	(100.0)	637.3	(99.9)	2,174.8	(99.8)

[a]Based on weighted values of direct recoveries in table 6.

[b]Parenthesized numbers under northern states and provinces are "weights" showing the number of wood ducks represented by each direct recovery.

[c]Parenthesized numbers adjacent to southern states reveal what percentage of the harvest is attributable to a norhern source.

Louisiana, Arkansas, Texas. The consanguinity of the northern wood ducks harvested in these 3 states is evident in Tables 5 and 7. A large percentage of the northern birds (86.0 to 99.4%) was derived from northern reference areas of the Mississippi Flyway and less than 5 percent of the northern wood ducks was obtained from the Atlantic Flyway (Table 5). Texas was characterized by an unusually high derivation of northern, immature wood ducks produced in the North Central reference area (90.9%) and an unusually low harvest of birds from Canada and the Northeastern reference area (0.5%) (Table 5). The most noticeable difference between Arkansas and Louisiana was a larger supply of eastern birds available to Louisiana (Table 5). Minnesota, Wisconsin, Illinois, and Missouri furnished 60 to 83 percent of northern immature birds harvested in Texas, Louisiana, or Arkansas (Table 7).

Tennessee and Kentucky. Low hunting pressure and a lack of northern wood ducks during state waterfowl seasons were 2 factors responsible for the reduced recoveries of northern banded birds and an inability to characterize derivation patterns.

Derivation Trends

Derivation patterns were similar for adults and immatures banded in northern states and later harvested in the Southern reference area. Twenty percent of the harvested birds was derived from Canadian and eastern sources, and 80 percent was obtained from Mississippi Flyway production areas. Another trend analogous to both age classes was the progressive decrease in importance of eastern production areas as a source of wood ducks for states located west of Alabama. In a similar fashion, the harvest contribution of birds produced in the North Central reference area decreased in importance when viewed for a west to east direction.

Unlike reference-area trends, individual southern states often exhibited dissimilarities in the source of adults and immatures harvested (Table 5). For example, Alabama derived a significantly larger percentage of immatures from the Northeastern reference area ($P < 0.01$). Likewise, the proportion of adults and immatures derived from the North Central area differed by age class for Mississippi, Louisiana, and Tennessee ($P < 0.05$). Such differences may be due to sampling vagaries, or they may be related to wood duck behavior during breeding, molting, and migrational periods. Little is known of the actual migrational corridors of wood ducks; however, Bellrose (1976) and Grice and Rogers (1965) have described some premigrational and migrational patterns. Characteristically, adult females begin post-nuptial molts later than males, and adult females are occupied with reproductive duties when premigratory flocks of immatures and adult

males are forming and drifting southward in a leisurely fashion. Bowers and Martin (1975) also detected differences among northern wood ducks in the distribution of harvest. Immatures and adult females dominated the October and early November harvest occurring in northern states, while adult males were more prevalent in December-January harvest characteristic of southern states. Correlations between migrational timing and geographical latitudes may also contribute to derivation discrepancies. Wood ducks native to the more northern states, such as Maine, begin migrating in September (Barden 1968) as opposed to October and later dates for such states as Iowa (Martin and Haugen 1960) and Massachusetts (Grice and Rogers 1965).

SUMMARY AND CONCLUSIONS

More than 2,400 band recoveries of 144,800 wood ducks banded in northern production areas and harvested in 7 southern states (the Southern reference area) were analyzed to describe the source of northern migrants. Northern production areas of the Atlantic Flyway were responsible for at least 9 percent of the northern, adult wood ducks harvested in the 7 seven southern states. Nine to 10 percent of the harvested adults originated from eastern Ontario and Quebec, and 81 percent of the harvest was obtained from 2 northern Mississippi Flyway production areas. Immature derivation patterns paralleled those of adults. Approximately 14 percent of the harvested immatures was derived from northern states of the Atlantic Flyway, 7 percent was obtained from the New York-Eastern Canada reference area, and 79 percent of the harvest was procured from northern production areas of the Mississippi Flyway.

Individual states of the Southern reference area did not conform to reference-area harvest trends. For states located progressively west of Alabama, there was a decrease in the harvest of northern wood ducks produced in eastern production areas. The reciprocal was true for northern ducks banded in the North Central reference area. Significant derivation differences between age-class groups within individual states were also noted.

Alabama exceeded other southern states in the harvest diversity of northern produced wood ducks. Also particular to Alabama was the large proportion of northern birds (40 to 50%) derived from eastern production areas. Unlike Alabama, Mississippi was characterized by a more than average dependency on wood ducks native to the New York-Eastern Canada reference area; however, 76 to 81 percent of the harvest of northern birds was derived from two northern reference areas of the Mississippi Flyway.

The derivation patterns for northern wood ducks shot in Louisiana, Arkansas, and Texas were quite similar. At least 90 percent of the northern immatures and 72 percent of the northern adults harvested within each state were obtained from the North Central reference area of the Mississippi Flyway. Texas was unique due to an almost complete reliance of northern birds indigenous to the North Central reference area, whereas Louisiana harvested more Lake States' wood ducks than either Arkansas or Texas.

The low number of northern-banded wood ducks harvested in Tennessee and Kentucky was probably due to comparatively few waterfowl hunters throughout these states, and the exodus of northern migrants prior to opening of state waterfowl seasons.

The uniform set of wood duck regulations which has been applied throughout eastern North America for the past 16 years need not continue for the future. We believe state and regional differences in harvest distribution and derivation patterns are sufficiently large to warrant a movement toward differential hunting regulations. A realization of derivation differences in the harvest of northern migrants could be utilized to more intensively manage the resource. For example, factors producing increased wood duck habitats or population numbers in northern sections of the Atlantic Flyway would be an impetus for more liberal wood duck regulations in Alabama, but not the other 6 southern states. Other such harvest derivation peculiarities exist, and they should be considered during the formulation of regulation guidelines. We believe a population unit—not a broad-brush management approach—would be appropriate for this waterfowl species.

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