

ANALYSIS OF WISCONSIN WOOD DUCK

BANDING DATA 1959-75

by

Bruce Folley

A Thesis

submitted in partial fulfillment of the  
requirements for the degree

MASTER OF SCIENCE

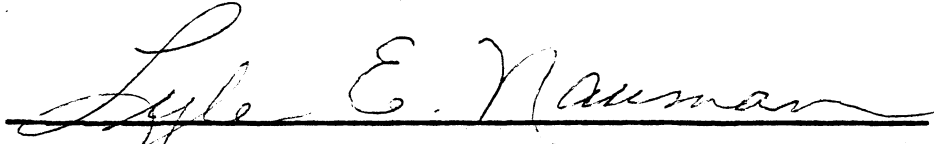
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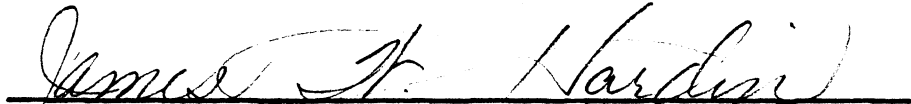
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August 1979

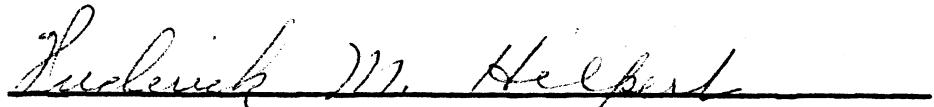
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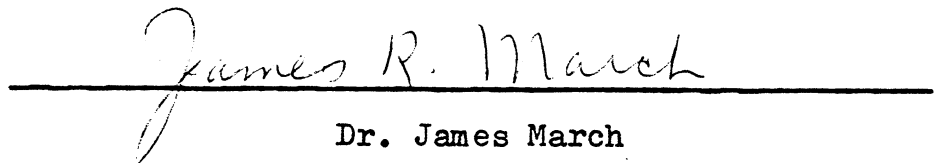
Dr. Lyle Nauman (Chairman)  
Associate Professor of Wildlife

  
\_\_\_\_\_

Dr. James Hardin  
Assistant Professor of Wildlife

  
\_\_\_\_\_

Dr. Frederick Hilpert  
Assistant Professor of Natural Resources

  
\_\_\_\_\_

Dr. James March

## ABSTRACT

Data from 33,025 wood ducks banded throughout Wisconsin and at 5 major banding areas, 1959-75 were analyzed.

The Upper Mississippi River contained most of the banded sample of young wood ducks. Adult banding was distributed evenly between the Upper Mississippi, Horicon and Necedah.

Young male and female, and adult female recoveries were dominant in October and adult male recoveries were dominant in January. Most recoveries obtained during October from all cohorts, occurred in Wisconsin. Recoveries from all cohorts peaked during the first 10 days of October. Males were recovered in southern states earlier in the hunting season than females. The first 2 days of the Wisconsin waterfowl season were most important for recoveries from all areas and cohorts. Most recoveries had been obtained after the first 21 days of the hunting season.

Wisconsin was the most important recovery state for its own wood ducks. The Mississippi Flyway contained most of the recoveries from Wisconsin wood ducks. Young males and all age females were recovered to the greatest extent in the Mississippi Flyway. Adult males were the dominant cohort recovered in the Atlantic Flyway. The southern states of Mississippi, Arkansas, Louisiana and eastern Texas were jointly responsible for 45 percent of all non-Wisconsin direct recoveries and 37 percent occurred in the northern states of Minnesota, Iowa and Illinois. Young were recovered in northern areas to a greater extent than adults. Direct and indirect recoveries show females were more likely to be recovered at

the area in which they were banded than males. Thus males apparently migrate before females, and females tend to come back to the same area more than males.

Direct recovery rates for adult and young wood ducks 1959-75 were 0.06 and 0.09 respectively; ranging from 0.05 (Necedah) to 0.11 (Mead) for adults, and from 0.07 (Necedah) to 0.13 (Mead) for young. Direct recovery rates varied significantly between years.

Mean kill rates for adult and young wood ducks were 24 and 34 percent, respectively. Wood ducks at Mead had the highest kill rate and those at Necedah had the lowest. Hunting mortality within and outside of Wisconsin made a significant contribution to total hunting mortality.

BROWNIE survival rates for wood ducks banded throughout Wisconsin were 53 and 36 percent for adults and young, respectively. Johnson survival rates for the major banding areas ranged from 51 (Horicon) to 66 (Crex Meadows) percent for adults and from 33 (Upper Mississippi River) to 49 (Horicon) percent for young. The average of young survival rates for Horicon, Necedah and Crex Meadows was 46 percent and may be more representative of Wisconsin than a young survival rate of 36 percent.

Date of opening day of the Wisconsin waterfowl hunting season and the number of October hunting days were correlated to adult and young kill rates within Wisconsin. Total season length, total bag limit and the number of active waterfowl hunters in Wisconsin were correlated to young kill rates

within Wisconsin. Kill rates were generally greater in years when regulations (wood duck bag days) were liberal as compared to restrictive years. Average adult kill rates under the point system were greater than kill rates under the bag limit system, while young kill rates under the point system were greater than the most restrictive bag day category (30-50). In years when the kill rate within Wisconsin decreased, the total kill rate also decreased. Reducing the kill rate within Wisconsin by opening the hunting season late in October would thus decrease the total hunting mortality on Wisconsin wood ducks.

A population model for Wisconsin wood ducks indicates that under the 1959-75 survival and hunting mortality rates the population would have been able to increase by 26 percent annually. Thus the Wisconsin wood duck population appears to be fairing well.

## ACKNOWLEDGEMENTS

I wish to thank my major professor Dr. Lyle E. Nauman and the members of my graduate committee Drs. Frederick Hilpert, James Hardin and James March for their guidance and advice throughout the course of this study. Dr. Dean Longrie, a former member of my graduate committee was very helpful during the early stages of the project.

Mr. Richard Hunt of Wisconsin Department of Natural Resources was instrumental in initiating this project and obtaining the wood duck banding data from the U.S. Fish and Wildlife Service. Tom Zeisler and Fred Hilpert offered computer programming and statistical expertise.

The managers of the Upper Mississippi River, Necedah and Horicon National Wildlife Refuges granted permission to use data from wood ducks banded on the federal refuges in Wisconsin.

The Wisconsin Department of Natural Resources and the University of Wisconsin-Stevens Point provided financial assistance.

My parents deserve special thanks and appreciation. Their support more than any other has allowed me to pursue my education.

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## INTRODUCTION

The wood duck (*Aix sponsa*) is an important species of waterfowl in Wisconsin (Jahn and Hunt 1964, March et al. 1973, Smith 1975). An average of 56,000 wood ducks were harvested annually in Wisconsin from 1961 to 1970, with the wood duck ranking second only to the mallard (*Anas platyrhynchos*) (Smith 1975). The wood duck harvest in Wisconsin ranged from 23,330 (1960) to 126,373 (1975) (Smith 1975, Schroeder et al. 1974, Schroeder et al. 1975, Carney et al. 1976 and Sorenson et al. 1977), and also exceeded 125,000 in 1974 (Carney et al. 1976).

Wisconsin lies on the northern edge of the wood duck breeding range. Bellrose (1976) felt that Wisconsin's wood duck breeding population ranged from relatively high in southwestern Wisconsin along the Upper Mississippi River to relatively sparse in northern Wisconsin along Lake Superior and the Wisconsin-Michigan border (Fig. 1). Most of Wisconsin contains a medium density wood duck population.

The wood duck was the third most common breeding duck in most of Wisconsin from 1965 to 1970 and the most common at the Upper Mississippi River National Wildlife Refuge (NWR) in southwestern Wisconsin (March et al. 1973). The wood duck comprised 57 percent of the 1965 to 1970 breeding duck population on the Upper Mississippi NWR.

Historically, wood duck populations have fluctuated greatly. In the early 1900's biologists feared the wood duck was doomed to extinction. Apparently, the drastic population decline was the result of overharvest and reduced habitat.

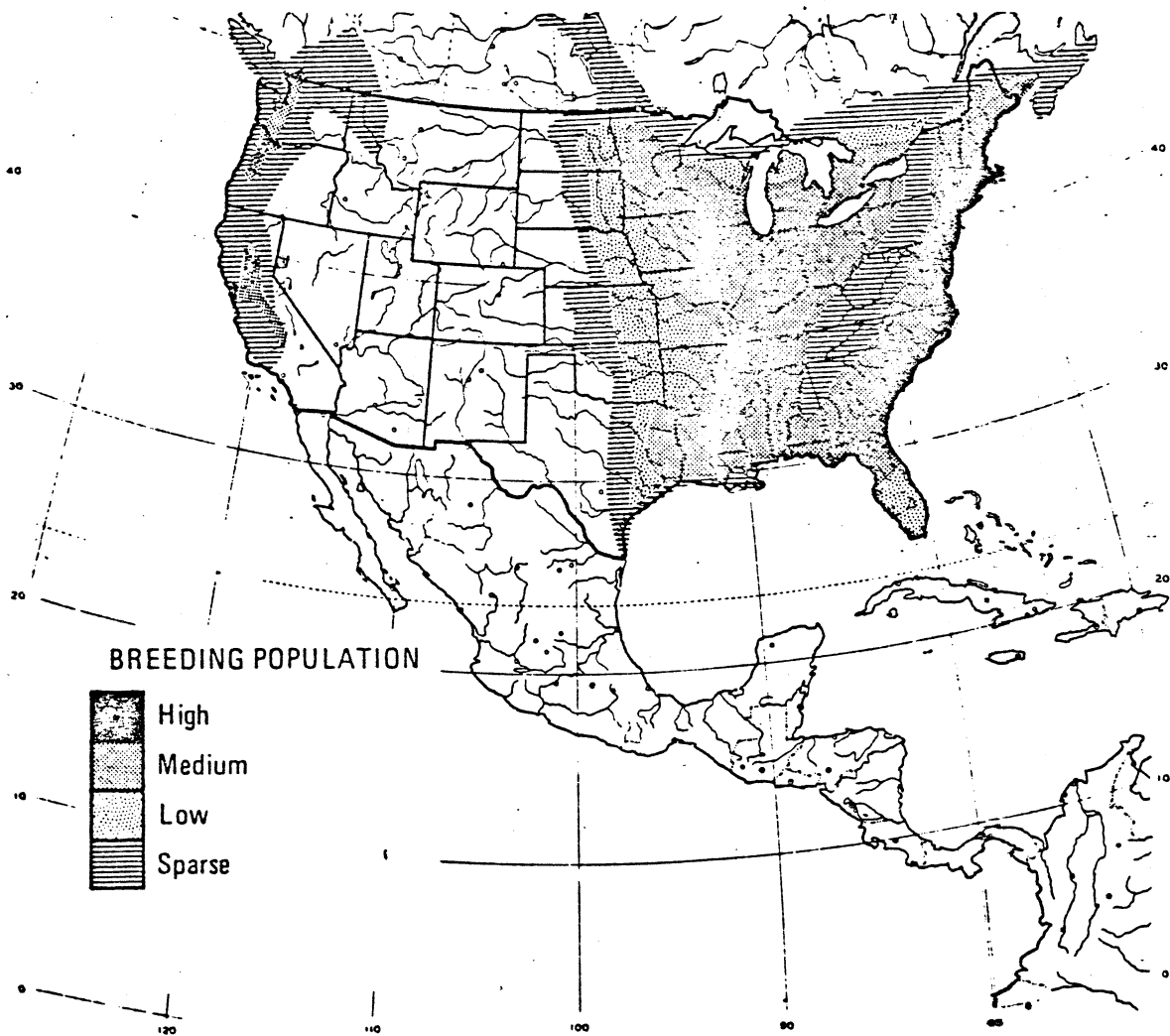


Fig. 1. Wood duck breeding populations in North America (Bellrose 1976).

The Federal Migratory Bird Act (1916) and the Migratory Bird Treaty Act (1918) afforded the wood duck complete protection under Federal law. Hunting seasons were closed from 1919 to 1941 (Bowers 1977, Reeves 1966) and wood duck populations increased. A second decline took place in the mid-1950's and hunting seasons were again closed. Populations responded favorably and Wisconsin has held a hunting season on wood ducks each year since 1959.

The wood duck is a secretive bird and utilizes wooded streams, lake shores and swamps for breeding and roosting. Consequently it is difficult or impossible to adequately census wood duck populations by conventional means (March et al. 1973). Wood duck banding data, however, offer a source of population and harvest information vital to understanding wood duck ecology.

In 1959 a wood duck banding program was initiated in the Mississippi Flyway and renewed emphasis placed on an existing program in the Atlantic Flyway (Kaczynski and Geis 1961). From 1959 to 1975 the Wisconsin Department of Natural Resources and the U. S. Fish and Wildlife Service banded 33,000 wood ducks in Wisconsin.

To properly manage Wisconsin's wood duck population it is necessary to understand the population and harvest dynamics of this species. With this in mind Wisconsin's wood duck banding data (1959-75) were analyzed under the following objectives: 1) to determine harvest characteristics, and 2) to determine survival and mortality rates.

## METHODS

Wisconsin's wood duck banding and recovery data were obtained from the U.S. Fish and Wildlife Service, Migratory Bird and Habitat Research Laboratory, Laurel Maryland. Data were stored in 2 files on magnetic tape. The first file (Banding Summary File) contained information concerning all wood ducks banded in Wisconsin. The second file (Recovery Statistical File) contained records of all recoveries of Wisconsin wood ducks and all wood ducks recovered in Wisconsin irrespective of banding location.

Data were tabulated using a Burroughs 6700 computer. Computer programs obtained from Northern Prairie Wildlife Research Center (Davenport 1977) were used for most analyses. Programs for survival rate estimation (BROWNIE and ESTIMATE) were obtained from the Migratory Bird and Habitat Research Laboratory, Patuxent Wildlife Research Center (Brownie et al. 1978).

All data were edited to include only "normal wild wood ducks" banded during the period 1 June to 30 September, 1959 to 1975. In addition recoveries were edited to include only those wood ducks reported as shot or found dead during the hunting season (1 September to 30 January). Davenport's (1977) EDITOR was used for editing the data.

Data were analyzed for the entire state and 5 major banding areas within the state. Major banding areas and their respective latitude and longitude coordinates were: 1) Upper Mississippi River 424-442, 905-920, 2) Horicon 432-435, 880-892, 3) Necedah 440-442, 900-903, 4) Mead Wildlife Area 444,

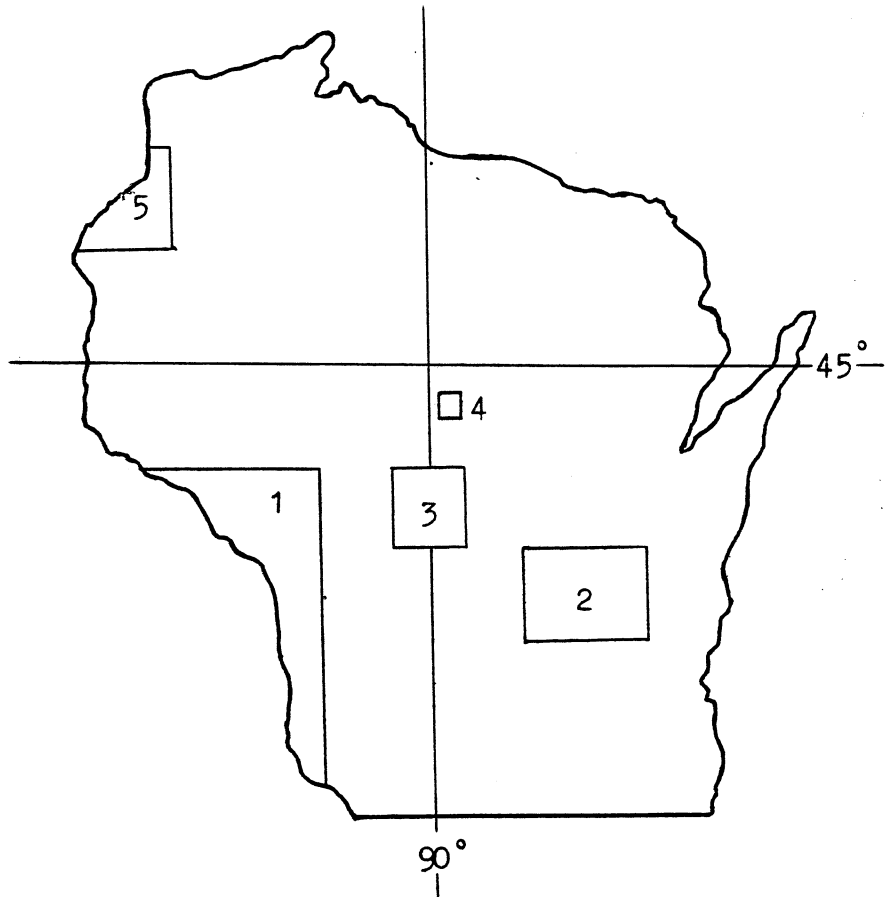
895 (includes only wood ducks banded at Mead), and 5) Crex Meadows 454-461, 920-923 (Figure 2).

All analyses were done for each age (local, immature and adult) and sex cohort of wood ducks banded in each major Wisconsin banding area, the state as a whole and each year of banding. When sample size criteria were not met or where statistical differences between cohorts were not significant, data were pooled between sexes, age classes or years.

Recovery chronology was determined by calculating the percent of the total recoveries which occurred in 10 day intervals throughout the hunting season. Davenport's (1977) RCOVTAB program was used for this tabulation. Chronology within Wisconsin was determined by calculating the percent of the total Wisconsin recoveries which occurred on each day of the Wisconsin waterfowl hunting season.

Geographic distribution of the harvest was determined by sorting recoveries into states and flyways of recovery. RCOVTAB was also used for this tabulation. Recoveries were also sorted into 10 minute and degree blocks of latitude and longitude used Davenport's (1977) LLPLOT.

The geographic derivation of the Wisconsin wood duck harvest was determined by sorting wood duck recoveries obtained in Wisconsin by states and Flyways of banding. Weight factors were calculated by dividing the number of birds banded in each state into the average pre hunting season population for that state (Geis 1972). Recoveries from each state were multiplied by their respective weighting factors to obtain a weighted recovery total. The percent of the weighted recovery



1. Upper Mississippi
2. Horicon
3. Necedah
4. Mead
5. Crex Meadows

Fig. 2. Major wood duck banding areas in Wisconsin 1959-75.

total from each state represents the relative importance of each state's wood ducks to the Wisconsin wood duck harvest. The number of wood ducks banded and the estimated pre-hunting season population in each state were taken from Bowers (1977).

Direct recovery rates were calculated using Davenport's (1977) BANDRCOV program. This program tabulated the number of wood ducks banded by sex and age cohort in each year. Recoveries were tabulated for each cohort and year of banding by hunting season of recovery. Recoveries occurring during the first hunting season after banding are termed "direct" recoveries and those occurring during the second or subsequent hunting seasons after banding are termed "indirect" recoveries. Direct recovery rates were determined by calculating the proportion of the birds banded which are recovered during the first hunting season after banding (Geis 1972). Differences in direct recovery rates were compared between age and sex cohorts, banding areas and banding years using a Chi-square test of independence (March pers. comm.).

Kill rates were determined after adjusting direct recoveries for non-reported bands (band reporting rate) and crippling loss (Geis 1972). Crippling loss was assumed to be 25 percent (March 1976 and Bowers 1977). Band reporting rates were assumed to be 0.317, 0.283, 0.358, 0.241 and 0.188 for Wisconsin, the Mississippi, Atlantic and Central Flyways and Canada, respectively (Bowers 1977). A band reporting rate of 0.255 was used for recoveries in unknown locations. Mean kill rates for years with 50 or more wood ducks in a banded cohort were used for this analysis.

Survival rates were estimated using the methods of Brownie et al. (1978) and Johnson (1974). The methods of Brownie et al. are superior to the older Composite Dynamic Life Table method. The latter method requires the following strict assumptions: 1) constant survival rate, 2) constant population size, 3) constant recruitment rate, 4) constant hunting pressure and 5) constant band reporting rate (Bowers 1977). These assumptions are untested statistically (Anderson 1975) and since survival is assumed to be constant the method is not applicable to young birds.

The methods of Brownie et al. (1978) test recovery data against a series of models whose assumptions range from very general to very restrictive. Chi-square goodness of fit tests and likelihood ratio tests between models are used to select the model which best describes the recovery data. The strict assumptions of the Composite Dynamic method are not required.

The effect of hunting regulations and active hunter numbers on Wisconsin wood duck kill rates within Wisconsin was examined by correlating adult and young kill rates with each of the following variables: 1) opening date of the Wisconsin waterfowl hunting season, 2) the number of October duck hunting days in Wisconsin, 3) total duck hunting days in Wisconsin, 4) wood duck daily bag limit, 5) mallard daily bag limit, 6) total daily bag limit, 7) October wood duck bag days (duck hunting days in October times wood duck daily bag limit) and 8) total wood duck bag days (total Wisconsin duck hunting days times the wood duck daily bag limit).

## RESULTS AND DISCUSSION

### Banded Samples

From 1959 through 1975, 33,025 wood ducks were banded in Wisconsin (Table 1). The sample included 20,901 males and 11,808 females. A total of 12,940, 18,288 and 1,706 adult, immature and local wood ducks were banded, respectively.

The Upper Mississippi River was the most important banding area. This area accounted for 84 and 73 percent of the immature and local males banded and 87 and 72 percent of the immature and local females banded, respectively. Twenty-five and 34 percent of the adult males and females, respectively, were banded on the Mississippi. Horicon and Necedah each accounted for 26 percent of the adult males banded and 27 and 25 percent, respectively of the adult females banded.

Brownie et al. (1978) recommend that at least 300 birds be banded in each age and sex cohort for a minimum of 5 consecutive years to accurately estimate recovery and survival rates. Kaczynski and Geis (1961) suggest using no less than 50 direct recoveries from any cohort to estimate direct recovery rates. Based on a total 1959-75 direct recovery rate of 0.0805 (all ages and sexes combined), approximately 650 wood ducks would have to be banded in each year to meet the 50 direct recoveries criteria in Wisconsin. A yearly banded sample of at least 50 birds is generally considered to be adequate for analysis of recoveries from individual banding areas or sex-age cohorts (March 1976 and Anderson 1975), and were used in this study.

Table 1. Total banded sample of Wisconsin wood ducks 1959-75.

SEX	AGE			TOTAL <sup>1</sup>
	ADULT	IMMATURE	LOCAL	
MALE	10185	9970	721	20901
FEMALE	2751	8289	738	11808
Total <sup>2</sup>	12940	18288	1706	33025

1. Includes wood ducks of unknown age.

2. Includes wood ducks of unknown sex.

At Mead, 1,610 wood ducks were banded (Table 2). Although this is an adequate banded sample, there is evidence that recovery parameters from wood ducks banded at Mead are biased (March pers. comm.). Wisconsin Department of Natural Resources personnel and students from the University of Wisconsin-Stevens Point annually conduct hunter bag checks at Mead. Hunters who have shot banded ducks are encouraged to report the bands. This practice raises the band reporting rate to an unknown extent, and causes artificially high recovery parameters. For this reason, data from Mead are presented but will not be discussed.

For wood ducks banded throughout Wisconsin yearly samples (sexes combined) ranged from 3 to 289 for locals, 185 to 2,902 for immatures, and 258 to 2,050 for adults (Table 2). Banded samples were not available each year from each banding area. Consecutive 1959-75 banded samples of at least 50 wood ducks are available from all areas except Mead for adults, the Mississippi River and Necedah for immatures, and the Mississippi River for locals (Table 2). Banded samples of locals

Table 2. Adult, immature and local wood ducks banded throughout Wisconsin and at each major banding area 1959-75. Sexes are combined.

Year	<u>Banding Area</u>					
	Upper Mississippi			Horicon		
	Adult	Immature	Local	Adult	Immature	Local
1959	180	633	22	13	0	0
1960	358	1408	123	47	4	0
1961	272	876	109	362	24	5
1962	225	425	228	752	60	2
1963	352	1288	108	801	12	0
1964	177	1423	15	70	10	1
1965	244	1685	21	619	93	0
1966	808	1778	59	226	29	8
1967	358	2760	51	97	14	18
1968	82	869	27	80	2	17
1969	56	976	193	86	5	5
1970	72	519	241	194	50	11
1971	39	52	60	34	5	21
1972	61	241	12	14	3	0
1973	41	326	15	0	0	0
1974	43	157	20	1	1	4
1975	88	237	1	22	5	1
Total <sup>2</sup>	3556	15647	1305	3418	308	93

See footnotes at end of table.

Table 2 (continued).

	<u>Banding Area</u>					
	Crex Meadows			Necedah		
	Adult	Immature	Local	Adult	Immature	Local
1959	0	0	0	65	5	0
1960	0	0	0	149	89	2
1961	0	0	0	273	138	19
1962	0	0	0	393	107	16
1963	83	44	0	814	66	5
1964	91	34	0	285	57	4
1965	205	89	7	105	30	0
1966	49	10	1	213	61	4
1967	94	22	0	104	95	0
1968	182	33	109	72	9	7
1969	243	83	70	168	47	5
1970	117	46	36	299	153	0
1971	177	55	0	12	13	0
1972	87	12	0	79	61	0
1973	82	14	0	0	0	0
1974	4	0	0	130	73	0
1975	1	0	0	192	101	0
Total <sup>2</sup>	1415	442	223	3353	1105	62

Table 2 (continued).

	<u>Banding Area</u>					
	Mead			State <sup>3</sup>		
	Adult	Immature	Local	Adult	Immature	Local
1959	0	0	0	258	638	22
1960	0	0	0	554	1501	125
1961	0	0	0	907	1038	133
1962	0	0	0	1370	592	246
1963	0	0	0	2050	1410	113
1964	0	0	0	623	1524	20
1965	0	0	0	1173	1897	28
1966	129	145	2	1439	2014	75
1967	0	3	0	727	2902	69
1968	4	0	3	431	913	168
1969	513	192	1	1110	1334	274
1970	25	5	0	708	773	289
1971	62	14	0	351	185	81
1972	116	57	0	365	385	12
1973	30	12	1	153	368	22
1974	81	65	0	262	294	26
1975	91	59	0	459	520	3
Total	1051	552	7	12940	18288	1706

1) includes birds of unknown sex.

2) includes birds whose exact year of banding is unknown.

3) includes wood ducks banded on the major banding areas and outside the major banding areas.

were combined with immatures for most of the analyses. These 2 cohorts are referred to collectively as young.

#### RECOVERY CHRONOLOGY

October was the most important month of recovery representing 64 percent of the total direct recoveries and 47 percent of the total indirect recoveries from wood ducks banded throughout Wisconsin (Table 3). From 39 (Crex Meadows) to 69 (Upper Mississippi) percent of the direct recoveries and from 32 (Necedah) to 53 (Crex Meadows) percent of the indirect recoveries from wood ducks banded in the major banding areas occurred in October (Table 4).

December was slightly more important than November for direct and indirect recoveries from wood ducks banded throughout Wisconsin. These 2 months combined contained one-third of the direct recoveries and nearly one-half of the indirect recoveries (Table 3). For wood ducks banded at the major banding areas from 29 (Upper Mississippi) to 53 (Necedah) percent of the direct recoveries and 39 (Crex Meadows) to 61 (Necedah) percent of the indirect recoveries occurred during November-December. (Table 4).

Few recoveries from wood ducks banded throughout Wisconsin were obtained in September (Tables 3 and 4). January was of minor importance for recoveries of wood ducks banded throughout Wisconsin (Table 3), with the exception of both direct and indirect recoveries from wood ducks banded at Crex Meadows (Table 4).

Immature and local male and adult female direct recovery chronology is similar to that for total direct recoveries

Table 3. Monthly chronology of direct and indirect recoveries of wood ducks banded in Wisconsin 1959-75. Figures are expressed as a percent.

	Direct							Indirect		
	Total <sup>1</sup>	Male			Female			Total <sup>2</sup>	Male	Female
	Adult	Imm.	Local <sup>3</sup>	Adult	Imm.	Local				
September	0.2	0.2	0.1	0.0	0.0	0.5	0.0	1.2	1.6	0.0
October	64.2	49.2	67.4	64.1	64.0	72.1	75.4	47.1	40.5	59.6
November	14.7	15.3	15.3	15.1	11.8	14.1	13.1	21.3	21.2	21.6
December	18.3	30.0	14.6	20.8	22.2	12.1	9.8	25.1	29.9	15.5
January	2.6	5.3	2.4	0.0	2.0	1.3	1.6	5.4	6.5	3.2
Total	100.0	100.0	99.8	100.0	100.0	100.1	99.9	100.0	99.7	99.9
N	2274	541	821	53	153	626	61	633	414	213

1) Includes wood ducks of unknown sex and age.

2) Includes birds of unknown sex.

3) Local is defined as flightless young.

Table 4. Monthly chronology of direct and indirect recoveries of wood ducks banded at each banding area in Wisconsin 1959-75. Figures are expressed as a percent.

Month	Banding Area				
	Upper Mississippi	Horicon	Crex Meadows	Necedah	Mead <sup>2</sup>
<b>Direct:</b>					
September	0.1	0.0	0.0	1.4	0.0
October	67.9	54.7	39.1	42.2	79.2
November	14.5	13.8	18.2	18.8	10.8
December	14.9	28.6	32.2	34.8	8.5
January	2.2	3.0	10.4	2.8	1.7
<b>Total</b>	<b>99.6</b>	<b>100.1</b>	<b>99.9</b>	<b>100.0</b>	<b>100.2</b>
<b>N</b>	<b>1637</b>	<b>203</b>	<b>213</b>	<b>115</b>	<b>178</b>
<b>Indirect:</b>					
September	1.2	0.0	0.0	3.4	0.0
October	50.4	39.7	52.7	32.1	61.5
November	22.0	24.0	22.2	21.8	10.3
December	21.4	31.5	16.7	39.0	12.9
January	4.9	4.6	8.3	3.4	15.4
<b>Total</b>	<b>99.8</b>	<b>99.8</b>	<b>99.9</b>	<b>99.7</b>	<b>100.1</b>
<b>N</b>	<b>345</b>	<b>108</b>	<b>36</b>	<b>87</b>	<b>39</b>

1) All age and sex cohorts are combined.

2) Data from Mead are biased to an unknown extent due to an inflated band reporting rate at the banding area.

(Table 3). A smaller percent of the adult male recoveries (direct and indirect), as compared to other cohorts, occurred in October and a larger percent occurred in January. Immature and local female recoveries were highest in October when compared to other cohorts (Table 3).

Bowers (1977) found adult females (as compared to adult males) from the North Central Population Unit (NCPU) were prominent in the October and combined October-November harvest, while adult males were prominent in the December-January harvest. Immatures of both sexes were most important in the October harvest and combined October-November harvest, compared to adults. Adults dominated the December harvest.

The difference in chronology between cohorts indicates that differences in migrational timing and/or vulnerability to hunting occurs. In Maine, most adult males molt in June and July, but the timing of the female molt is individually variable (Barden 1968). Gilmer et al. (1977) found that about 9 percent of the adult hens were still in the preflightless condition on 10 September in Minnesota. Most drakes had completed the molt and were flying by mid-August. In Illinois (Bellrose 1976) and Massachusetts (Grice and Rogers 1965) some drakes were still flightless in late September. The delayed female molt is undoubtedly due to her maternal duties of egg laying, incubation and brood rearing.

Because the adult female molt often extends into late summer and early fall, additional stress is placed on hens already weakened by nesting and brood rearing. This stress could leave adult females more vulnerable to hunting early

in the season than adult males, or cause a differential migration between the sexes.

That immature and local wood ducks are recovered to a greater extent early in the hunting season than adults would be expected since they have never before experienced a hunting season. Biologically, a greater proportion of the immature and local female recoveries, as compared to immature and local male recoveries, occurring in October is difficult to explain. Theoretically these cohorts should be subject to the same hunting pressure and timing of the molt. It does appear, however, that young females are more vulnerable to hunting in October than young males, or that a differential migration occurs.

Direct recoveries of ducks banded as flightless young and indirect recoveries of ducks banded as flying immatures or adults should provide the best description of recovery chronology because the influence of harvest on or adjacent to the banding area is minimal (March 1976). Figure 3 shows the chronology of local male and female direct recoveries and all male and female indirect recoveries.

Both indirect and local recoveries show that females are recovered to a greater extent in October than males. This is also true of Wisconsin mallards (March 1976).

During October most recoveries from all cohorts were within Wisconsin. Recoveries within Wisconsin peaked during the first ten days of October with the exception of local males. Local male recoveries peaked during the second 10 days of October. Few recoveries were obtained within Wisconsin after 1 November.

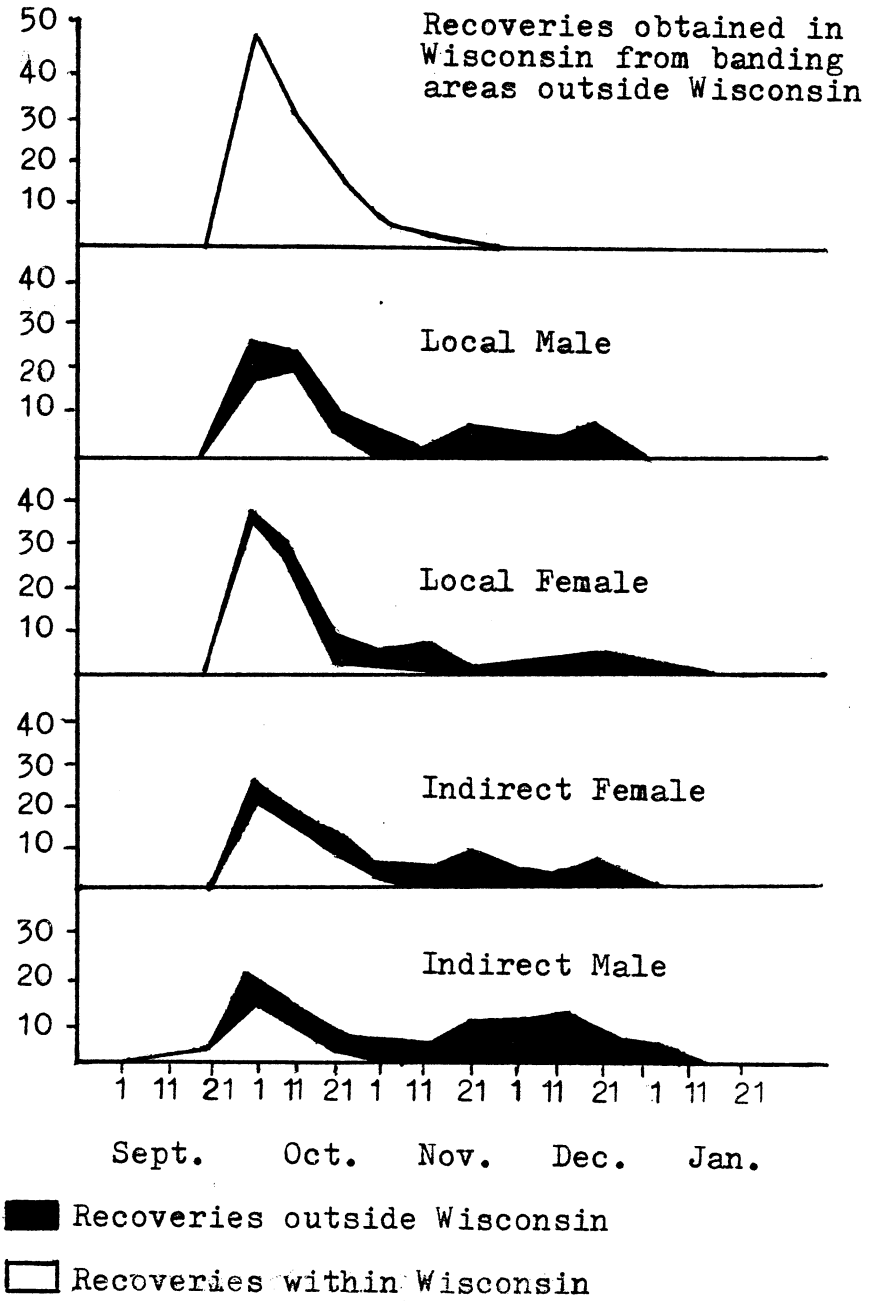


Fig. 3. Recovery chronology within Wisconsin and outside of Wisconsin, by 10 day interval.

Total recoveries for all cohorts peaked during the first 10 days of October. Recoveries declined after 10 October reaching subsequent peaks during 21-30 November for local males and females (indirect). Male indirect recoveries increased slightly until 11-20 December, and declined thereafter. Local females reached a second peak during 11-20 November, 10 days earlier than other cohorts and a third peak during 21-31 December concurrent with local males and indirect females.

Indirect recoveries show males arriving in southern states before females. For example, indirect recoveries were reported from Arkansas, Louisiana and Missouri during 21-30 October, whereas no indirect female recoveries were reported from these states until 1-10 November, 10 days later. Indirect male recoveries were also reported from Florida during 1-10 November, while no indirect female recoveries came from this state before 21-30 November. Local males also appear to be further south before local females, however differences in the state of recovery with respect to the dates of recovery are negligible.

The chronology of foreign wood duck recoveries within Wisconsin (Figure 3) is similar to that for Wisconsin wood ducks, except that foreign recoveries in Wisconsin occurred until the end of November, 10 days later than recoveries of Wisconsin banded wood ducks. This indicates that the harvest of Wisconsin wood ducks in October is diluted to some extent by migrant wood ducks and late in the season it may consist totally of migrants.

Jahn and Hunt (1964) show wood duck abundance in Wisconsin peaking shortly after 1 October, declining thereafter until few wood ducks remain in early November. This was also documented for other northern states (Grice and Rogers 1965, Barden 1968). Recoveries of wood ducks in Wisconsin (local and foreign) support these findings.

#### Recovery Chronology Throughout the Hunting Season

Opening day of the Wisconsin waterfowl hunting season accounted for 36 and 32 percent of the adult and young direct recoveries, respectively (Table 5). Opening day was responsible for from 11 (Crex Meadows and Necedah) to 41 (Horicon) percent of the adult, and from 12 (Crex Meadows) to 32 (Upper Mississippi) percent of the direct recoveries of young wood ducks banded in the major banding areas. The first 2 days of the hunting season accounted for 50 and 49 percent of the total adult and young direct recoveries. The range of values for the major banding areas was 24 (Necedah) to 53 (Horicon) percent for adults and from 12 (Crex Meadows) to 49 (Upper Mississippi) percent for young.

Barden (1968) found 65 percent of the wood ducks banded in Maine were recovered during the first 3 days of the Maine hunting season. More than 90 percent of the adult and young direct recoveries of wood ducks banded throughout Wisconsin occurred during the first 21 days of the season (Table 5). This was true for recoveries of wood ducks banded at all areas except Crex Meadows adults and both age cohorts from Necedah. After the first 14 days of the season 100 percent

Table 5. Chronology of direct recoveries within Wisconsin by opening day, first two days and seven day interval of the Wisconsin waterfowl hunting season 1959-75 (percent).

	ADULTS <sup>1</sup>						
	Upper Mississippi	Horicon	Crex Meadows	Necedah	Mead <sup>4</sup>	State	Foreign <sup>3</sup>
Opening Day	24.3	41.3	11.1	11.1	61.8	35.8	29.1
1st 2 Days	37.8	53.3	33.3	24.4	78.9	50.4	47.7
1st 7 Days	50.1	72.0	44.4	46.6	84.1	63.7	61.3
1st 14 Days	82.6	87.9	77.7	73.2	93.2	84.9	79.0
1st 21 Days	92.1	95.9	77.7	86.5	95.8	93.0	91.1
1st 28 Days	97.6	98.5	99.9	95.4	98.4	98.1	95.1
1st 35 Days	100.4	99.8	99.9	97.6	98.4	99.4	97.1
1st 42 Days	100.4	99.9	99.9	99.8	98.4	99.4	98.8
> 42 Days	100.4	100.9	99.8	99.8	99.7	99.7	100.2
N	74	75	9	45	76	288	361

See footnotes at end of table.

Table 5 (continued).

	YOUNG <sup>2</sup>						
	Upper Mississippi	Horicon	Crex Meadows	Necedah	Mead <sup>4</sup>	State	Foreign <sup>3</sup>
Opening Day	31.9	18.2	12.5	17.2	57.1	32.0	29.1
1st 2 Days	48.9	40.9	12.5	41.3	71.4	49.2	47.7
1st 7 Days	64.4	63.5	37.5	48.2	89.3	61.8	61.3
1st 14 Days	87.0	72.5	100.0	65.3	91.1	86.0	79.0
1st 21 Days	94.4	95.1	100.0	85.8	92.9	93.8	91.1
1st 28 Days	97.4	99.6	100.0	92.6	96.5	97.1	95.1
1st 35 Days	100.3	99.6	100.0	99.5	98.3	98.6	97.1
1st 42 Days	100.3	99.6	100.0	99.5	98.3	100.0	99.8
42 Days	100.3	99.6	100.0	99.5	100.1	100.0	100.2
N	634	22	17	29	56	765	361

- 1) Sexes are combined.
- 2) Young = local plus immatures.
- 3) Foreign recoveries are from birds recovered anywhere in Wisconsin but banded outside of Wisconsin. All age and sex groups are combined.
- 4) Data from Mead are biased to an unknown extent due to an inflated band reporting rate at the banding area.

of the young direct recoveries from Crex Meadows had been obtained.

The chronology of foreign banded wood duck direct recoveries was similar to that for adult and young wood ducks banded in Wisconsin except that fewer of the foreign recoveries occurred on opening day and at the end of the first 14 days of the hunting season compared to Wisconsin banded recoveries (Table 5).

Smith (1975) found 32 percent of the wood duck harvest occurred on the opening day of the Wisconsin waterfowl hunting season. The first 2, 7, and 9 days accounted for 53, 70 and 81 percent, respectively, of the Wisconsin wood duck harvest. Thus the chronology of the Wisconsin wood duck harvest conforms to the recovery chronology through the hunting season (Table 5).

Opening the waterfowl season during the first 10 days of October allows for maximum use of the wood duck resource in Wisconsin. Since the number of wood ducks in Wisconsin decreases sharply during October, opening the waterfowl season after 10 October or increasing the point value on wood ducks during the first 10 days of October could decrease the harvest of wood ducks in Wisconsin. This possibility will be discussed in the section on kill rates. March (1976) found that foreign-banded mallards were recovered in Wisconsin in smaller proportions than Wisconsin-banded mallards early in the hunting season. Opening the hunting season after 5 October should take greater advantage of migrant mallards and also provide a dilution factor of migrants which could decrease the harvest of Wisconsin wood ducks.

## RECOVERY DISTRIBUTION

Wisconsin accounted for 43 percent of the adult (Appendix Q) and 50 percent of the young (Appendix R) direct recoveries from Wisconsin-banded wood ducks. For individual banding areas, Wisconsin accounted for from 24 (Crex Meadows) to 47 (Horicon) percent of the adult direct recoveries and from 45 (Crex Meadows) to 68 percent (Horicon) of the young direct recoveries.

Since Wisconsin is the most important recovery area for its banded wood ducks, it was excluded from the analysis in order to more properly determine important harvest areas outside of Wisconsin.

The Mississippi Flyway accounted for 82 percent of the total non-Wisconsin direct wood duck recoveries. The Atlantic and Central Flyways contained 5 and 12 percent, respectively (Table 6).

The Mississippi Flyway totalled 78 and 86 percent of the non-Wisconsin adult male and female recoveries, respectively (Table 7). Atlantic Flyway states totaled 4 and 14 percent. The distribution between flyways of the non-Wisconsin direct recoveries was similar for immature males and females, with approximately 80 percent of the recoveries occurring in the Mississippi Flyway. Local males were recovered to a greater extent in the Mississippi Flyway than local females while local females were more likely to be recovered in the Central Flyway.

At least 75 percent of the non-Wisconsin direct recoveries from each banding area occurred in the Mississippi Flyway. With one exception, the direct recovery distribution of wood ducks banded at Crex Meadows, and Necedah showed similar recovery

Table 6. Direct recovery distribution by states and Flyway for all age/sex wood ducks banded throughout Wisconsin 1959-75.<sup>1</sup> Figures are expressed as a percent.

RECOVERY STATE	WISC. EXCLUDED	TOTAL
Florida	2.33	1.22
Georgia	1.75	0.92
N. Carolina	0.29	0.15
S. Carolina	0.07	0.04
Pennsylvania	0.73	0.38
Atlantic Flyway	5.17	2.71
Alabama	2.70	1.41
Arkansas	9.99	5.23
Illinois	5.54	2.89
Indiana	0.58	0.31
Iowa	12.84	6.71
Kentucky	0.07	0.04
Louisiana	17.87	9.34
Michigan	0.58	0.31
Minnesota	18.60	9.73
Mississippi	7.22	3.78
Missouri	3.79	1.98
Ohio	0.66	0.34
Tennessee	1.60	0.84
Wisconsin	****	47.71
Mississippi Flyway	82.04	90.62
Kansas	1.17	0.61
Montana	0.07	0.04
Nebraska	0.22	0.11
Oklahoma	1.39	0.72
Texas	9.48	4.96
Central Flyway	12.33	6.44
Idaho	0.07	0.04
Ontario	0.14	0.76
Newfoundland	0.07	0.04
Unknown	0.14	0.76
Miscellaneous	0.42	1.60
<b>Total</b>	<b>99.96</b>	<b>101.37</b>

1) Includes wood ducks of unknown age and sex.

Table 7. Direct recovery distribution (percent) by state and flyway for each age and sex class banded throughout Wisconsin 1959-75.<sup>1</sup>

State	Male			Female		
	Adult	Immature	Local	Adult	Immature	Local
Florida	6.1	0.8	0.0	1.2	1.1	0.0
Georgia	4.5	0.6	0.0	2.3	0.3	3.8
N. Carolina	0.8	0.2	0.0	0.0	0.0	0.0
S. Carolina	1.9	0.6	0.0	0.0	0.0	0.0
Pennsylvania	0.3	0.0	0.0	0.0	0.0	0.0
Atlantic Flyway	13.6	2.2	0.0	3.5	1.4	3.8
Alabama	5.3	1.8	3.2	7.0	0.3	0.0
Arkansas	12.8	7.5	16.1	10.5	10.0	11.5
Illinois	4.3	5.1	3.2	9.3	6.6	7.7
Indiana	1.9	0.2	0.0	0.0	0.0	0.0
Iowa	4.3	15.6	22.6	7.0	18.3	19.2
Kentucky	0.0	0.0	0.0	0.0	0.3	0.0
Louisiana	24.3	16.2	19.4	20.9	12.3	26.9
Michigan	1.6	0.4	0.0	0.0	0.0	0.0
Minnesota	7.5	23.7	19.4	10.5	26.4	7.7
Mississippi	9.9	5.5	9.7	16.3	4.3	0.0
Missouri	2.7	4.8	3.2	3.5	3.4	3.8
Ohio	1.1	0.4	0.0	0.0	0.6	3.8
Tennessee	1.9	1.6	0.0	1.2	1.7	0.0
Wisconsin	***	***	***	***	***	***
Mississippi Flyway	77.6	82.8	96.8	86.2	84.2	80.6
Kansas	0.0	1.2	0.0	3.5	1.4	7.7
Montana	0.0	0.2	0.0	0.0	0.0	0.0
Nebraska	0.0	0.2	0.0	0.0	0.6	0.0
Oklahoma	0.5	1.6	0.0	1.2	2.0	0.0
Texas	8.0	11.3	3.2	5.8	9.7	7.7
Central Flyway	8.5	14.5	3.2	10.5	13.7	15.4
Idaho	0.3	0.0	0.0	0.0	0.0	0.0
Ontario	0.0	0.2	0.0	0.0	0.3	0.0
Newfoundland	0.0	0.2	0.0	0.0	0.0	0.0
Unknown	0.26	0.0	0.0	0.0	0.3	0.0

1) Wisconsin was excluded from this tabulation to reduce the importance of the banding area.

patterns (Table 8) except that slightly more of the wood ducks banded at Crex Meadows were recovered in the Central Flyway and slightly less were recovered in the Atlantic Flyway. Seventeen percent of the direct recoveries from wood ducks banded at Horicon were recovered in the Atlantic Flyway compared to only 2 percent of those banded on the Upper Mississippi River. Thus wood ducks banded in eastern Wisconsin tend to be recovered further east and those banded in western Wisconsin further west.

Bowers (1977) lists Alabama, Arkansas, Illinois, Louisiana, Minnesota, Mississippi and Wisconsin as the most important states which harvest wood ducks from the North Central Population Unit (NCPU). Mississippi Flyway states of Arkansas, Iowa, Louisiana and Minnesota contained 10-20 percent of the total non-Wisconsin direct recoveries in this study (Table 6). In the Central Flyway, Texas was the only important recovery state containing 9 percent of all direct recoveries. Florida and Georgia were the most important states in the Atlantic Flyway but represented only 2 percent each of the non-Wisconsin direct recoveries (Table 6). Iowa and Minnesota were the most important recovery states for wood ducks banded on the Upper Mississippi River. Louisiana and Arkansas were most important for all other banding areas. Adult males tended to be recovered in Louisiana more than any other cohort except local females (Table 7). Florida and Georgia combined accounted for 11 percent of the adult male non-Wisconsin direct recoveries.

Bowers (1977) noted that recovery distributions were similar for adult and immature wood ducks from the NCPU, except that adults are more prominent in southern states. This

Table 8. Direct recovery distribution (percent) for each major banding area in Wisconsin (1959-75). All age and sex cohorts are combined.<sup>1</sup>

RECOVERY STATE	CREX MEADOWS	MEAD <sup>2</sup>	NECEDAH	UPPER MISS. RIVER	HORICON
Florida	1.1	2.9	5.6	0.8	8.6
Georgia	4.5	2.9	1.4	1.1	5.2
N. Carolina	0.0	0.0	1.4	0.1	0.9
S. Carolina	1.1	2.9	2.1	0.2	2.6
Pennsylvania	1.1	0.0	0.0	0.0	0.0
Atlantic Flyway	7.8	8.7	10.5	2.2	17.3
Alabama	5.7	11.4	8.4	0.7	7.8
Arkansas	10.2	14.3	14.0	9.2	10.3
Illinois	3.4	2.9	4.9	5.3	10.3
Indiana	1.1	0.0	0.0	0.2	3.5
Iowa	1.1	2.9	2.1	17.2	2.6
Kentucky	0.0	0.0	0.0	0.1	0.0
Louisiana	27.3	31.4	31.5	14.1	21.5
Michigan	0.0	0.0	1.4	0.4	0.9
Minnesota	10.2	0.0	0.0	25.1	0.0
Mississippi	7.9	8.6	11.2	5.7	13.8
Missouri	7.9	5.7	2.1	4.1	0.0
Ohio	1.1	0.0	1.4	0.6	0.9
Tennessee	0.0	0.0	2.1	1.5	3.5
Mississippi Flyway	75.9	77.2	79.1	84.2	75.1
Kansas	3.4	2.9	0.0	1.2	0.0
Montana	0.0	0.0	0.0	0.1	0.0
Nebraska	0.0	0.0	0.0	0.3	0.0
Oklahoma	1.1	2.9	2.1	1.4	0.0
Texas	11.4	5.7	9.1	9.9	6.9
Central Flyway	15.9	11.5	11.2	12.9	6.9
Idaho	0.0	2.9	0.0	0.0	0.0
Ontario	0.0	0.0	0.0	0.2	0.0
Newfoundland	0.0	0.0	0.0	0.0	0.9
Unknown	0.0	0.0	0.0	0.2	0.0
TOTAL	99.6	100.3	100.8	99.7	100.2

1) Includes wood ducks of unknown age or sex.

2) Data from Mead are biased to an unknown extent due to an inflated band reporting rate at the banding area.

same relationship appears to be true for Wisconsin wood ducks (Table 7).

The four southern states of Mississippi, Arkansas, Louisiana and eastern Texas were jointly responsible for 45 percent of all non-Wisconsin direct recoveries (Table 6), ranging from 39 (Upper Mississippi River) to 66 percent (Necedah) at the individual banding areas (Table 8). These states also contain 36 percent of the indirect recoveries (Appendix L), and 55, 41 and 48 percent of the adult, immature and local male direct recoveries, respectively, and 53, 36 and 46 percent of the adult, immature and local female direct recoveries (Table 7).

For the individual banding areas Minnesota, Iowa and Illinois contained from 7 (Necedah) to 48 (Upper Mississippi River) percent of the non-Wisconsin direct recoveries (Table 8). Minnesota, Iowa and Illinois contained 36 percent of the adult non-Wisconsin direct recoveries of wood ducks banded on the Upper Mississippi, but only 16 percent of the adult recoveries from the entire state (Table 9). These three states were responsible for 35 percent of the young non-Wisconsin direct recoveries (Table 10) from the Upper Mississippi and 47 percent of the young recoveries from the entire state. Since 86 percent of the young wood ducks were banded at the Upper Mississippi River, these three states are extremely important in their influence on estimates of young recovery and survival rates derived for the entire state.

Radial dispersal in wood ducks has been documented by

Table 9. Direct recovery distribution (percent) for adult wood ducks banded throughout Wisconsin and each major banding area within Wisconsin 1959-75. Sexes are combined<sup>1</sup> and Wisconsin is excluded.

Recovery State	Banding Area					
	State	Upper Miss.	Horicon	Crex Meadows	Necedah	Mead <sup>2</sup>
Florida	6.1	3.2	7.7	1.6	6.5	0.0
Georgia	4.5	3.8	5.8	6.5	1.9	4.2
N. Carolina	0.8	0.0	1.0	0.0	1.9	0.0
Pennsylvania	0.3	0.0	0.0	1.6	0.0	0.0
S. Carolina	1.9	0.0	2.9	1.6	2.8	0.0
Atlantic Flyway	13.6	7.0	17.4	11.3	13.1	4.2
Alabama	5.3	0.0	8.7	6.5	9.3	12.5
Arkansas	12.8	14.1	9.6	8.1	13.9	20.8
Illinois	4.3	3.2	9.6	4.8	5.5	0.0
Indiana	1.9	1.3	3.8	1.6	0.0	0.0
Iowa	4.3	10.9	1.9	0.0	1.9	4.2
Kentucky	0.0	0.0	0.0	0.0	0.0	0.0
Louisiana	24.2	17.3	21.1	30.6	29.6	29.2
Michigan	1.6	1.3	1.0	0.0	1.9	0.0
Minnesota	7.5	21.8	0.0	4.8	0.0	0.0
Mississippi	9.9	7.1	15.4	9.7	13.0	12.5
Missouri	2.7	3.8	0.0	4.8	1.2	8.3
Ohio	1.1	0.6	1.0	1.6	0.9	0.0
Tennessee	1.9	1.3	3.8	0.0	1.2	0.0
Wisconsin	***	***	***	***	***	***
Mississippi Flyway	77.5	82.7	75.9	72.5	78.4	87.5
Kansas	0.0	1.3	0.0	1.6	0.0	0.0
Montana	0.0	0.0	0.0	0.0	0.0	0.0
Nebraska	0.0	0.0	0.0	0.0	0.0	0.0
Oklahoma	0.5	0.0	0.0	1.6	1.2	0.0
Texas	8.0	8.3	6.7	12.9	5.5	4.2
Central Flyway	8.5	9.6	6.7	16.1	6.7	4.2
Idaho	0.3	0.0	0.0	0.0	0.0	4.2
Ontario	0.0	0.0	0.0	0.0	0.0	0.0
Newfoundland	0.0	0.0	0.0	0.0	0.0	0.0
Unknown	0.3	0.6	0.0	0.0	0.0	0.0
Total	100.2	99.9	100.0	99.9	98.2	100.1
N	375	51	104	62	108	24

1) Includes wood ducks of unknown sex.

2) Data from Mead are biased to unknown extent due to an inflated band reporting rate at the banding area.

Table 10. Direct recovery distribution (percent) for young wood ducks banded throughout Wisconsin and each major banding area within Wisconsin 1959-75. Sexes are combined and Wisconsin is excluded<sup>1</sup>.

Recovery State	Banding Area					
	State	Upper Miss.	Horicon	Crex Meadows	Necedah	Mead <sup>2</sup>
Florida	0.9	0.4	16.7	0.0	2.9	9.1
Georgia	0.5	0.6	0.0	0.0	0.0	0.0
N. Carolina	0.1	0.1	0.0	0.0	0.0	0.0
Pennsylvania	0.0	0.0	0.0	0.0	0.0	0.0
S. Carolina	0.3	0.2	0.0	0.0	0.0	9.1
Atlantic Flyway	1.8	1.3	16.7	0.0	2.9	18.2
Alabama	1.2	0.9	0.0	3.8	5.7	9.1
Arkansas	8.9	8.3	16.7	15.4	14.3	0.0
Illinois	5.7	5.7	16.7	0.0	2.9	9.1
Indiana	0.1	0.0	0.0	0.0	0.0	0.0
Iowa	17.0	18.4	8.3	3.8	2.9	0.0
Kentucky	0.1	0.1	0.0	0.0	0.0	0.0
Louisiana	15.1	13.5	25.0	19.2	37.1	36.4
Michigan	0.2	0.2	0.0	0.0	0.0	0.0
Minnesota	24.1	25.8	0.0	23.1	0.0	0.0
Mississippi	5.0	5.4	0.0	3.8	5.7	0.0
Missouri	4.2	4.0	0.0	15.4	2.9	0.0
Ohio	0.5	0.6	0.0	0.0	0.0	0.0
Tennessee	1.5	1.6	0.0	0.0	2.9	0.0
Wisconsin	***	***	***	***	***	***
Mississippi Flyway	83.6	84.5	66.7	84.5	74.4	54.6
Kansas	1.4	1.2	0.0	7.7	0.0	9.1
Montana	0.1	0.1	0.0	0.0	0.0	0.0
Nebraska	0.3	0.4	0.0	0.0	0.0	0.0
Oklahoma	1.7	1.7	0.0	0.0	2.9	9.1
Texas	10.3	10.2	8.3	7.7	20.0	9.1
Central Flyway	13.8	13.6	8.3	15.4	22.9	27.3
Idaho	0.0	0.0	0.0	0.0	0.0	0.0
Ontario	0.2	0.2	0.0	0.0	0.0	0.0
Newfoundland	0.1	0.0	8.3	0.0	0.0	0.0
Unknown	0.1	0.1	0.0	0.0	0.0	0.0
Total	99.6	99.7	100.0	99.9	100.2	100.1
N	900	921	12	47	35	11

1) Includes wood ducks of unknown sex.

2) Data from Mead are biased to an unknown extent due to an inflated band reporting rate at the banding area.

Stewart (1977a, 1977b) and Bellrose (1976), and in other species of waterfowl by Hochbaum (1955). This dispersal prior to the hunting season occurs in Wisconsin wood ducks as evidenced by recoveries in Newfoundland, Idaho, Montana and Ontario.

#### Recovery Distribution Within Wisconsin

From 23 (Crex Meadows) to 56 (Upper Mississippi) percent of the direct recoveries were obtained within the same banding area where the birds were banded (Table 11). This stresses the importance of shooting losses within the banding area in determining recovery parameters. With the exception of adults at Necedah, immatures at Mead and locals at Crex Meadows, females were recovered to a greater extent than males in their banding area (Table 11). This indicates that males migrate, disperse or are less vulnerable to hunting within the banding area than females.

From 17 (Necedah) to 30 (Upper Mississippi) percent of the indirect recoveries (Table 12) occurred in the area where the birds were banded. Indirect female recoveries within the banding areas were twice as great as males. Grice and Rogers (1968), Barden (1968), Bellrose (1976) and Bowers (1977) found that female wood ducks homed back to their natal areas or previous nesting areas to a greater extent than males. Wisconsin's recovery data suggests that this is also true of Wisconsin wood ducks.

Martz (1965) defined 3 harvest areas within Wisconsin which were later used by Smith (1975) (Fig. 4). The Southwest harvest area contained most of the direct (73%) and indirect (60%)

Table 11. Percent of the total direct wood duck recoveries occurring in the banding area where the bird was banded.

BANDING AREA		ADULT	IMMATURE	LOCAL	YOUNG	TOTAL
Upper Mississippi	M	46.86	55.10	52.50	54.98	53.55
	F	48.53	61.36	66.67	61.75	60.66
	T	47.54	57.84	60.55	58.03	56.63
Horicon	M	33.12	40.00	57.14	47.62	34.64
	F	38.46	44.44	85.71	62.50	45.45
	T	34.18	41.67	71.43	52.63	37.18
Crex Meadows	M	15.94	21.05	40.00	25.00	18.28
	F	33.33	42.86	22.22	34.78	34.29
	T	18.52	30.30	28.57	29.79	22.66
Necedah	M	27.82	39.58	***** <sup>2</sup>	39.58	30.60
	F	21.21	48.15	*****	48.15	32.79
	T	26.51	42.67	*****	42.67	31.15
Mead <sup>1</sup>	M	60.67	77.42	*****	77.42	65.00
	F	76.19	75.00	*****	75.00	75.41
	T	63.64	76.06	*****	76.06	68.51

1) Data from Mead are biased to an unknown extent due to an inflated band reporting rate at the banding area.

2) No recoveries were obtained within the banding area.

Table 12. Percent of the total indirect wood duck recoveries occurring in the banding area where the bird was banded.

Banding Area	Sex	Adult		Young <sup>1</sup>		Total	
		N	%	N	%	N	%
Upper Mississippi	M	166	27.7	397	19.6	563	22.0
	F	42	40.5	313	41.5	358	41.6
	T	208	30.3	717	29.1	928	29.5
Horicon	M	183	20.2	17	11.8	200	19.5
	F	37	37.8	7	57.1	44	40.9
	T	220	23.2	24	25.0	244	23.4
Crex Meadows	M	69	18.8	21	14.3	90	17.8
	F	15	33.3	11	45.4	26	38.5
	T	84	21.4	32	25.0	116	22.4
Necedah	M	159	15.7	32	3.1	193	13.5
	F	37	35.1	19	31.6	57	28.1
	T	196	17.9	51	13.7	252	16.7
Mead <sup>2</sup>	M	44	25.0	11	27.3	55	25.4
	F	4	50.0	8	62.5	13	53.9
	T	48	27.1	19	63.2	68	30.9

1) Banded as flightless locals or flying immatures.

2) Data from Mead are biased to an unknown extent due to an inflated band reporting rate at the banding area.

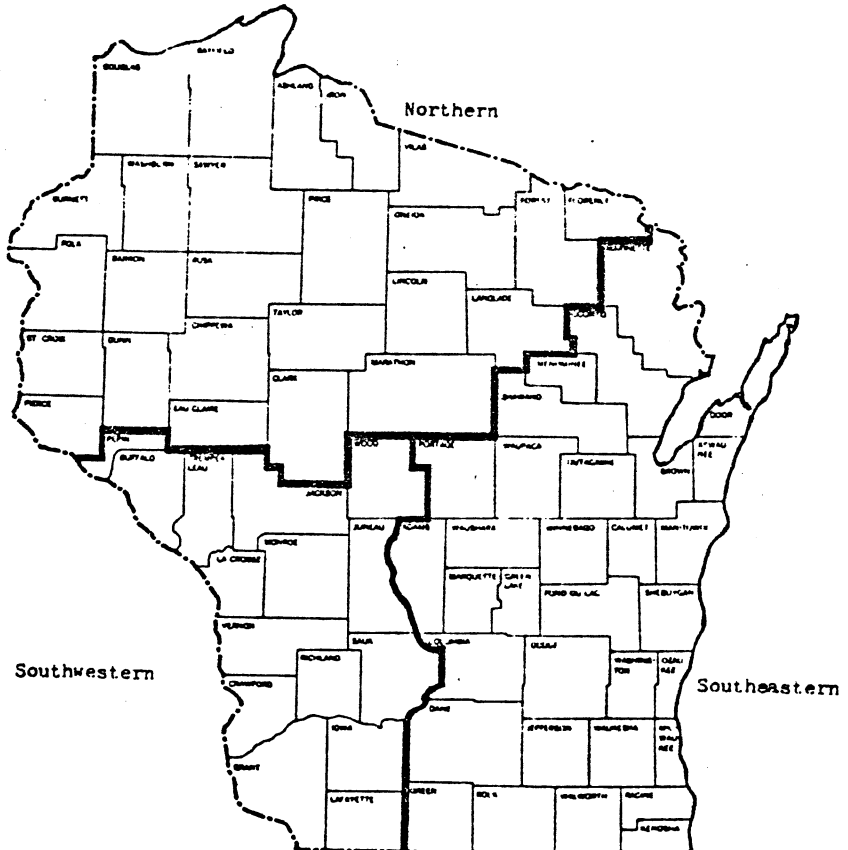


Fig. 4. Waterfowl harvest areas in Wisconsin (figure from Smith 1975).

recoveries in Wisconsin followed by the Southeast (23 and 31%) and Northern areas (0.1 and 8%). Smith (1975) found 19, 14 and 10 percent of the wood duck harvest occurred in these same three areas, respectively.

The greatest wood duck harvest in Wisconsin from 1949 to 1952 was along the Upper Mississippi River (Jahn and Hunt 1964). Smith (1975) found that 7.4, 5.3, 4.5 and 4.5 percent of the 1961-70 Wisconsin wood duck harvest occurred along the Mississippi River in Grant, Buffalo, Crawford and LaCrosse counties respectively. Within the Southwest harvest area, 63 and 53 percent of the direct and indirect recoveries, respectively, fell in 10 minute blocks of longitude and latitude bordering the Mississippi River. Since most of the wood duck banding in Wisconsin was done on the Mississippi River (Table 2), and the highest wood duck population in Wisconsin is also in this area (Figure 1), this is not surprising. However it does indicate that the Mississippi River is also an important harvest area for Wisconsin wood ducks.

#### DERIVATION OF WISCONSIN'S WOOD DUCK HARVEST

Jahn and Hunt (1964) and March et al. (1973) felt that the Wisconsin wood duck harvest consisted primarily of wood ducks produced in Wisconsin. This was expected since Wisconsin is on the northern edge of the wood duck breeding range (Fig 1).

Using band recoveries to determine the derivation of the harvest depends on the assumptions: 1) that all populations contributing significantly to the harvest are represented by banded birds; and 2) that the relative size of the populations

contributing to the harvest is known. The population estimates can be crude and still be useful (Geis 1972).

Seventy-five percent of all direct wood duck recoveries obtained in Wisconsin were from wood ducks banded in Wisconsin; 12 and 10 percent were from Iowa and Minnesota, respectively (Table 13). With the exception of 1 Manitoba recovery, all recoveries were from wood ducks banded in the Mississippi Flyway.

Weighted recoveries show that 75 percent of the wood ducks harvested in Wisconsin were produced there (Table 13). The only other state contributing significantly to the Wisconsin wood duck harvest was Minnesota (22 percent).

#### DIRECT RECOVERY RATES

Since locals are banded at an earlier age than immatures, a lower survival rate from the time of banding to the hunting season, resulting in a lower probability of being shot might be expected (Anderson 1975). Banded samples of local wood ducks were generally small, especially when broken down by years and banding areas. Direct 1959-75 recovery rates of local and immature wood ducks (Appendix R) were not significantly different (Males, Chi-square = 2.42, 12d.f.,  $P > 0.05$ ; (females, Chi-square = 0.37, 12d.f.,  $P > 0.05$ ) and the 2 juvenile age cohorts were combined as young males and young females.

The direct 1959-75 recovery rates of male and female wood ducks were not significantly different for any age class (Table 14). Also, the Chi-square contingency test of Brownie et al. (1978) did not show any sex differences in recovery

Table 13. Derivation of the Wisconsin wood duck harvest.

State	Preseason Population Est. (1950-68) <sup>1</sup>	#Banded <sup>1</sup>	Weight <sup>2</sup>	#Recoveries	#Wood Ducks Per Recovery <sup>3</sup>	Derivation (%)
Illinois	272,870	22,066	12.4	7	86.8	0.19
Indiana	220,170	6,952	31.7	6	190.2	0.43
Iowa	149,801	13,953	10.7	199	209.7	0.47
Kentucky	83,951	456	184.1	1	184.1	0.41
Michigan	401,968	4,858	82.7	20	102.7	0.23
Minnesota	751,950	11,906	63.2	158	9,985.6	22.48
Mississippi	390,837	2,569	152.1	1	152.1	0.34
Missouri	262,269	9,267	28.3	8	226.4	0.51
Tennessee	68,157	12,435	5.5	1	5.5	0.01
Wisconsin	645,373	24,238	26.6	1,251	33,276.6	74.90

1) Bowers (1977)

2) Wood duck population in each state divided by the number of wood ducks banded in each state.

3) Number of recoveries of wood ducks banded in each state multiplied by the weighting factor.

Table 14. Results of the Chi-square Tests of Independence of the hypothesis that direct recovery rates vary between sex classes.

Hypothesis Tested	Chi-square <sup>1</sup> Value	d.f.
Adult Male vs. Adult Female	0.14	1
Immature Male vs. Immature Female	1.73	1
Local Male vs. Local Female	1.58	1
Young Male vs. Young Female	0.86	1

1) Reference value at  $P=0.05$  and 1 d.f. is 3.84.

and survival rates ( $<0.05$ ; adult Chi-square=39.44, 27 d.f.; young Chi-square=43.4, 33 d.f.). Therefore, male and female data were also pooled.

The direct recovery rate of young wood ducks 1959-75 (0.09, Table 15) was significantly greater (Chi-square=87.08, 1 d.f.,  $P < 0.05$ ) than that of adults (0.06, Table 15). Jahn and Hunt (1964) and Smith (1975) and others have shown that young ducks are generally more vulnerable to hunting than adults. Bowers (1977), Grice and Rogers (1965), Cringen (1971) and Barden (1968) have documented this in wood ducks. The greater vulnerability to hunting of young wood ducks as compared to adults may be due to a lack of wariness, differences in migrational timing or behavioral differences (Bowers 1977).

Direct recovery rates varied significantly between years for both adult (Chi-square=70.46, 16 d.f.,  $P < 0.05$ ) and young (Chi-square=103.47, 16 d.f.,  $P < 0.05$ ) wood ducks. Direct recovery rates ranged from 0.03 (1961) to 0.10 (1969) for adults and from 0.05 (1961 and 1973) to 0.13 (1966) for young wood ducks (Table 15). Annual differences in recovery rates are expected since hunting regulations, hunter numbers and weather patterns have varied widely from year to year.

Bowers (1977) found that direct recovery rates varied between age and sex classes for wood ducks banded in Eastern North America, and in the NCPU although he did not analyze data for locals. He found direct recovery rates of 0.05, 0.04, 0.07 and 0.06 for adult males and females, and immature males and females, respectively in the Mississippi Flyway and 0.05, 0.05, 0.07 and 0.07 in the NCPU.

Table 15. Direct recovery rates for adult wood ducks banded throughout Wisconsin and for each banding area within Wisconsin 1959-75. Sexes are combined.<sup>1</sup>

Year	Upper Mississippi		Horicon		Crescent Meadows	
	Adult	Young	Adult	Young	Adult	Young
1959	0.0556	0.0840	(0.0769) <sup>2</sup>	(0.0000)	***** <sup>3</sup>	*****
1960	0.0503	0.0934	(0.1064)	(0.0000)	*****	*****
1961	0.0184	0.0477	0.0304	(0.0345)	*****	*****
1962	0.0711	0.0490	0.0372	0.0484	*****	*****
1963	0.0966	0.0867	0.0799	(0.0000)	0.0602	(0.0682)
1964	0.0847	0.0967	0.0571	(0.1818)	0.0440	(0.0294)
1965	0.0656	0.0862	0.0468	0.1075	0.0878	0.0937
1966	0.0879	0.1345	0.0482	(0.0357)	0.0408	(0.0000)
1967	0.0782	0.0946	0.1134	(0.1875)	0.0426	(0.1364)
1968	0.0244	0.0502	0.0500	(0.2105)	0.0440	0.0704
1969	0.0714	0.1197	0.0698	(0.1000)	0.0617	0.0653
1970	0.0417	0.1211	0.0876	0.0984	0.1026	0.0488
1971	(0.1538)	0.1607	0.0882	(0.1538)	0.0282	0.0909
1972	0.0820	0.0765	(0.1429)	(0.0000)	0.0575	(0.1667)
1973	(0.0488)	0.0499	*****	*****	0.0610	(0.0000)
1974	(0.0930)	0.0936	(1.0000)	(0.0000)	(0.0000)	(0.0000)
1975	0.0909	0.1303	(0.0714)	(0.1395)	(0.0000)	(0.0000)
Total	0.0715	0.1146	0.0578	0.1005	0.0587	0.0706

See footnotes at end of table.

Table 15 (continued).

Year	Necedah		Mead <sup>4</sup>		State	
	Adult	Young	Adult	Young	Adult	Young
1959	0.0462	(0.0000)	*****	*****	0.0543	0.0833
1960	0.0470	0.0989	*****	*****	0.0542	0.0935
1961	0.0440	0.0382	*****	*****	0.0309	0.0461
1962	0.0382	0.0244	*****	*****	0.0431	0.0573
1963	0.0590	0.0845	*****	*****	0.0737	0.0853
1964	0.0316	0.0820	*****	*****	0.0514	0.1017
1965	0.0095	(0.1333)	*****	*****	0.0554	0.0871
1966	0.0657	0.0769	0.1085	0.1156	0.0778	0.1292
1967	0.0577	0.0421	(0.0000)	(0.0000)	0.0688	0.0939
1968	0.0405	(0.0625)	(0.0000)	(0.0000)	0.0394	0.0555
1969	0.0476	0.0769	0.1345	0.2021	0.0964	0.1150
1970	0.0736	0.1242	(0.0000)	(0.0000)	0.0763	0.1158
1971	(0.0833)	(0.0769)	0.1129	(0.0000)	0.0684	0.1203
1972	0.0380	0.0492	0.0690	0.0351	0.0658	0.0856
1973	*****	*****	(0.0667)	(0.0000)	0.0523	0.0487
1974	0.0154	0.0548	0.0370	0.0923	0.0344	0.0813
1975	0.0672	0.0495	0.0879	0.0847	0.0741	0.1070
Total	0.0498	0.0677	0.1056	0.1270	0.0632	0.0919

- 1) Includes wood ducks of unknown sex.
- 2) Less than 50 wood ducks banded.
- 3) No wood ducks banded.
- 4) Data from Mead are biased to an unknown extent due to an inflated band reporting rate at the banding area.

Direct recovery rates for all cohorts banded in Wisconsin (1959-75) were higher than Bower's (1977) rates for either of these areas. A higher recovery rate should be expected for Wisconsin wood ducks because they are exposed to longer hunting seasons and more opening days as they migrate to wintering areas (Benson 1972, Bowers 1977, Cringen 1971). However, wood ducks banded in Minnesota (1950-68) (Bowers 1977) also on the northern edge of the Mississippi Flyway and NCPU had lower direct recovery rates than those banded in Wisconsin (1950-68). Minnesota's band reporting rate (0.296), however, is lower than Wisconsin's (0.317) (Bowers 1977) and may be responsible for the difference in recovery rates. Bowers' (1977) direct (1950-68) recovery rates for Wisconsin banded wood ducks were 0.06, 0.06, 0.09 and 0.08 for adult males and females, and immature males and females, respectively. Bowers' (1977) rates for Wisconsin (1950-68) were lower than those for Minnesota (1950-68) or those calculated in this study (1959-75). This indicates that gunning pressure or the band reporting rate has increased in recent years.

For the major banding areas direct recovery rates ranged from 0.05 (Necedah) to 0.07 (Upper Mississippi) for adults (Table 15), and 0.07 (Necedah and Crex Meadows) to 0.11 (Upper Mississippi) for young (Table 15). The direct recovery rate (1959-75) of adult wood ducks banded at the Upper Mississippi River were recovered at a significantly higher rate (0.07) than those banded at Horicon (0.06), Crex Meadows (0.06) and Necedah (0.05) (Table 16). Young wood ducks banded in the

Table 16. Chi-square test statistics for the hypotheses that direct recovery rates 1959-75 varied between major banding areas within Wisconsin.

	Upper Mississippi	Horicon	Crex Meadows
<b>Adult:</b>			
Upper Mississippi			
Horicon	5.29*		
Crex Meadows	4.06*	0.26	
Necedah	14.03***	2.17	0.25
<b>Young:</b>			
Upper Mississippi			
Horicon	0.26		
Crex Meadows	2.03	2.00	
Necedah	8.58***	4.83*	0.23

\*  $P=0.05$  reference value at 1 d.f. is 3.84

\*\*\*  $P=0.005$  reference value at 1 d.f. is 7.88.

Upper Mississippi and Horicon areas had direct recovery rates (0.11 and 0.1, respectively) which were significantly greater (Table 16) than young banded in the Necedah area (0.07, Table 16). The variation in direct recovery rates between banding areas may be due to differences in the timing of migration, differences in hunting pressure at the banding areas, or differences in band reporting rates.

#### KILL RATES

Kill rates represent the proportion of a population dying directly as a result of hunting, and therefore represent total hunting mortality. Annual kill rates are shown in Appendixes S and T.

Mean kill rates for wood ducks banded throughout Wisconsin were 24 and 34 percent for adults and young, respectively. Kill rates ranged from 20 (Necedah) to 29 (Horicon) percent for adults and from 30 (Necedah) to 39 (Horicon) percent for young (Table 17).

Young wood duck kill rates were generally higher than adult kill rates for the entire state and in each banding area. Adult kill rates for wood ducks banded throughout Wisconsin were lowest in 1961 (0.09) and highest in 1969 (0.38). Young kill rates were lowest in 1961 (0.15) and highest in 1971 (0.54).

An attempt to relate duck stamp sales (as index to duck hunter numbers) in the vicinity of the banding areas to kill rates was unsuccessful, probably due to the considerable annual variability in the kill rates. Also, changing weather patterns act to cause variations in migrational patterns between years.

Bowers (1977) calculated kill rates (1950-68) for Eastern North America of 26, 23, 35 and 29 percent for adult males and females, and immature males and females, respectively. These rates agree with rates calculated in this study. Cringen (1971) found kill rates of 41 and 39 percent, respectively for adult and immature wood ducks banded in Ontario from 1964 to 1966. The adult rates of Cringen (1971) were higher than those for Wisconsin for the same years, which would be expected since Ontario is further north. Ontario's immature rates were comparable to those for Wisconsin, indicating that young Wisconsin wood ducks are exposed to a proportionally higher rate of hunting mortality than adults.

#### Kill Rates Within Wisconsin

Mean kill rates within Wisconsin (derived solely from in-state recoveries of Wisconsin banded birds) were 15 percent for both adult and young wood ducks banded statewide. For the individual banding areas mean kill rates ranged from 6 (Crex Meadows) to 15 (Horicon) percent for adults and from 12 (Crex Meadows) to 18 (Upper Mississippi) percent for young (Table 17).

Hunting mortality within Wisconsin accounted for 59 and 45 percent, respectively, of the total hunting mortality on adult and young wood ducks banded throughout the state. From 24 (Crex Meadows) to 50 (Horicon) percent of the adult and 35 (Crex Meadows) to 48 (Upper Mississippi) percent of the young wood duck hunting mortality for the individual banding areas occurred within Wisconsin.

Table 17. Mean kill rates for adult and young wood ducks banded in Wisconsin and at the major banding areas<sup>1,2</sup>  
 Rates within Wisconsin are shown in parentheses.<sup>1,2</sup>

	ADULTS		YOUNG	
	Mean	S.D.	Mean	S.D.
Mississippi River	0.267 ± 0.120 (0.0879 ± 0.505)		0.360 ± 0.237 (0.1755 ± 0.0861)	
Crex Meadows	0.254 ± 0.120 (0.062 ± 0.0516)		0.334 ± 0.125 (0.1187 ± 0.0413)	
Horicon	0.298 ± 0.115 (0.1524 ± 0.103)		0.387 ± 0.146 (0.1772 ± 0.106)	
Necedah NWR	0.203 ± 0.077 (0.0661 ± 0.0471)		0.304 ± 0.133 (0.139 ± 0.125)	
Mead	0.3909 ± 0.145 (0.302 ± 0.129)		0.458 ± 0.254 (0.3558 ± 0.241)	
State	0.247 ± 0.0809 (0.1457 ± 0.204)		0.344 ± 0.114 (0.1531 ± 0.0795)	

- 1) Mean rates are computed from data in Appendices S and T.
- 2) Based on banded samples of 50 or more.
- 3) Data from Mead are biased to an unknown extent due to an inflated band reporting rate at the banding area.

The low kill rates associated with Crex Meadows reflect the lower hunter densities in northern Wisconsin (Smith 1975). The relatively low proportion of the hunting mortality occurring in Wisconsin for adult wood ducks banded on the Mississippi River probably reflects the harvest of these birds in the bordering states of Minnesota, Iowa and Illinois even though they are still in the banding area.

#### Relationship between Wisconsin, Non-Wisconsin and Total Kill Rates

Wisconsin kill rates were significantly and positively correlated to total kill rates for adults and young wood ducks banded throughout Wisconsin, adults from all banding areas, and young from the Upper Mississippi River and Necedah (Table 18). Non-Wisconsin kill rates were significantly correlated with total kill rates for both age classes banded throughout the state, the Mississippi River and Crex Meadows, and for adults at Necedah. Wisconsin and non-Wisconsin kill rates were not correlated (Table 18).

Hunting mortality within Wisconsin accounts for the largest proportion of total hunting mortality, therefore a significant relationship between Wisconsin and total kill rates was expected. The lack of a significant relationship between Wisconsin and total kill rates for young from Crex Meadows and Horicon may be due to the small sample size from these areas (5 and 3 years respectively). However, the lack of a significant relationship between Wisconsin and total kill rates for young from Crex Meadows is substantiated to some extent, by the

Table 18. Correlation coefficients between total kill rate and Wisconsin kill rate, total kill rate and non-Wisconsin kill rate, and Wisconsin and non-Wisconsin kill rate.

BANDING SITE	ADULT	d.f.	YOUNG	d.f.
Total vs. Wisconsin				
Upper Mississippi	0.535*	12	0.824**	15
Crex Meadows	0.660*	9	0.861	3
Horicon	0.698*	8	0.812	1
Necedah	0.654**	12	0.555*	12
Mead	0.922*	4	0.979**	3
State	0.841**	15	0.746**	15
Total vs. non-Wisconsin				
Upper Mississippi	0.910**	12	0.881**	15
Crex Meadows	0.912**	9	0.973**	3
Horicon	0.506	8	0.695	1
Necedah	0.794*	12	0.520	12
Mead	0.456	4	0.339	3
State	0.741**	15	0.792**	15
Wisconsin vs. non-Wisconsin				
Upper Mississippi	0.136	12	0.458	15
Crex Meadows	0.293	9	0.721	3
Horicon	-0.294	8	0.145	1
Necedah	0.059	12	-0.422	12
Mead	0.075	4	0.140	3
State	0.259	15	0.184	15

\*  $p = 0.05$

\*\*  $p = 0.01$

small proportion of the direct recoveries from Crex Meadows wood ducks occurring in the banding area (Table 11). The relationship between non-Wisconsin and total kill rates at the Upper Mississippi River again reflects the recoveries occurring in Minnesota, Iowa and Illinois before the birds have started migrating.

The lack of a significant relationship between Wisconsin and non-Wisconsin kill rates was expected. Similar results were found for Wisconsin-banded mallards (March 1976).

#### Effect of Regulations and Hunter Numbers on Hunting Mortality

Wisconsin waterfowl hunting regulations and the number of active adult waterfowl hunters are shown in Appendix Z. Conventional daily bag limit regulations were in effect from 1959 to 1972, and point system regulations were in effect from 1973 to 1975. Wood duck daily bag limits were either 1 or 2 birds, while the maximum conventional daily bag limits for all ducks ranged from 2 to 6 birds. Under the point system a hunter was allowed 100 points per day and wood ducks were assigned 90 points in each of the 1973-75 seasons. Opening date of the Wisconsin waterfowl hunting seasons ranged from 1 October to 14 October, and season lengths from 25 to 55 days. With the exception of 1973 a noon starting time on opening day was in effect from 1964 to 1975. Opening days fell on weekends except in 1959-60 and 1973. In 1973, a split season opened on 1 October (Monday) and ran thru 7 October, and was closed from 8-12 October and reopened on 13 October (Saturday).

Active adult hunter numbers from 1959-75 ranged from 63,500 (1962) to 135,500 (1971) (Appendix Z).

Date of opening of the Wisconsin waterfowl hunting season and the number of October hunting days in Wisconsin were significantly correlated with adult and young Wisconsin wood duck kill rates (Table 19). Total season length, total bag limit, and the number of active waterfowl hunters were significantly correlated with the young Wisconsin wood duck kill rate (Table 19).

No significant correlation was found between wood duck bag limits and Wisconsin wood duck kill rates for adult or young wood ducks. This is probably due to small annual variation in bag limits.

Wisconsin wood duck kill rates were generally greater in years when regulations became more liberal. Average adult Wisconsin wood duck kill rates increased as wood duck bag days of opportunity increased from 30-50 to 60-80 (Table 20). In years with bag days of opportunity greater than 80, kill rates were greater than in years when bag days were 30-50. Young Wisconsin kill rates increased when bag days of opportunity increased from 30-50 to 60-80 and greater than 80 (Table 20). Wisconsin kill rates under the point system were greater than all bag day categories for adults and greater than the 30-50 bag day category for young.

No relationship between Wisconsin kill rates and 1-or 2-bird bag limits was found with the exception of 1962. When the wood duck bag limit changed from 1 to 2 the adult kill

Table 19. Correlation coefficients between Wisconsin water-fowl hunting regulations, active hunter numbers and total and Wisconsin kill rates for adult and young wood ducks banded in Wisconsin 1959-75.

Regulations and Active Hunter Numbers	Age	
	Adult	Young
Wisconsin		
Date of Opening Day	-0.731**	-0.670**
Season Length	0.275	0.609*
October Hunting Days	0.731**	0.670**
Wood Duck Bag Limit	0.164	0.279
Mallard Bag Limit	-0.005	0.298
Total Bag Limit	0.432	0.639**
Oct. Wood Duck Bag Days	0.391	0.474
Total Wood Duck Bag Days	0.255	0.519
Number of Active Hunters	0.477	0.828**

d.f. = 12 for each test.

\*  $P < 0.05$ , reference value = 0.532.

\*\*  $P < 0.01$ , reference value = 0.661.

Table 20. Wisconsin kill rates for wood duck bag days 30-50, 60-80, greater than 80 and the point system for adult and young wood ducks banded throughout Wisconsin 1959-75.

ADULT			
Bag Days			
30-50	60-80	80	point system
0.0652	0.1272	0.1081	0.1374
0.0911	0.0338	0.1069	0.0803
0.0371	0.0502	0.1318	0.1466
0.0399	0.0683	0.0807	
0.1215	0.2311		
Mean $\pm$ S.D.			
0.0710 $\pm$ 0.0357	0.1021 $\pm$ 0.0803	0.1069 $\pm$ 0.0209	0.1214 $\pm$ 0.0359
YOUNG			
0.1247	0.0257	0.2235	0.0539
0.1190	0.1226	0.2574	0.1446
0.0647	0.1639	0.2846	0.1689
0.0652	0.1089	0.1695	
0.2223	0.2799		
Mean $\pm$ S.D.			
0.1192 $\pm$ 0.0643	0.1402 $\pm$ 0.0928	0.2337 $\pm$ 0.0496	0.1225 $\pm$ 0.0606

rate increased by only 7 percent. However, when kill rates of adult and young wood ducks in years with similar bag limits were averaged the kill rate under a 2 bird bag limit was 24 and 27 percent greater, respectively, than when the bag limit was 1. March (1976) found no correlation between Wisconsin mallard kill rates and hunter days, season length, daily bag limit, opening date or the number of active waterfowl hunters. However, kill rates were generally greater in years of liberal regulations.

The influence of hunting regulations on wood duck harvest and hunting mortality has been investigated previously. Bowers (1977) found direct recovery rates were lowest in restrictive seasons as compared to liberal seasons, with season length and bag limits being the most important factors. In northern areas, the number of October hunting days has the most influence on recovery rates. Smith et al. (1963) found recovery rates changed in the same direction as season length in 23 of 28 comparisons and increased in 8 of 8 comparisons when the wood duck bag limit increased from 1 to 2 in 1962. However the increase in wood duck recovery rates could also have been caused by a reduction in the mallard bag limit from 2 to 1 in the same year. Mallard restrictions apparently placed greater pressure on wood ducks as Carney (1963) found a 21 percent increase in the wood duck harvest in the same year. Carney and Croft (1968) found a 23 percent decrease in the wood duck harvest and a 30 percent decrease in the kill rate when the wood duck daily bag limit was reduced from 2 to 1 in 1967.

Smith (1975) found a 33 percent decrease in the Wisconsin wood duck harvest in the same year.

Smart and Carney (1964) felt that liberal regulations on other waterfowl species could also result in a larger kill of wood ducks. Smith et al. (1963) and Reeves (1966) point out that restrictive mallard regulations coupled with a liberal total bag limit and season length may result in a shift in hunting pressure to wood ducks. The fact that duck stamp sales and ultimately the numbers of active hunters are influenced by season length and total bag limits (Smith 1975) indicates that this relationship may exist in Wisconsin, masking any effect of wood duck bag limits on kill rates.

The relationships between dates of opening of the Wisconsin waterfowl hunting season, the number of October hunting days and kill rates was expected since the wood duck migrates early (Jahn and Hunt 1964, Bowers 1977, and Bellrose 1976). The obvious management implication is that opening the waterfowl hunting season later in October will reduce hunting mortality. However, if hunting mortality in Wisconsin is decreased, hunting mortality outside Wisconsin may increase with a net result of the same total kill rate. This possibility was examined by sorting Wisconsin, non-Wisconsin and total kill rates into: 1) seasons for which the Wisconsin kill rate increased over the previous year; and 2) those in which the Wisconsin kill rate decreased from the previous year (March 1976). Total kill rates for adults and young were lower in years in which the Wisconsin kill

rate decreased than in years in which the Wisconsin kill rate increased (Table 21). This indicates that efforts to reduce the Wisconsin kill rate, such as opening the Wisconsin waterfowl hunting season at a later date should result in a reduced total kill rate.

#### SURVIVAL

The Brownie Chi-square contingency tests (Brownie et al. 1978) indicated that survival and recovery parameters were not sex specific for adult (Chi-square=39.44, 27 d.f.,  $P=0.06$ ) wood ducks. The low probability for adults indicates differences may exist between male and female survival rates. However, the Chi-square contingency table shows major differences in only 3 of the 14 years compared (1960, 1962 and 1964). Adult female banded samples in 1960 and 1964 were small (95 and 130, respectively, Appendix A). Recoveries of adult females banded in 1964 occurred in only 4 years compared to 9 years for adult males banded in the same year. Since the adult test was not significant at  $P=0.05$ , major differences were not present in 11 of 14 years, and adult female banded samples were small, male and female data sets for the entire state were pooled. Smaller banded samples from each of the major banding areas also prohibited analysis by male and female cohorts, and these data were also pooled.

ESTIMATE Model 2 and BROWNIE Model H02 provided the best description of recovery data for wood ducks banded throughout Wisconsin. BROWNIE Model H02 was best for the Upper Mississippi River data. Data from all other banding

Table 21. Wisconsin, non-Wisconsin and total kill rates for years when the Wisconsin kill rate decreased from the previous year ("- years) and for years when the Wisconsin kill rate increased from the previous year ("+" years).

<u>YOUNG</u>							
Year	Kill Rates (-years)			Year	Kill rates (+years)		
	Wisc.	Non-Wisc.	Total		Wisc.	Non-Wisc.	Total
1960	.119	.2595	.3785	1962	.0652	.1528	.2180
1961	.0647	.0881	.1528	1964	.1226	.2073	.3299
1963	.0257	.0277	.3026	1965	.1639	.145	.3089
1968	.1089	.115	.2239	1966	.2235	.3069	.5304
1970	.2574	.1891	.4465	1969	.2799	.1866	.4665
1972	.1695	.1384	.3079	1971	.2846	.2573	.5419
1973	.0539	.145	.1989	1974	.1446	.166	.3106
				1975	.1689	.2833	.4522
$\bar{x}$	.1142	.1731	.2873	$\bar{x}$	.1816	.2132	.3914
<u>ADULTS</u>							
1961	.0371	.0571	.0942	1960	.0911	.1461	.2372
1964	.0338	.1741	.2079	1962	.0399	.2338	.2737
1968	.0683	.0749	.1432	1963	.1272	.1232	.2504
1970	.1069	.1734	.2803	1965	.0502	.1197	.1699
1972	.0807	.1455	.2262	1966	.1081	.2208	.3289
1974	.0803	.0539	.1342	1967	.1215	.1959	.3174
				1969	.2311	.1468	.3779
				1971	.1318	.1994	.3312
				1973	.1374	.214	.3514
				1975	.1466	.1164	.263
$\bar{x}$	.0679	.1131	.181	$\bar{x}$	.1185	.1716	.2901

areas was insufficient for survival estimation using either ESTIMATE or BROWNIE, and survival was estimated using Johnson's (1974) model.

ESTIMATE Model 2 and BROWNIE Model H02 both assume time specific recovery rates and constant survival rates. ESTIMATE assumes recovery and survival rates are age independent and young survival cannot be estimated (Brownie et al. 1978). BROWNIE assumes recovery and survival rates are age dependent and estimates both adult and young survival. Johnson's (1974) model assumes young recovery and survival rates are proportional to adult rates and that both rates are time specific. Based on the BROWNIE model, Johnson's (1974) model does not fit the data very well.

A corollary to the assumptions of ESTIMATE Model 2 and BROWNIE Model H02 is that of compensatory hunting mortality. since hunting mortality varies from year to year and survival is constant. However, the power of the Chi-square test comparing these models (Model 2 and H02) to those assuming variable survival rates is low (Brownie et al. 1978). Hence small annual differences in survival rates are unlikely to show up even though they may exist. The compensatory hypotheses is discussed further by Anderson and Burnham (1976).

Adult survival estimates for wood ducks banded throughout Wisconsin using Model 2 and Model H02 were similar (Table 22). The adult estimate produced with Johnson's (1974) model was slightly higher than those of the other models (Table 22) and the confidence intervals indicate less precision than estimates using BROWNIE and ESTIMATE. Since BROWNIE estimates both adult

Table 22. Survival estimates using ESTIMATE, Model 2, BROWNIE Model H02 and Johnson's (1974) model<sup>1</sup> for wood ducks banded throughout the state and each banding area.<sup>2</sup>

AREA	ADULT	YOUNG
Horicon (1960-72)		
Johnson	0.5151 (0.1220)	0.4887 (0.1160)
Upper Mississippi (1959-75)		
Johnson	0.5436 (0.1570)	0.3318 (0.0960)
BROWNIE (H02)	0.5383 (0.0115)	0.335 (0.0203)
Crex Meadows (1962-75)		
Johnson	0.6590 (0.3410)	0.4391 (0.2279)
Necedah (1959-77)		
Johnson	0.6054 (0.2584)	0.4440 (0.1890)
State (1959-75)		
BROWNIE (H02)	0.5278 (0.0078)	0.3565 (0.0151)
ESTIMATE (M2)	0.5175 (0.96)	
Johnson	0.5520 (0.430)	0.3617 (0.0938)

- 1) Johnson survival estimates are average values computed from Appendices U and V.
- 2) Standard error of the estimated survival rates are shown in parentheses.

and young survival, the BROWNIE model results are considered the best estimate of wood duck survival for the entire state (52.8 and 35.6 percent, respectively for adult and young).

For the major banding areas adult survival rates (Johnson estimates) ranged from 51 (Horicon) to 66 (Crex Meadows) percent and for young wood ducks from 33 (Upper Mississippi) to 49 (Horicon) percent. BROWNIE estimates for the Upper Mississippi River were 54 and 33 percent for adult and young wood ducks, respectively, and were in close agreement with the Johnson estimates (Table 22).

Jahn and Hunt (1964) used survival rates derived by Smith et al. (1963) of 41-55 and 25-44 percent for adult and young, respectively, banded in Wisconsin. Male and female adult survival rates calculated by Bowers (1977) were 52 and 47 percent, respectively, and 42 and 46 percent for immature males and females banded in the NCPU. Respective rates in the Mississippi Flyway were 56, 52, 47 and 51 percent. Bowers (1977) survival rates for the Mississippi Flyway and the NCPU (1950-68) agreed very well with those calculated for adults in this study (1959-75). Young survival rates calculated in this study are considerably lower than those calculated by Bowers' (1977) for either area.

Most of the young wood ducks (86 percent) banded in Wisconsin were banded along the Upper Mississippi River system and therefore greatly influence the young survival estimates for the entire state. The young survival estimate for young banded on the Mississippi River agree with the young survival estimate for the entire state.

If hunting and nonhunting mortality are additive, wood ducks banded in northern states would be expected to survive at a lower rate than those banded in southern states, because they are subjected to longer hunting seasons. However, Anderson and Burnham (1976), working with mallard banding data, have found hunting and nonhunting mortality are probably compensatory, until hunting mortality exceeds some unknown threshold point. Whether or not hunting and nonhunting mortality are compensatory in Wisconsin wood ducks is not known. If, in fact the compensatory hypothesis does apply to Wisconsin's wood ducks, then it appears that hunting mortality has exceeded the threshold point for young Wisconsin wood ducks banded on the Upper Mississippi River, depressing the survival rate below that for the Mississippi Flyway and the NCFU.

#### POPULATION MODEL FOR WISCONSIN WOOD DUCKS

The relationship between survival, mortality and productivity was investigated by means of a deterministic population model developed by March (1976). His model was an updated version of one used by Jahn and Hunt (1964).

This model deals only with the female segment of the wood duck population in order to avoid complications which arise from changes in the adult sex ratio. The following assumptions apply to the model: 1) adult and young mortality is 47 and 64 percent, respectively; 2) hunting mortality for adult and young wood ducks is 24 and 34 percent, respectively;

3) 65 percent of the females present on 1 May successfully rear a brood of 5 which survives to 1 September (Jahn and Hunt 1964); and 4) the sex ratio of young wood ducks is 1.2 males per female.

Mortality is not uniform throughout the year (March 1976). Hunting mortality is assumed to be the primary mortality factor from 1 September to 30 January. The remaining mortality was assumed constant throughout the remainder of the year. Thus total mortality from 1 September to 1 May was assumed to be 34 and 47 percent for adults and young, respectively.

Table 23 indicates that the population was able to increase approximately 26 percent using the preceding assumptions. A decrease in survival, reduced recruitment, or an increase in hunting mortality would cause the population to stabilize or decline. If the mortality rate is not representative of the entire state (as previously discussed) and young wood duck mortality from Horicon, Crex Meadows and Necedah (54 percent) was used instead, a larger increase in the population would result.

The Wisconsin Department of Natural Resources has data which indicate only 30-40 percent (rather than 65 percent) of the females present on 1 May successfully rear a brood (Jim March, pers comm). If this, and the remaining assumptions are true, the population (assuming 40 percent pair success) would be barely maintaining itself or (assuming 30 percent pair success) decreasing 18 percent per year.

Table 23. A population model for Wisconsin wood ducks.

		1	2	3	4	5	6	Total # of wood ducks	% Increase
Year A	Sept. 1	100 (A)	100 (A)	293 (Y)				493	
	May 1	66	66	153 (Y)					
Year B	Sept. 1	53	53	105 (A)	419 (Y)			630	27.89
	May 1	35	35	69	222 (Y)				
Year C	Sept. 1	28	28	56	151 (A)	528 (Y)		719	25.60
	May 1	18	18	37	100	280 (Y)			
Year D	Sept. 1	15	15	30	80	190	663 (Y)	1246	25.50
	May 1	10	10	20	53	125	351		

There is evidence that all young wood ducks do not breed during their first year. Heussmann (1975) found only 42 percent of 121 young females nested in their first year, and Grice and Rogers (1965) found only 40 percent nested as yearlings. If this were true for Wisconsin wood ducks, the population would have increased only 10 percent (assuming 65 percent of the adult females were successful in rearing a brood).

Jahn and Hunt (1964) used an age ratio of 4.2 young per adult female as opposed to the 2.93 ratio used here (Wisconsin stream float survey 1977, unpublished DNR files). The age ratio in the preseason banded sample (1959-75) of wood ducks was 3.27. Whether the age ratio has actually declined is not known. However, the population should have increased even with the low age ratio used in this study (assuming pair success was 65 percent).

Although this model is based on several assumptions which may be somewhat unrealistic, it does indicate that under average conditions from 1959 to 1975 the Wisconsin wood duck population should have at least maintained itself.

#### SUMMARY

Data for wood ducks banded throughout Wisconsin and at 5 major banding areas from 1959 to 1975 were analyzed. From 1959 through 1975, 33,025 wood ducks were banded in Wisconsin. The Upper Mississippi River was the most important banding area for young wood ducks, and the Upper Mississippi River, Horicon and Necedah were of equal importance for adult wood ducks.

A yearly banded sample of 50 wood ducks for any cohort was considered the minimum sample size used for analysis in this study. Data from Mead Wildlife area were not discussed because of the high band reporting rate from this area. October was the most important month of recovery followed by December and November. January was of minor importance. Immature and local females were recovered to a greater extent in October than other cohorts, followed by immature and local males and adult females. Adult males were the predominant group recovered in January. Differences between cohorts in the time of migration, or differences in vulnerability to hunting early in the hunting season apparently exist.

During October most recoveries were obtained within Wisconsin, with the first 10 days of October being the peak period of recovery for recoveries obtained within and outside of Wisconsin. Indirect and direct recoveries show adult and local males arriving in southern states before females.

The chronology of foreign wood duck recoveries was similar to that of Wisconsin wood ducks, but foreign recoveries occurred through the first 10 days of November. This indicates that the Wisconsin wood duck harvest is diluted in October by wood ducks from other locations and that in November it may be totally dependent on migrants.

Opening day, and the first 2 days of the Wisconsin waterfowl hunting season were most important for recoveries from wood ducks banded throughout Wisconsin and at each banding area. More than 90 percent of the recoveries of wood ducks banded throughout Wisconsin occurred during the

first 21 days of the hunting season. Wood ducks banded at Necedah and adults banded at Crex Meadows were recovered over a longer period, and young banded at Crex Meadows were recovered over a shorter period than those banded at other areas. The chronology of wood duck recoveries throughout the hunting season conforms to the wood duck harvest chronology in Wisconsin as determined from wing collection data.

Opening the waterfowl hunting season after the first 10 days of October should provide a means of protecting the Wisconsin wood duck population. However, opening the season early in October provides for maximum use of the local wood duck population.

Wisconsin was the most important recovery state for its own wood ducks. The Mississippi Flyway was the most important recovery area outside of Wisconsin followed by the Central and Atlantic Flyways. Wood ducks banded in eastern Wisconsin were recovered to a greater extent in the Atlantic Flyway than those banded in Western Wisconsin, and vice-versa.

Local males were recovered to the greatest extent in the Mississippi Flyway followed by all female cohorts and immature males. Adult males were recovered to the lowest extent in the Mississippi Flyway compared to other cohorts, and to a greater extent in the Atlantic Flyway than any other cohort.

The four southern states of Mississippi, Arkansas, Louisiana, and eastern Texas were jointly responsible for 45 percent of all non-Wisconsin direct recoveries. Adults were more likely than young to be recovered in these states. Wood ducks

banded at Necedah were recovered in these states to a greater extent than those from any other banding area.

The northern states of Minnesota, Iowa and Illinois were responsible for 34 percent of non-Wisconsin direct recoveries. Young were more likely to be recovered in these states than adults. These three states accounted for a larger proportion of the recoveries from the Upper Mississippi River than from any other banding area. Since most of the young wood ducks were banded on the Mississippi, these three states affect young recovery rates and survival estimates to a large extent.

The areas in which wood ducks were banded accounted for a large proportion of the direct and indirect recoveries of wood ducks banded in that area. In general, females were more likely than males to be recovered in the area where they were banded (both direct and indirect). This indicates that females migrate later and have a higher rate of homing than males.

The Southwest harvest area of Wisconsin contained most of the direct and indirect recoveries followed by the Southeast and Northern areas. This agrees with the distribution of the 1961-70 wood duck harvest as determined from wing collection data. Within the Southwest harvest area most recoveries occurred along the Mississippi River.

Direct recovery rates of local and immature wood ducks were not significantly different for males (Chi-square=2.42, 1 d.f.,  $P > 0.05$ ) or females (Chi-square=0.37, 1 d.f.,  $P > 0.05$ ), and these cohorts were combined as young. Male and female direct recovery rates were not significantly different for

adults or young, and the sexes were also combined within each age cohort.

Young wood ducks banded throughout Wisconsin were recovered at a higher rate than adults. This may be due to the lack of wariness in young, differences in migrational timing, or behavioral differences.

Direct recovery rates varied significantly between years for adults (Chi-square=70.46, 16 d.f.,  $P < 0.05$ ) and young (Chi-square=103.47, 16 d.f.,  $P < 0.05$ ) which would be expected since hunting regulations have changed annually.

Direct recovery rates for Wisconsin wood ducks were generally higher than rates for the Mississippi Flyway or the North Central Population Unit overall. Adult rates were generally comparable to those from other northern states and young rates were generally higher. Higher direct recovery rates for Wisconsin wood ducks would be expected since Wisconsin birds are subject to longer hunting seasons and Wisconsin's band reporting rate is generally higher, than in other states. Direct recovery rates have increased in recent years indicating that increased gunning pressure is taking place.

Direct recovery rates varied between banding areas. Differences in direct recovery rates between banding areas may be due to differences in migrational timing, hunting pressure at the banding areas, or band reporting rates.

Mean kill rates for wood ducks banded throughout Wisconsin were 24 and 34 percent for adults and young, respectively. Young kill rates were higher than adult kill rates.

Wisconsin kill rates were comparable to those for eastern North America. Adult rates were lower than rates for Ontario wood ducks, and young rates were comparable to the Ontario rates. Wisconsin wood ducks should have lower kill rates than those banded in Ontario since Wisconsin lies further south. The higher rate of recovery here indicates that young Wisconsin wood ducks are exposed to a proportionately higher kill rate than young Ontario wood ducks. Mean kill rates within Wisconsin were 15 percent for both adult and young wood ducks banded throughout Wisconsin.

Hunting mortality within Wisconsin accounted for 59 and 45 percent of the total hunting mortality of adult and young wood ducks, respectively, banded throughout Wisconsin.

Wisconsin and non-Wisconsin kill rates were positively correlated with total kill rates for adult and young wood ducks banded throughout Wisconsin. This indicates that hunting both within Wisconsin and outside the state contributes significantly to total hunting mortality incurred by Wisconsin wood ducks.

Brownie Model HO2 provided the best description of recovery data for wood ducks banded throughout Wisconsin and on the Upper Mississippi River. The assumptions of this model are: 1) recovery rates are time specific, 2) survival rates are constant, and 3) recovery and survival rates are age dependent.

Data from all other banding areas were sufficient to estimate survival using Johnson's (1974) model only. The Johnson model assumes: 1) young recovery and survival rates are proportional to adult rates, and 2) recovery and survival rates are time specific.

Mean annual survival estimates for adult and young wood ducks banded throughout Wisconsin were 53 and 36 percent respectively. For wood ducks banded in the individual banding areas mean annual survival ranged from 51 (Horicon) to 66 (Crex Meadows) percent for adults and from 33 (Upper Mississippi) to 49 (Horicon) percent for young.

Wisconsin survival rates for adults were comparable to those for other northern states, while young Wisconsin survival rates were lower than those in most northern states. Most young wood ducks banded in Wisconsin were banded on the Mississippi River. These birds could be subject to opening day hunting pressure in Wisconsin, Minnesota, Iowa and Illinois before beginning to migrate. The average survival rate for Horicon, Necedah and Crex Meadows young was 46 percent which may be more representative of survival for the entire state.

Date of opening day of the Wisconsin waterfowl hunting season and the number of October hunting days in Wisconsin were significantly correlated ( $P < 0.05$ ) with the young Wisconsin wood duck kill rate.

Wisconsin wood duck kill rates were generally greater in years when regulations were liberal as compared to restrictive years. Adult kill rates were generally greater under the point system than under the conventional bag limits and young kill rates under the point system were greater than the 30-50 bag day category. Average kill rates when the wood duck daily bag limit was 2 were 24 and 27 percent greater for adults and young, respectively than when the wood duck daily bag limit was 1. Changes in wood duck harvests and kill rates could be

accomplished by restricting the mallard daily bag limit and liberalizing the total duck bag limit, which would result in a shift in hunting pressure from mallards to wood ducks.

Date of opening day of the Wisconsin waterfowl hunting season was expected to influence the Wisconsin kill rate since the wood duck migrates early. Decreasing hunting mortality on wood ducks banded in Wisconsin resulted in a decrease in their total kill rate. Therefore, opening the Wisconsin waterfowl hunting season at a later date should result in a decreased total wood duck kill rate.

The relationship between survival, mortality and productivity was investigated by means of a deterministic population model developed by March (1976). The model deals only with the female segment of the population and assumes: 1) adult and young mortality is 47 and 64 percent, respectively; 2) hunting mortality for adult and young wood ducks is 24 and 34 percent, respectively; 3) 65 percent of the females present on 1 May successfully rear a brood of 5 which survives to 1 September; and 4) the sex ratio of young wood ducks is 1.2 males per female. Using these assumptions the model shows that the wood duck population was able to increase 26 percent. Although this model is based on several assumptions which may be somewhat unrealistic, it does indicate that, under average conditions, from 1959 to 1975 the Wisconsin wood duck population should have at least maintained itself.

## LITERATURE CITED

- Anderson, D.R. 1975. Population ecology of the mallard: V. Temporal and geographic estimates of survival and harvest rates. U.S. Fish and Wildl. Ser. Resour. Publ. 125. 110pp.
- Anderson, D.R., and K.P. Burnham. 1976. Population ecology of the mallard: VI. The effect of exploitation on survival. U.S. Fish and Wildl. Ser. Resour. Publ. 128. 66pp.
- Barden, L.S. 1968. A population analysis of Maine-banded wood ducks. M.S. thesis. Univ. Maine, Orono. 109pp.
- Bellrose, F.C. 1976. Ducks, geese, and swans of North America. Stackpole books, Harrisburg, Pa. 544pp.
- Benson, R.I. 1972. Migration and mortality of wood ducks banded in western Minnesota. Minnesota Dept. Nat. Resour. mimeo. 9pp.
- Bowers, E.F. 1977. Population dynamics and distribution of the wood duck (Aix sponsa) in Eastern North America. Ph. D. thesis. Louisiana State Univ., Baton Rouge. 273pp.
- Brownie, C., D.R. Anderson, K.P. Burnham, and D.S. Robson. 1978. Statistical inference from band recovery data - a handbook. U.S. Dept. Interior, Fish and Wildl. Ser., Resour. Publ. No. 131. Wash., D.C. 212pp.
- Carney, S.M. 1963. Effect of the changes in the daily bag limit in 1962 on the wood duck kill in the Mississippi Flyway. U.S. Fish and Wildl. Ser., Admin. Rep. No. 29. mimeo. 4pp.
- Carney, S.M., and R.L. Croft. 1968. Probable effects of changes in the daily bag limit on wood duck kill during the 1967 hunting season in the Mississippi Flyway. U.S. Fish and Wildl. Serv., Adm. Rep. No. 160. 4pp.
- Carney, S.M., M.F. Sorenson, and L.D. Schroeder. 1976. Waterfowl harvest and hunter activity in the United States during the 1975 hunting season. U.S. Fish and Wildl. Serv., Unnumbered Admin. Rep. 27pp.
- Cringen, A.T. 1971. Status of the wood duck in Ontario. Trans. N. Am. Wildl. Conf. 36:292-212.
- Davenport, D.A. 1977. Computer tabulation and display of band recovery data. U.S. Fish and Wildl. Serv., Spec. Sci. Rep.: Wildl. No. 199. 6pp.

## Literature Cited (continued).

- Geis, A.D. 1972. Use of banding data in migratory game bird research. U.S. Fish and Wildl. Serv., Spec. Sci. Rep.: Wildl. No. 154. 47pp.
- Gilmer, D.S., R.E. Kirby, I.J. Ball, J.H. Reichmann. 1977. Post-breeding activities of mallards and wood ducks in north central Minnesota. J. Wildl. Manage. 41(3):345-359.
- Grice, D., and J.P. Rogers. 1965. The wood duck in Massachusetts. Mass. Div. of Fisheries and Game, Final Rep. Proj. No. W-19-R. 96pp.
- Hester, F.E. 1965. Survival, re-nesting, and return of adult wood ducks to previously used nest boxes. Proc. 16th Annual Conf. Southeastern Assoc. of Game & Fish Commissioners: 67-70.
- Heussmann, H.W. 1975. Several aspects of the nesting biology of yearling wood ducks. J. Wildl. Manage. 39(3): 503-507.
- Hochbaum, H.A. 1955. Travels and traditions of waterfowl. U. of Minn. press., Minneapolis. 301pp.
- Jahn, L.R. and R.A. Hunt. 1964. Duck and coot ecology and management in Wisconsin. Wisc. Cons. Dept., Tech. Bull. No.33. 212pp.
- Johnson, D.H. 1974. Estimating survival rates from banding adult and juvenile birds. J. Wildl. Manage. 38(2):290-297.
- 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. Rep.: Wildl. No. 59. 41pp.
- March, J.R., G.F. Martz, and R.A. Hunt. 1973. Breeding duck populations and habitat requirements in Wisconsin. Wisc. Dept. Nat. Resources, Tech. Bull. No. 68. 37pp.
- March, J.R. 1976. Mallard population and harvest dynamics in Wisconsin. Ph.D. thesis. Univ. Wisc., Madison. 368pp.
- Martz, G.F. 1965. Wisconsin waterfowl harvest characteristics based on duck wing collections, 1959-64. Wisc. Cons. Dept. 28pp.

## Literature Cited (continued).

- Reeves, H.M. 1966. Influence of hunting regulations on wood duck population levels. Pages 165-177 in L.R. Jahn, ed. Wood duck management and research: a symposium. Wildl. Manage. Inst., Wash., D.C. 212pp.
- Schroeder, L.D., M.F. Sorenson, and S.M. Carney. 1974. Waterfowl harvest and hunter activity in the United States during the 1973 hunting season. U.S. Fish and Wildl. Serv. Unnumbered Admin. Rep. 28pp.
- Schroeder, L.D., M.F. Sorenson, and S.M. Carney. 1975. Waterfowl harvest and hunter activity in the United States during the 1974 hunting season. U.S. Fish and Wildl. Serv. Unnumbered Admin. Rep. 28pp.
- Smart, G., and S.M. Carney. 1964. The increased wood duck kill rate to second wood ducks in the bag, 1962-63 and 1963-64 seasons compared. U.S. Fish and Wildl. Serv. Admin. Rep. No. 53. 3pp.
- Smith, R.I., 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. Admin. Rep. No. 21. 4pp.
- Smith, T.S. 1975. The Wisconsin duck harvest 1961-1970 as determined from the wing collection survey. M.S. thesis, Univ. Wisc., Stevens Point. 351pp.
- Sorenson, M.F., S.M. Carney, and E.M. Martin. 1977. Waterfowl harvest and hunter activity in the United States during the 1976 hunting season. U.S. Fish and Wildl. Serv. Unnumbered Admin. Rep. 25pp.
- Stewart, P.A. 1977. Radial dispersal and southward migration of wood ducks banded in Iowa. Iowa Bird Life. XLVII:48-50.
- Stewart, P.A. 1977. Radial dispersal and southward migration of wood ducks banded in Vermont. Bird Banding. 48(4):333-336.

Appendix A. Number of wood ducks banded throughout Wisconsin and in each major banding area 1959-75.

Year	<u>Banding Area</u>					
	Upper Mississippi			Horicon		
	Adult	Immature	Local	Adult	Immature	Local
MALE:						
1959	85	359	10	8	0	0
1960	294	802	55	30	1	0
1961	201	448	26	287	11	0
1962	158	253	106	577	32	0
1963	266	722	23	608	7	0
1964	143	745	4	48	8	0
1965	198	877	7	522	67	0
1966	577	962	26	182	13	3
1967	252	1466	28	82	9	6
1968	43	423	14	61	1	8
1969	29	521	87	75	4	5
1970	59	263	106	149	28	6
1971	37	32	23	21	3	11
1972	36	144	5	11	3	0
1973	32	161	10	0	0	0
1974	35	79	2	1	1	2
1975	62	144	0	26	26	1
Total	2507	8401	529	2688	214	44

Appendix A (continued).

Year	<u>Banding Area</u>					
	Crex Meadows			Necedah		
	Adult	Immature	Local	Adult	Immature	Local
MALE:						
1959	0	0	0	50	3	0
1960	0	0	0	135	70	0
1961	0	0	0	230	74	11
1962	0	0	0	279	69	4
1963	66	25	0	631	36	3
1964	66	25	0	236	36	1
1965	180	55	3	78	13	0
1966	43	8	1	180	42	2
1967	82	13	0	87	66	0
1968	164	17	56	61	6	4
1969	189	38	36	138	29	1
1970	96	28	17	227	97	0
1971	160	36	0	7	7	0
1972	79	10	0	69	44	0
1973	78	11	0	0	0	0
1974	4	0	0	105	46	0
1975	1	0	0	151	60	0
Total	1208	266	113	2664	698	26

Appendix A (continued).

Year	<u>Banding Area</u>			State Total		
	Mead Adult	Mead Immature	Local	Adult	Immature	Local
MALE:						
1959	0	0	0	143	362	10
1960	0	0	0	459	873	55
1961	0	0	0	718	533	37
1962	0	0	0	1014	354	112
1963	0	0	0	1571	790	23
1964	0	0	0	493	814	5
1965	0	0	0	978	1012	10
1966	102	64	0	1094	1089	33
1967	0	1	0	576	1561	34
1968	4	0	1	341	447	85
1969	457	91	0	926	696	129
1970	24	4	0	555	420	129
1971	58	11	0	304	110	34
1972	104	41	0	302	251	5
1973	29	7	1	139	189	14
1974	67	34	0	215	162	5
1975	80	33	0	357	307	1
Total	925	286	2	10185	9970	721

Appendix A (continued).

Year	<u>Banding Area</u>					
	Upper Mississippi			Horicon		
	Adult	Immature	Local	Adult	Immature	Local
<b>FEMALE:</b>						
1959	95	274	7	5	0	0
1960	64	599	49	17	0	0
1961	71	425	16	75	13	0
1962	67	172	95	175	28	0
1963	85	559	14	193	5	0
1964	34	676	1	22	2	1
1965	46	808	4	97	26	0
1966	229	815	8	46	7	5
1967	106	1291	23	15	5	12
1968	39	446	13	19	1	9
1969	27	453	106	11	1	0
1970	13	256	135	45	22	5
1971	2	20	34	13	2	10
1972	25	97	7	3	0	0
1973	8	165	5	0	0	0
1974	8	72	16	0	0	2
1975	26	93	1	16	16	0
<b>Total</b>	<b>945</b>	<b>7221</b>	<b>534</b>	<b>752</b>	<b>128</b>	<b>44</b>

Appendix A (continued).

Year	<u>Banding Area</u>					
	Crex Meadows			Necedah		
	Adult	Immature	Local	Adult	Immature	Local
<b>FEMALE:</b>						
1959	0	0	0	15	2	0
1960	0	0	0	14	19	2
1961	0	0	0	43	64	8
1962	0	0	0	114	38	12
1963	17	19	0	183	30	2
1964	25	9	0	49	21	3
1965	25	34	4	27	17	0
1966	6	2	0	33	19	2
1967	12	9	0	17	29	0
1968	18	16	53	13	3	3
1969	54	45	34	30	18	4
1970	21	18	19	72	56	0
1971	17	19	0	5	6	0
1972	8	2	0	10	17	0
1973	4	3	0	0	0	0
1974	0	1	0	25	27	0
1975	0	0	0	41	41	0
<b>Total</b>	<b>207</b>	<b>177</b>	<b>110</b>	<b>691</b>	<b>407</b>	<b>36</b>

Appendix A (continued).

Year	<u>Banding Area</u>					
	Mead			State Total		
	Adult	Immature	Local	Adult	Immature	Local
FEMALE:						
1959	0	0	0	115	276	7
1960	0	0	0	95	618	51
1961	0	0	0	189	502	24
1962	0	0	0	356	238	107
1963	0	0	0	478	613	16
1964	0	0	0	130	708	5
1965	0	0	0	195	885	8
1966	27	81	2	343	924	17
1967	0	2	0	151	1338	35
1968	0	0	2	90	466	83
1969	56	101	1	184	636	145
1970	1	1	0	153	353	160
1971	4	3	0	47	75	44
1972	12	16	0	63	134	7
1973	1	5	0	13	179	8
1974	14	30	0	47	131	19
1975	11	26	0	102	213	2
Total	126	265	5	2751	8289	738

Appendix B. Direct recovery rates for wood ducks banded in Wisconsin by year and age, 1959-75. (Sexes combined)

YEAR	DIRECT RECOVERY RATE			
	ADULT	IMMATURE	LOCAL	ALL AGE
1959	0.0543	0.0846	0.0455 <sup>a</sup>	0.0751
1960	0.0542	0.0939	0.0880	0.0831
1961	0.0309	0.0482	0.0301	0.0395
1962	0.0431	0.0591	0.0528	0.0485
1963	0.0737	0.0844	0.0973	0.0786
1964	0.0514	0.0951	0.1000 <sup>a</sup>	0.0826
1965	0.0554	0.0891	0.0357 <sup>a</sup>	0.0759
1966	0.0778	0.1306	0.0933	0.1083
1967	0.0688	0.0937	0.1014	0.0889
1968	0.0394	0.0515	0.0774	0.0509
1969	0.0964	0.1199	0.9012	0.1066
1970	0.0763	0.1138	0.1211	0.0996
1971	0.0684	0.1081	0.1481	0.0908
1972	0.0658	0.0857	0.0833 <sup>a</sup>	0.0760
1973	0.0523	0.0435	0.1364 <sup>a</sup>	0.0497
1974	0.0344	0.0884	0.0000 <sup>a</sup>	0.0601
1975	0.0741	0.1019	0.0000 <sup>a</sup>	0.0886
TOTAL <sup>1</sup>	0.0632	0.0925	0.0856	0.0805

1) Based on total number banded and total number of direct recoveries.

a) Based on a banded sample of less than 50 wood ducks.

Appendix C. Direct recovery rates by age, sex and year for wood ducks banded in Wisconsin, 1959-75.

DIRECT RECOVERY RATES								
YEAR	MALES				FEMALES			
	ADULT	IMMATURE	LOCAL	ALL AGE	ADULT	IMMATURE	LOCAL	ALL AGE
1959	0.0490	0.718	0.1000 <sup>a</sup>	0.0660	0.0609	0.1014	0.0000 <sup>a</sup>	0.0877
1960	0.0523	0.1008	0.0545	0.0828	0.0632	0.0858	0.1176	0.0845
1961	0.0348	0.0469	0.0272 <sup>a</sup>	0.0392	0.0159	0.0498	0.0000 <sup>a</sup>	0.0401
1962	0.0464	0.0706	0.0536	0.0527	0.0337	0.0420	0.0467	0.0385
1963	0.0745	0.0835	0.0870 <sup>a</sup>	0.0776	0.0711	0.0865	0.0000 <sup>a</sup>	0.0786
1964	0.0507	0.0934	0.2000 <sup>a</sup>	0.0777	0.0538	0.0975	0.2000 <sup>a</sup>	0.0913
1965	0.0573	0.0860	0.0000 <sup>a</sup>	0.0715	0.0462	0.0927	0.0000 <sup>a</sup>	0.0836
1966	0.0731	0.1460	0.1212 <sup>a</sup>	0.1097	0.0933	0.1126	0.0588	0.1067
1967	0.0642	0.0955	0.0588 <sup>a</sup>	0.0867	0.0861	0.0919	0.1429 <sup>a</sup>	0.0923
1968	0.0411	0.0649	0.0588	0.0550	0.0333	0.0386	0.0964	0.0453
1969	0.0940	0.1164	0.0698	0.1010	0.1087	0.1242	0.1103	0.1192
1970	0.0829	0.1167	0.1163	0.0996	0.0523	0.1105	0.1250	0.1006
1971	0.0625	0.1364	0.1471 <sup>a</sup>	0.0871	0.1064	0.0667	0.1591 <sup>a</sup>	0.1024
1972	0.0596	0.0876	0.0000 <sup>a</sup>	0.0717	0.0952	0.0821	0.1429 <sup>a</sup>	0.0882
1973	0.0504	0.0317	0.1429 <sup>a</sup>	0.0439	0.0000 <sup>a</sup>	0.0559	0.1250 <sup>a</sup>	0.0550
1974	0.0326	0.0802	0.0000 <sup>a</sup>	0.0524	0.0426 <sup>a</sup>	0.0992	0.0000 <sup>a</sup>	0.0761
1975	0.0644	0.1075	0.0000 <sup>a</sup>	0.0842	0.1078	0.0939	0.0000 <sup>a</sup>	0.0978
TOTAL <sup>1</sup>	0.0627	0.0952	0.0777	0.0787	0.0647	0.0895	0.0962	0.0841

1) Based on total number banded and total number of direct recoveries.

a) Based on a banded sample of less than 50 wood ducks.

Appendix D. Direct recovery rates for wood ducks banded throughout Wisconsin and in each major banding area in Wisconsin, 1959-75.

Year	<u>Banding Area</u>					
	Upper Mississippi			Horicon		
	Adult	Immature	Local	Adult	Immature	Local
MALE:						
1959	0.0471	0.0724	(0.1000) <sup>1</sup>	(0.1250)	(0.1250)	(0.0000)
1960	0.0510	0.0510	0.0545	(0.1000)	(0.1000)	(0.0000)
1961	0.0249	0.0249	(0.0385)	0.0383	0.0383	(0.0000)
1962	0.0823	0.0823	0.0566	0.0364	0.0364	(0.0000)
1963	0.0940	0.0940	(0.1000)	0.0839	0.0839	(0.0000)
1964	0.0979	0.0979	(0.0000)	(0.0417)	(0.0417)	(0.0000)
1965	0.0657	0.0657	(0.0000)	0.0460	0.0460	(0.0000)
1966	0.0867	0.0867	(0.1154)	0.0440	0.0440	(0.0000)
1967	0.0714	0.0714	(0.0357)	0.1220	0.1220	(0.1667)
1968	(0.0233)	(0.0233)	(0.0000)	0.0492	0.0492	(0.1250)
1969	(0.0345)	(0.0345)	0.0920	0.0667	0.0667	(0.2000)
1970	0.0508	0.0508	0.1226	0.1007	0.1007	(0.1667)
1971	(0.1622)	(0.1622)	(0.0870)	(0.0952)	(0.0952)	0.2727
1972	(0.0278)	(0.0278)	(0.0000)	(0.1818) <sub>2</sub>	(0.1818)	(0.0000)
1973	(0.0313)	(0.0313)	(0.1000)	*****	*****	*****
1974	(0.0857)	(0.0857)	(0.0000)	(1.0000)	(1.0000)	(0.0000)
1975	0.0806	0.0806	0.0000	(0.0385)	(0.0385)	(0.0000)
Total	0.0710	0.0710	0.0775	0.0595	0.0841	0.1591

Appendix D (continued).

Year	<u>Banding Area</u>					
	Crex Meadows			Necedah		
	Adult	Immature	Local	Adult	Immature	Local
MALE:						
1959	*****	*****	*****	0.0400	(0.0000)	(0.0000)
1960	*****	*****	*****	0.0444	0.1286	(0.0000)
1961	*****	*****	*****	0.0391	0.0405	(0.0000)
1962	*****	*****	*****	0.0466	0.0435	(0.0000)
1963	0.0606	(0.0400)	(0.0000)	0.0586	(0.0833)	(0.0000)
1964	0.0303	(0.0400)	(0.0000)	0.0297	(0.0833)	(1.0000)
1965	0.0944	0.1091	(0.0000)	0.0128	(0.2308)	(0.0000)
1966	(0.0465)	(0.0000)	(0.0000)	0.0611	(0.0238)	(0.5000)
1967	0.0366	(0.1538)	(0.0000)	0.0575	0.0455	0.0000
1968	0.0488	(0.0000)	0.0714	0.0328	(0.1667)	(0.0000)
1969	0.0529	(0.0526)	0.0000	0.0580	(0.0000)	(0.0000)
1970	0.1146	(0.0357)	(0.0588)	0.0749	0.1031	(0.0000)
1971	0.0250	(0.1111)	(0.0000)	(0.0000)	(0.1429)	(0.0000)
1972	0.0633	(0.2000)	(0.0000)	0.0435	(0.0682)	(0.0000)
1973	0.0641	(0.0000)	*****	*****	*****	*****
1974	(0.0000)	*****	*****	0.0190	(0.0652)	(0.0000)
1975	(0.0000)	*****	*****	0.0662	0.0500	(0.0000)
Total	0.0588	0.0714	0.0442	0.0499	0.0702	0.0769

Appendix D (continued).

Year	<u>Banding Area</u>		
	Adult	Mead <sup>3</sup> Immature	Local
MALE:			
1959	*****	*****	*****
1960	*****	*****	*****
1961	*****	*****	*****
1962	*****	*****	*****
1963	*****	*****	*****
1964	*****	*****	*****
1965	*****	*****	*****
1966	0.0882	0.1406	(0.0000)
1967	*****	(0.0000)	*****
1968	(0.0000)	*****	(0.0000)
1969	0.1291	0.1319	(0.0000)
1970	(0.0000)	(0.5000)	(0.0000)
1971	0.0862	(0.0000)	(0.0000)
1972	0.0577	(0.0488)	(0.0000)
1973	(0.0690)	(0.0000)	(0.0000)
1974	0.0299	(0.0882)	(0.0000)
1975	0.0750	(0.0909)	(0.0000)
Total	0.0962	0.1084	(0.0000)

Appendix D (continued).

Year	<u>Banding Area</u>					
	Upper Mississippi		Horicon			
	Adult	Immature	Local	Adult	Immature	Local
<b>FEMALE:</b>						
1959	0.0632	0.1022	(0.0000)	(0.4000)	(0.0000)	(0.0000)
1960	0.0469	0.0885	(0.1224)	(0.1176)	(0.0000)	(0.0000)
1961	0.0000	0.0494	(0.0000)	0.0000	(0.0769)	(0.0000)
1962	0.0448	0.0465	0.0526	0.0400	(0.0714)	(0.0000)
1963	0.1059	0.0859	(0.0000)	0.0674	(0.0000)	(0.0000)
1964	(0.0294)	0.1021	(0.0000)	(0.0909)	(0.0000)	(0.0000)
1965	(0.0652)	(0.0941)	(0.0000)	0.0515	0.0769	(0.0000)
1966	(0.0917)	0.1141	(0.1250)	(0.0652)	(0.0000)	(0.0000)
1967	0.0943	0.0930	(0.1304)	0.0667	(0.2000)	(0.1667)
1968	(0.0256)	0.0381	(0.0000)	(0.0526)	(0.0000)	(0.3333)
1969	(0.1111)	0.0949	0.1038	(0.0909)	(0.0000)	*****
1970	(0.0000)	0.0977	0.1407	(0.0444)	(0.1364)	(0.2000)
1971	(0.0000)	(0.2000)	0.1765	0.0769	(0.0000)	(0.1000)
1972	(0.1600)	0.1134	(0.1429)	(0.0000)	*****	*****
1973	(0.0000)	0.0606	(0.0000)	*****	*****	*****
1974	(0.1250)	0.1250	(0.0000)	*****	*****	(0.0000)
1975	(0.1154)	0.1075	(0.0000)	(0.1250)	(0.1875)	(0.0000)
<b>Total</b>	<b>0.0720</b>	<b>0.0893</b>	<b>0.0974</b>	<b>0.0532</b>	<b>0.0938</b>	<b>(0.1591)</b>

Appendix D (continued).

Year	<u>Banding Area</u>					
	Crex Meadows			Necedah		
	Adult	Immature	Local	Adult	Immature	Local
FEMALE:						
1959	*****	*****	*****	(0.0667)	(0.0000)	(0.0000)
1960	*****	*****	*****	(0.0714)	(0.0000)	(0.0000)
1961	*****	*****	*****	(0.0698)	0.0469	(0.0000)
1962	*****	*****	*****	0.0175	(0.0000)	(0.0000)
1963	(0.0588)	(0.1053)	(0.0000)	0.0601	(0.1000)	(0.0000)
1964	(0.0800)	(0.0000)	(0.0000)	(0.0408)	(0.0000)	(0.3333)
1965	(0.0400)	(0.0882)	(0.0000)	(0.0000)	(0.0588)	(0.0000)
1966	(0.0000)	(0.5000)	(0.0000)	(0.0909)	(0.1579)	(0.0000)
1967	(0.0833)	(0.1111)	(0.0000)	(0.0588)	(0.0345)	(0.0000)
1968	(0.0000)	(0.0625)	0.0943	(0.0769)	(0.0000)	(0.0000)
1969	0.0926	0.0889	(0.1176)	(0.0000)	(0.2222)	(0.0000)
1970	(0.0476)	(0.1111)	(0.0000)	0.0694	0.1607	(0.0000)
1971	(0.0588)	(0.0586)	(0.0000)	(0.2000)	(0.0000)	(0.0000)
1972	(0.0000)	(0.0000)	*****	(0.1000)	(0.0000)	(0.0000)
1973	0.0641	(0.0000)	(0.0000)	*****	*****	*****
1974	*****	*****	*****	(0.0000)	(0.0370)	(0.0000)
1975	*****	*****	*****	(0.0732)	(0.0488)	(0.0000)
Total	0.0580	0.0791	0.0818	0.0492	0.0663	(0.0278)

Appendix D (continued).

Year	<u>Banding Area</u>		
	Adult	Mead <sup>3</sup> Immature	Local
<b>FEMALE:</b>			
1959	*****	*****	*****
1960	*****	*****	*****
1961	*****	*****	*****
1962	*****	*****	*****
1963	*****	*****	*****
1964	*****	*****	*****
1965	*****	*****	*****
1966	0.1852	0.0988	(0.0000)
1967	*****	(0.0000)	*****
1968	*****	*****	(0.0000)
1969	0.1786	0.2673	(0.0000)
1970	(0.0000)	(0.0000)	*****
1971	(0.5000)	(0.0000)	(0.0000)
1972	(0.1667)	(0.0000)	(0.0000)
1973	(0.0000)	(0.4000)	(0.0000)
1974	(0.0714)	(0.1000)	(0.0000)
1975	(0.1818)	(0.0769)	(0.0000)
<b>Total</b>	<b>0.1746</b>	<b>0.1509</b>	<b>(0.0000)</b>

- 1) Based on a banded sample of less than 50.
- 2) No recoveries obtained.
- 3) Data from Mead are biased to an unknown extent due to an inflated band reporting rate at the banding area.

Appendix E. Direct recovery chronology for adult and young wood ducks banded in Wisconsin and each major banding area within Wisconsin 1959-75<sup>1</sup> expressed as a percent.

Recovery Month	State	Upper Miss.	Banding Area			
			Horicon	Crex Meadows	Necedah	Mead <sup>2</sup>
<b>Adult</b>						
September	0.1	0.0	0.0	0.0	0.7	0.0
October	52.5	59.1	53.0	25.8	36.0	76.7
November	14.5	13.4	13.0	15.1	19.8	11.6
December	28.1	22.7	30.8	43.9	39.7	9.7
January	4.6	4.2	3.7	15.1	3.6	1.9
<b>Total</b>	<b>99.8</b>	<b>99.4</b>	<b>100.5</b>	<b>99.9</b>	<b>99.8</b>	<b>99.9</b>
<b>N</b>	<b>695</b>	<b>216</b>	<b>162</b>	<b>66</b>	<b>136</b>	<b>103</b>
<b>Young</b>						
September	0.2	0.1	0.0	0.0	3.1	0.0
October	69.5	69.9	71.8	55.2	51.5	82.8
November	14.7	14.4	18.8	23.7	18.8	8.6
December	13.7	13.1	9.4	15.7	25.0	7.1
January	1.9	2.0	0.0	5.3	1.6	1.4
<b>Total</b>	<b>100.0</b>	<b>99.5</b>	<b>100.0</b>	<b>99.9</b>	<b>100.0</b>	<b>99.9</b>
<b>N</b>	<b>1576</b>	<b>1354</b>	<b>32</b>	<b>38</b>	<b>64</b>	<b>70</b>

1) Includes wood ducks of unknown sex.

2) Data from Mead are biased to an unknown extent due to an inflated band reporting rate at the banding area.

Appendix F. Chronology of direct recoveries from birds banded in Wisconsin and recovered anywhere, by 10 day intervals, 1959-75, expressed as a percent.

Ten day interval	Total	MALE			FEMALE		
		Adult	Immat.	Local	Adult	Immat.	Local
9/1-9/10	0.1	0.0	0.1	0.0	0.0	0.2	0.0
9/11-9/20	0.1	0.2	0.0	0.0	0.0	0.3	0.0
9/21-9/30	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10/1-10/10	32.9	26.1	34.2	28.3	33.3	37.4	37.7
10/11-10/20	20.4	15.3	20.9	24.5	17.0	23.2	29.5
10/21-10/31	10.9	7.8	12.3	11.3	13.7	11.5	8.2
11/1-11/10	6.2	5.4	7.1	5.7	5.9	6.1	4.9
11/11-11/20	3.1	3.1	3.5	1.9	1.3	2.4	6.6
11/21-11/30	5.4	6.8	4.7	7.5	4.6	5.6	1.6
12/1-12/10	6.0	10.0	4.3	5.7	8.5	4.6	1.6
12/11-12/20	5.6	7.4	5.6	5.7	8.5	3.5	3.3
12/21-12/31	6.7	12.6	4.7	9.4	5.2	4.0	4.9
1/1-1/10	2.3	4.4	1.9	0.0	2.0	1.3	1.6
1/11-1/20	0.3	0.9	0.4	0.0	0.0	0.0	0.0
1/21-1/31	0.0	0.0	0.1	0.0	0.0	0.0	0.0
	100.0	100.0	99.8	100.0	100.0	100.1	99.9
N	2274	541	821	53	153	626	61

Appendix G. Chronology of indirect recoveries for the entire state by ten day intervals, for wood ducks banded through Wisconsin as adult, young, male and female, 1959-75<sup>1</sup>.

Ten Day Interval	Age		Sex		Total
	Adult	Young	Male	Female	
9/1-9/10	0.3	0.0	0.2	0.0	0.2
9/11-9/20	0.0	0.3	0.2	0.0	0.2
9/21-9/30	1.0	0.6	1.2	0.0	0.8
10/1-10/10	22.7	22.7	20.5	26.3	22.6
10/11-10/20	11.0	18.6	12.8	19.2	15.0
10/21-10/31	7.1	11.8	7.2	14.1	9.5
11/1-11/10	5.8	6.2	5.8	6.1	6.0
11/11-11/20	3.9	6.8	4.8	6.6	5.4
11/21-11/30	11.7	8.4	10.6	8.9	9.9
12/1-12/10	11.7	7.1	11.1	5.2	9.3
12/11-12/20	10.3	7.5	11.6	4.2	9.0
12/21-12/31	8.7	5.0	7.2	6.1	6.8
1/1-1/10	4.9	4.3	5.8	2.3	4.6
1/11-1/20	1.0	0.6	0.7	0.9	0.8
1/21-1/31	0.0	0.0	0.0	0.0	0.0

1) Figures are expressed as a percent.

Appendix H. Chronology of direct recoveries from birds banded and recovered in Wisconsin, by 10 day intervals, 1959-75<sup>1</sup>.

Ten day interval	Total	MALE			FEMALE		
		Adult	Immat.	Local	Adult	Immat.	Local
9/1-9/10	0.1	0.0	0.1	0.0	0.0	0.2	0.0
9/11-9/20	0.1	0.2	0.0	0.0	0.0	0.2	0.0
9/21-9/30	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10/1-10/10	26.3	23.1	25.6	17.0	29.4	29.2	36.1
10/11-10/20	15.3	12.0	14.7	20.7	15.7	17.3	22.9
10/21-10/31	4.9	5.0	5.2	5.7	6.5	4.1	1.6
11/1-11/10	1.7	0.9	2.3	0.0	1.3	1.8	1.6
11/11-11/20	0.2	0.2	0.1	0.0	0.0	0.3	0.0
11/21-11/30	0.0	0.0	0.0	0.0	0.0	0.2	0.0
% in Wisc.	48.6	41.4	48.0	43.4	52.9	53.3	62.2
N	2274	541	821	53	153	626	61

1) This tabulation is based on the total number of recoveries obtained from all locations. The percent is determined by dividing the number of recoveries within Wisconsin by the total number obtained (n).

Appendix I. Recovery chronology based on direct wood duck recoveries within Wisconsin from all banding locations, by 10 day interval, 1959-75, expressed as a percent.

Ten Day Interval	Banding Location <sup>2</sup>			Banding Location	
	% Foreign <sup>1</sup>	% from Wisconsin	Total	only Foreign	only Wisconsin
9/1-9/10	0.0	0.1	0.1	0.0	0.2
9/11-9/20	0.1	0.1	0.2	0.3	0.2
9/21-9/30	0.1	0.0	0.1	0.3	0.0
10/1-10/10	12.4	38.5	50.9	48.2	51.8
10/11-10/20	7.5	22.5	30.0	29.1	30.3
10/21-10/31	3.6	10.2	13.8	14.1	13.7
11/1-11/10	1.2	2.5	3.7	4.8	3.4
11/11-11/20	0.4	0.3	0.6	1.5	0.3
11/21-11/30	0.5	0.1	0.5	1.8	0.1
Total	25.8	74.3	99.9	100.1	100.0
N	398	1152	1550	398	1152

1) Represents recoveries of birds banded outside the state of Wisconsin.

2) Based on the total recoveries occurring within Wisconsin.

Appendix J. Chronology of direct recoveries within Wisconsin based on recoveries from Wisconsin only, by 10 day interval, 1959-75, expressed as a percent.

Ten day interval	Total	MALE			FEMALE		
		Adult	Immat.	Local	Adult	Immat.	Local
9/1-9/10	0.2	0.0	0.3	0.0	0.0	0.3	0.0
9/11-9/20	0.2	0.5	0.0	0.0	0.0	0.3	0.0
9/21-9/30	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10/1-10/10	54.0	55.8	53.2	39.1	55.6	54.9	57.9
10/11-10/20	31.6	29.0	30.6	47.8	29.6	32.4	36.8
10/21-10/31	10.0	12.1	10.9	13.0	12.3	7.8	2.6
11/1-11/10	3.5	2.2	4.8	0.0	2.5	3.3	2.6
11/11-11/20	0.4	0.5	0.3	0.0	0.0	0.6	0.0
11/21-11/30	0.1	0.0	0.0	0.0	0.0	0.3	0.0
Total	100.0	100.1	100.1	99.9	100.0	99.9	99.9
N	1105	224	395	23	81	333	38

Appendix K. Chronology of direct wood duck band recoveries by ten day interval for birds banded at each major banding area in Wisconsin 1959-75. All cohorts combined.

Ten Day Interval	Banding Area				
	Upper Mississippi	Horicon	Crex Meadows	Necedah	Mead <sup>2</sup>
9/1-9/10	0.0	0.0	0.0	0.9	0.0
9/11-9/20	0.1	0.0	0.0	0.5	0.0
9/21-9/30	0.0	0.0	0.0	0.0	0.0
10/1-10/10	31.5	26.6	11.3	17.8	64.6
10/11-10/20	22.2	18.7	13.9	11.3	9.5
10/21-10/31	14.2	9.4	13.9	13.1	5.1
11/1-11/10	6.3	4.9	7.8	6.1	2.3
11/11-11/20	2.9	1.5	4.3	3.3	3.4
11/21-11/30	5.3	7.4	6.1	9.4	5.1
12/1-12/10	4.9	9.4	7.8	8.5	3.4
12/11-12/20	4.6	4.9	12.2	9.9	2.8
12/21-12/31	5.4	14.3	12.2	16.4	2.3
1/1-1/10	1.9	2.5	8.7	1.9	1.1
1/11-1/20	0.1	0.5	1.7	0.9	0.6
1/21-1/31	0.2	0.0	0.0	0.0	0.0
Total	99.6	100.6	100.0	99.9	100.2
N	1637	203	213	115	178

- 1) Figures are expressed as a percent.
- 2) Data from Mead are biased to an unknown extent due to an inflated band reporting rate at the banding area.

Appendix L. Direct recovery chronology by ten day interval for adult wood ducks banded in Wisconsin and each major banding area within Wisconsin, 1959-75 expressed as a percent.

Ten Day Interval	Banding Area					
	State	Upper Miss.	Horicon	Crex Meadows	Necedah	Mead <sup>1</sup>
9/1-9/10	0.0	0.0	0.0	0.0	0.0	0.0
9/11-9/20	0.1	0.0	0.0	0.0	0.7	0.0
9/21-9/30	0.0	0.0	0.0	0.0	0.0	0.0
10/1-10/10	27.6	23.1	29.6	10.6	14.7	63.1
10/11-10/20	15.8	21.7	16.6	9.1	11.8	11.7
10/21-10/31	9.1	14.3	6.8	6.1	9.5	1.9
11/1-11/10	5.5	6.0	4.9	9.1	6.6	1.9
11/11-11/20	2.7	1.9	1.9	3.0	2.9	5.8
11/21-11/30	6.3	5.5	6.2	3.0	10.3	3.9
12/1-12/10	9.6	10.2	11.1	12.1	11.0	1.9
12/11-12/20	7.6	5.5	6.2	15.1	11.8	4.9
12/21-12/31	10.9	7.0	13.5	16.7	16.9	2.9
1/1-1/10	3.9	3.7	3.1	12.1	2.9	1.9
1/11-1/31	0.7	0.5	0.6	3.0	0.7	0.0
1/21-1/31	0.0	0.0	0.0	0.0	0.0	0.0
Total	99.8	99.4	99.9	99.9	99.8	99.9
N	695	216	162	66	136	103

1) Data from Mead are biased to an unknown extent due to an inflated band reporting rate at the banding area.

Appendix M. Direct recovery chronology for young wood ducks banded in Wisconsin and each major banding area within Wisconsin, 1959-75 expressed as a percent. Sexes are combined.

Ten Day Interval	Banding Area					
	State	Upper Miss.	Horicon	Crex Meadows	Necedah	Mead <sup>1</sup>
9/1-9/10	0.1	0.0	0.0	0.0	3.1	0.0
9/11-9/20	0.1	0.1	0.0	0.0	0.0	0.0
9/21-9/30	0.0	0.0	0.0	0.0	0.0	0.0
10/1-10/10	35.3	34.4	18.7	15.8	28.1	71.4
10/11-10/20	22.4	23.3	37.5	26.3	12.5	7.1
10/21-10/31	11.8	12.2	15.6	13.1	10.9	4.3
11/1-11/10	6.5	6.6	6.3	7.9	6.3	2.9
11/11-11/20	3.2	3.2	0.0	7.9	4.7	0.0
11/21-11/30	5.0	4.6	12.5	7.9	7.8	5.7
12/1-12/10	4.4	4.3	3.1	2.6	4.7	5.7
12/11-12/20	4.7	4.7	0.0	10.5	7.8	0.0
12/21-12/31	4.6	4.1	6.3	2.6	12.5	1.4
1/1-1/10	1.6	1.8	0.0	5.3	0.0	0.0
1/11-1/20	0.2	0.1	0.0	0.0	1.6	1.4
1/21-1/31	0.1	0.1	0.0	0.0	0.0	0.0
Total	100.0	99.5	100.0	99.9	100.0	99.9
N	1576	1354	32	38	64	70

1) Data from Mead are biased to an unknown extent due to an inflated band reporting rate at the banding area.

Appendix N. Chronology of indirect recoveries of wood ducks banded at each major banding area within Wisconsin, by 10 day interval, 1959-75 expressed as a percent. Ages and sexes combined.

Ten Day Interval	Banding Area					Total
	Upper Miss.	Horicon	Crex Meadows	Necedah	Mead <sup>1</sup>	
9/1-9/10	0.0	0.0	0.0	1.1	0.0	0.2
9/11-9/20	0.3	0.0	0.0	0.0	0.0	0.2
9/21-9/30	0.9	0.0	0.0	2.3	0.0	0.8
10/1-10/10	21.4	23.1	33.3	12.6	41.0	22.6
10/11-10/20	18.0	12.0	8.3	11.5	15.4	15.0
10/21-10/31	11.0	4.6	11.1	8.0	5.1	9.5
11/1-11/10	7.2	5.5	8.3	3.4	0.0	6.0
11/11-11/20	6.4	5.5	0.0	6.9	0.0	5.4
11/21-11/30	8.4	13.0	13.9	11.5	10.3	9.9
12/1-12/10	8.1	12.0	2.8	14.9	2.6	9.3
12/11-12/20	6.9	9.3	11.1	16.1	7.7	9.0
12/21-12/31	6.4	10.2	2.8	8.0	2.6	6.8
1/1-1/10	4.6	4.6	5.5	3.4	7.7	4.6
1/11-1/20	0.3	0.0	2.8	0.0	7.7	0.8
1/21-1/31	0.0	0.0	0.0	0.0	0.0	0.0
<b>Total</b>	<b>99.8</b>	<b>99.8</b>	<b>99.9</b>	<b>99.7</b>	<b>100.1</b>	<b>100.1</b>
<b>N</b>	<b>345</b>	<b>108</b>	<b>36</b>	<b>87</b>	<b>39</b>	<b>633</b>

1) Data from Mead are biased to an unknown extent due to an inflated band reporting rate at the banding area.

Appendix O. Indirect recovery distribution within states and Flyways for adult and young wood ducks banded in Wisconsin, 1959-75 expressed as a percent.

State	Male		Female		Total
	Adult	Young	Adult	Young	
Florida	3.8	2.0	4.1	1.6	2.8
Georgia	1.7	1.5	0.0	0.5	1.2
New Jersey	0.0	0.5	0.0	0.0	0.1
Massachusetts	0.3	0.0	0.0	0.0	0.1
New York	0.7	0.5	0.0	0.0	0.4
N. Carolina	0.0	1.5	0.0	0.0	0.4
S. Carolina	0.0	1.5	0.0	0.0	0.4
Pennsylvania	0.3	0.0	0.0	0.0	0.1
Virginia	0.0	0.3	0.0	0.0	0.1
Atlantic Flyway	6.9	7.8	4.1	2.1	5.6
Alabama	4.5	2.5	1.3	1.1	2.8
Arkansas	9.3	3.0	10.8	4.4	6.7
Illinois	4.1	4.5	6.8	3.3	4.3
Indiana	2.4	1.0	0.0	0.0	1.2
Iowa	2.1	6.5	2.7	5.5	4.4
Kentucky	0.3	0.0	0.0	0.0	0.1
Louisiana	17.0	13.4	12.2	13.7	15.0
Michigan	1.4	3.0	0.0	1.6	1.7
Minnesota	6.2	13.9	4.1	10.4	9.2
Mississippi	10.7	6.0	4.1	3.3	7.0
Missouri	0.0	2.5	1.3	0.5	0.9
Ohio	0.0	0.3	0.0	0.5	0.3
Tennessee	1.7	0.3	0.0	0.5	0.9
Wisconsin	27.0	21.9	41.9	43.9	31.5
Mississippi Flyway	86.9	78.8	85.1	88.7	86.0
Oklahoma	0.3	1.5	1.3	1.1	0.9
S. Dakota	0.0	0.0	1.3	0.0	0.1
Texas	4.8	10.0	6.8	7.7	7.1
Central Flyway	5.2	11.5	9.6	8.8	8.1
Manitoba	0.3	0.0	0.0	0.0	0.1
Ontario	0.7	1.5	0.0	0.0	0.7
Saskatchewan	0.0	0.0	1.3	0.0	0.1
Canada	1.0	1.5	1.3	0.0	0.9
Total	99.6	99.6	100.	99.6	100.6
N	289	201	74	182	747

Appendix P. Direct recovery distribution from each major banding area, 1959-75<sup>1</sup>. All age and sex classes<sup>2</sup>.

Recovery State	BANDING SITE				
	Crex Meadows	Mead <sup>3</sup>	Necedah	Upper Mississippi	Horicon
Florida	0.78	0.552	3.28	0.44	4.27
Georgia	3.12	0.552	0.82	0.61	2.56
N. Carolina			0.82	0.06	0.43
S. Carolina	0.78	0.552	1.23	0.11	1.28
Pensylvania	0.78				
Atlantic Flyway	5.46	1.65	6.15	1.22	8.54
Alabama	3.91	2.21	4.92	0.39	3.85
Arkansas	7.03	2.76	8.2	4.99	5.13
Illinois	2.34	0.55	2.87	2.88	5.13
Indiana	0.78			0.11	1.71
Iowa	0.78	0.55	1.23	9.32	1.28
Kentucky				0.06	
Louisiana	18.75	6.08	18.44	7.65	10.68
Michigan			0.82	0.22	0.43
Minnesota	7.03			13.65	
Mississippi	5.47	1.66	6.56	3.10	6.84
Missouri	5.47	1.10	1.23	2.22	
Ohio	0.78		0.41	0.33	0.43
Tennessee			1.23	0.83	1.71
Wisconsin	31.25	80.66	41.39	45.76	50.43
Mississippi Flyway	83.59	95.97	87.30	91.51	87.62
Kansas	2.34	0.55		0.66	
Montana				0.06	
Nebraska				0.17	
Oklahoma	0.78	0.55	1.23	0.78	
Texas	7.81	1.10	5.33	5.38	3.42
Central Flyway	10.93	2.2	6.56	7.08	3.42
Idaho		0.55			
Ontario				0.11	
Newfoundland					0.43
Unknown				0.11	

- 1) Figures are expressed as a percent.
- 2) Includes wood ducks of unknown age and sex.
- 3) Data from Mead are biased to an unknown extent due to an inflated band reporting rate at the banding area.

Appendix Q. Direct recovery distribution for adult wood ducks banded in Wisconsin and for each major banding area within Wisconsin, 1959-75<sup>1</sup>. Sexes are combined<sup>2</sup>.

Recovery State	State	Upper Miss.	Horicon	Crex Meadows	Necedah	Mead <sup>3</sup>
Florida	3.0	2.0	4.1	1.2	4.2	0.0
Georgia	2.3	2.5	3.1	4.9	1.2	0.9
N. Carolina	0.4	0.0	0.5	0.0	1.2	0.0
Pennsylvania	0.1	0.0	0.0	1.2	0.0	0.0
S. Carolina	0.9	0.0	1.5	1.2	1.8	0.0
Atlantic Flyway	6.7	4.5	9.2	8.5	8.4	0.9
Alabama	3.2	0.0	4.6	4.9	6.0	2.7
Arkansas	7.0	9.0	5.1	6.2	9.0	4.5
Illinois	3.0	2.0	5.1	3.7	3.6	0.0
Indiana	0.9	0.8	2.0	1.2	0.0	0.0
Iowa	2.7	7.0	1.0	0.0	1.2	0.9
Kentucky	0.0	0.0	0.0	0.0	0.0	0.0
Louisiana	13.5	11.1	11.2	23.5	19.3	6.4
Michigan	0.7	0.8	0.5	0.0	1.2	0.0
Minnesota	4.6	13.9	0.0	3.7	0.0	0.0
Mississippi	6.3	4.5	8.2	7.4	8.4	2.7
Missouri	1.6	2.5	0.0	3.7	1.2	1.8
Ohio	0.5	0.4	0.5	1.2	0.6	0.0
Tennessee	1.0	0.8	2.0	0.0	1.2	0.0
Wisconsin	43.0	36.1	46.9	23.5	34.9	78.2
Mississippi Flyway	88.0	88.9	87.1	79.0	86.6	97.2
Kansas	0.4	0.8	0.0	1.2	0.0	0.0
Montana	0.0	0.0	0.0	0.0	0.0	0.0
Nebraska	0.0	0.0	0.0	0.0	0.0	0.0
Oklahoma	0.4	0.0	0.0	1.2	1.2	0.0
Texas	4.3	5.3	3.6	9.9	3.6	0.9
Central Flyway	5.1	6.1	3.6	12.3	4.8	0.9
Idaho	0.1	0.0	0.0	0.0	0.0	0.9
Ontario	0.0	0.0	0.0	0.0	0.0	0.0
Newfoundland	0.0	0.0	0.0	0.0	0.0	0.0
Unknown	0.1	0.4	0.0	0.0	0.0	0.0
Total	100.0	99.9	99.9	99.8	99.8	99.6
N	809	156	196	81	166	110

1) Figures are expressed as a percent.

2) Includes wood ducks of unknown sex.

3) Data from Mead are biased to an unknown extent due to an inflated band reporting rate at the banding area.

Appendix R. Direct recovery distribution for young wood ducks banded in Wisconsin and for each major banding area within Wisconsin, 1959-75<sup>1</sup>. Sexes are combined.<sup>2</sup>

Recovery State	Banding Area					
	State	Upper Miss.	Horicon	Crex Meadows	Necedah	Mead <sup>3</sup>
Florida	0.5	0.2	5.3	0.0	1.3	1.4
Georgia	0.3	0.3	0.0	0.0	0.0	0.0
N. Carolina	0.1	0.1	0.0	0.0	0.0	0.0
Pennsylvania	0.0	0.0	0.0	0.0	0.0	0.0
S. Carolina	0.2	0.1	0.0	0.0	0.0	1.4
Atlantic Flyway	1.1	0.7	5.3	0.0	1.3	2.8
Alabama	0.6	0.4	0.0	2.1	2.6	1.4
Arkansas	4.5	4.4	5.3	8.5	6.4	0.0
Illinois	2.8	3.0	5.3	0.0	1.3	1.4
Indiana	0.1	0.0	0.0	0.0	0.0	0.0
Iowa	8.5	9.7	2.6	2.1	1.3	0.0
Kentucky	0.1	0.1	0.0	0.0	0.0	0.0
Louisiana	7.6	7.1	7.9	10.6	16.7	5.6
Michigan	0.1	0.1	0.0	0.0	0.0	0.0
Minnesota	12.1	13.6	0.0	12.8	0.0	0.0
Mississippi	2.5	2.9	0.0	2.1	2.6	0.0
Missouri	2.1	2.1	0.0	8.5	1.3	0.0
Ohio	0.3	0.0	0.0	0.0	0.0	0.0
Tennessee	0.8	0.8	0.0	0.0	1.3	0.0
Wisconsin	49.7	47.2	68.4	44.7	55.1	84.5
Mississippi Flyway	91.8	91.7	89.5	91.4	88.6	92.9
Kansas	0.7	0.6	0.0	4.3	0.0	1.4
Montana	0.1	0.1	0.0	0.0	0.0	0.0
Nebraska	0.2	0.2	0.0	0.0	0.0	0.0
Oklahoma	0.8	0.9	0.0	0.0	1.3	1.4
Texas	5.2	5.4	2.6	4.3	9.0	1.4
Central Flyway	7.0	7.2	2.6	8.6	10.3	4.2
Idaho	0.0	0.0	0.0	0.0	0.0	0.0
Ontario	0.1	0.1	0.0	0.0	0.0	0.0
Newfoundland	0.1	0.0	2.6	0.0	0.0	0.0
Unknown	0.1	0.1	0.0	0.0	0.0	0.0
Total	100.2	99.8	100.0	100.0	100.2	99.9
N	1791	1556	38	47	78	71

1) Figures are expressed as a percent.

2) Includes wood ducks of unknown sex.

3) Data from Mead are biased to an unknown extent due to an inflated band reporting rate at the banding area.

Appendix S. Adult total and Wisconsin kill rates for each major banding area and the entire state, 1959-75. Rates within Wisconsin are shown in parentheses.

	MISSISSIPPI RIVER	CREX MEADOWS	HORICON	NECEDAH	MEAD WILD. AREA <sup>2</sup>	STATE
1959	0.2317 (0.0701)		0.3620 <sup>1</sup> (0.0000)	0.1370 (0.0646)		0.2145 (0.0652)
1960	0.1493 (0.0223)		0.4689 <sup>1</sup> (0.2684)	0.2428 (0.0846)		0.2372 (0.0911)
1961	0.0989 (0.0098)		0.1343 (0.0581)	0.1872 (0.0462)		0.0942 (0.0371)
1962	0.3282 (0.0748)		0.1630 (0.4480)	0.1714 (0.0321)		0.2737 (0.0399)
1963	0.4342 (0.0415)	0.2209 (0.0506)	0.3410 (0.1943)	0.2553 (0.1137)		0.2504 (0.1272)
1964	0.1026 (0.0713)	0.2440 (0.0924)	0.3966 (0.0600)	0.1801 (0.0147)		0.2079 (0.0338)
1965	0.2751 (0.1207)	0.3706 (0.0624)	0.1994 (0.0544)	0.0527 (0.0000)		0.1699 (0.0502)
1966	0.3409 (0.1197)	0.3943 (0.0000)	0.4407 (0.2978)	0.3066 (0.0197)	0.4643 (0.3912)	0.3289 (0.1081)
1967	0.4125 (0.1292)	0.1897 (0.0895)	0.4511 (0.3035)	0.2506 (0.1213)		0.3174 (0.1215)
1968	0.1026 (0.1026)	0.1775 (0.0000)	0.2165 (0.1577)	0.1822 (0.1169)	0.0000 <sup>1</sup> (0.0000)	0.1432 (0.1683)
1969	0.3331 (0.1502)	0.2947 (0.0519)	0.2992 (0.2445)	0.2132 (0.0751)	0.5581 (0.4264)	0.3779 (0.2311)
1970	0.2006 (0.0583)	0.4353 (0.1797)	0.3403 (0.1084)	0.3010 (0.1406)	0.3771 <sup>1</sup> (0.0000)	0.2803 (0.1069)
1971	0.5781 (0.2157)	0.1540 (0.0475)	0.5135 (0.3710)	1.1490 <sup>1</sup> (0.0000)	0.4912 (0.3391)	0.3312 (0.1318)
1972	0.3141 (0.0688)	0.5410 (0.0000)	0.6733 (0.0000)	0.1828 (0.0532)	0.3001 (0.1813)	0.2262 (0.0807)
1973	0.3115 (0.2052)	0.3977 (0.0512)			0.2804 (0.2804)	0.3514 (0.1374)

1) Based on less than 50 banded birds.

Appendix S (continued).

	MISSISSIPPI RIVER	CREX MEADOWS	HORICON	NECEDAH	MEAD WILD. AREA <sup>2</sup>	STATE
1974	0.3913 <sup>1</sup> (0.3913)	1.1770 <sup>1</sup> (0.0000)	0.0000 <sup>1</sup> (0.0000)	0.0725 (0.0000)	0.1620 (0.1039)	0.1342 (0.0803)
1975	0.4147 (0.1912)	0.0000 <sup>1</sup> (0.0000)	0.1909 <sup>1</sup> (0.1910)	0.3040 <sup>1</sup> (0.1095)	0.3698 (0.3698)	0.2630 (0.1466)

1) Based on less than 50 banded birds.

2) Data from Mead are biased to an unknown extent due to an inflated band reporting rate at the banding area.

Appendix T. Kill rates for young wood ducks banded in the major Wisconsin banding areas and for the entire state, 1959-75. Rates within Wisconsin are shown in parentheses.

	MISSISSIPPI RIVER	CREX MEADOWS	HORICON	NECEDAH	MEAD WILD. AREA <sup>2</sup>	STATE
1959	0.3475 (0.1349)			0.0000 <sup>1</sup> (0.0000)		0.3004 (0.1245)
1960	0.3944 (0.1291)		0.0000 <sup>1</sup> (0.0000)	0.4648 (0.1878)		0.3785 (0.2372)
1961	0.2067 (0.0726)		0.1448 (0.1448)	0.1639 (0.1339)		0.1528 (0.0647)
1962	0.3116 (0.0902)		0.2198 (0.0677)	0.1216 (0.0341)		0.2180 (0.0652)
1963	0.3773 (0.1386)	0.2867 <sup>1</sup> (0.2867)	0.0000 <sup>1</sup> (0.0000)	0.3767 (0.1777)		0.3026 (0.0257)
1964	0.4516 (0.1550)	0.1235 <sup>1</sup> (0.1235)	0.7782 <sup>1</sup> (0.3818)	0.3696 (0.1379)		0.3299 (0.1226)
1965	0.3745 (0.2145)	0.3728 (0.1314)	0.4928 (0.1838)	0.6280 <sup>1</sup> (0.0000)		0.3089 (0.1639)
1966	0.6048 (0.2280)	0.4279 <sup>1</sup> (0.0000)	0.1681 <sup>1</sup> (0.0000)	0.3877 (0.0000)	0.4898 (0.4578)	0.5304 (0.2235)
1967	0.4203 (0.2377)	0.5964 <sup>1</sup> (0.3824)	0.7888 <sup>1</sup> (0.7888)	0.1910 (0.1328)		0.3784 (0.2223)
1968	0.2200 (0.1033)	0.3197 (0.1481)	0.8996 <sup>1</sup> (0.8996)	0.3458 <sup>1</sup> (0.3458)	0.0000 <sup>1</sup> (0.0000)	0.2239 (0.2089)
1969	0.4941 (0.2734)	0.3001 (0.1100)	0.4200 <sup>1</sup> (0.4200)	0.3872 (0.1064)	0.8463 (0.6974)	0.4665 (0.2799)
1970	0.5629 (0.2490)	0.1661 (0.0512)	0.4481 (0.2802)	0.5256 (0.4948)	1.6830 <sup>1</sup> (1.6830)	0.4465 (0.2574)
1971	0.8529 (0.3745)	0.5105 (0.1530)	0.6574 <sup>1</sup> (0.6574)	0.4256 <sup>1</sup> (0.4256)	0.0000 (0.0000)	0.5419 (0.2846)
1972	0.4640 (0.2494)	0.8533 <sup>1</sup> (0.0000)	0.0000 <sup>1</sup> (0.0000)	0.1379 (0.1379)	0.1502 (0.0736)	0.3079 (0.1695)

1) Based on less than 50 banded birds.

Appendix T (continued).

	MISSISSIPPI RIVER	CREX MEADOWS	HORICON	NECEDAH	MEAD WILD. AREA <sup>2</sup>	STATE
1973	0.2304 (0.0370)	0.0000 <sup>1</sup>			0.0000 <sup>1</sup> (0.0000)	0.1989 (0.0539)
1974	0.3704 (0.1722)		0.0000 <sup>1</sup> (0.0000)	0.2696 (0.0758)	0.3516 (0.1940)	0.3106 (0.1446)
1975	0.5790 (0.1237)		0.0000 <sup>1</sup> (0.0000)	0.2577 (0.0548)	0.4502 (0.3564)	0.4522 (0.1689)

1) Based on less than 50 banded birds.

2) Data from Mead are biased to an unknown extent due to an inflated band reporting rate at the banding area.

Appendix U. Recovery and survival rates for young wood ducks from the entire state and each major banding area within Wisconsin, 1959-75, as estimated by the Johnson's (1974) model.

Year	Recovery Rate <sup>1</sup>					Survival Rate				
	State	Upper Miss.	Horicon	Crex Meadows	Necedah	State	Upper Miss.	Horicon	Crex Meadows	Necedah
1959	0.0838	0.0847	*****	*****	0.0601	0.3773	0.3653	*****	*****	0.2833
1960	0.0917	0.0910	0.1653	*****	0.0801	0.3404	0.3017	0.6430	*****	0.4203
1961	0.0458	0.0451	0.0482	*****	0.0498	0.4182	0.4135	0.5373	*****	0.4204
1962	0.6553	0.0714	0.0694	*****	0.0498	0.4090	0.3718	0.5133	*****	0.5451
1963	0.1001	0.0977	0.1252	0.0736	0.0869	0.2661	0.2582	0.4554	0.2746	0.4418
1964	0.0897	0.0967	0.0664	0.0497	0.0604	0.3656	0.3684	0.4225	0.5658	0.2533
1965	0.0863	0.0856	0.0892	0.0941	0.0694	0.3490	0.3531	0.4309	0.7749	0.4175
1966	0.1254	0.1317	0.1101	0.0460	0.0917	0.2932	0.2659	0.3937	0.0889	0.3675
1967	0.0909	0.0947	0.1323	0.0600	0.0494	0.3647	0.3384	0.5462	0.3038	0.5554
1968	0.0627	0.0586	0.1170	0.0633	0.0488	0.4028	0.3953	0.7389	0.6159	0.4916
1969	0.1150	0.1008	0.1345	0.0617	0.0733	0.3027	0.2967	0.3501	0.2958	0.3365
1970	0.1143	0.1134	0.1244	0.0934	0.1123	0.3058	0.1915	0.3566	0.4608	0.2575
1971	0.1040	0.1573	0.1238	0.5989	0.1245	0.3174	0.3856	0.4770	0.1516	0.9813
1972	0.0866	0.1087	0.0525 <sub>2</sub>	0.0794	0.0409	0.6294	0.5728	*****	0.6455	*****
1973	0.0586	0.0533	*****	0.0576	*****	0.2066	0.1740	*****	0.6451	*****
1974	0.0766	0.1047	*****	0.0393	*****	0.4389	0.2573	*****	*****	*****
1975	0.1060	0.1318	*****	*****	*****	*****	*****	*****	*****	*****
Mean	0.0884	0.0957	0.1045	0.0648	0.0713	0.3617	0.3318	0.4887	0.4391	0.4440
S.E.	0.0217	0.0291	0.0360	0.0173	0.0253	0.0938	0.0960	0.1160	0.2270	0.1890

1) Standard error of these estimates is constant from year to year under this model and is for recovery rates: and for survival rates:

0.0361 State  
 0.0385 Upper Mississippi  
 0.2607 Horicon  
 0.1874 Crex Meadows  
 0.1732 Necedah

0.0229 State  
 0.0233 Upper Mississippi  
 0.1937 Horicon  
 0.1216 Crex Meadows  
 0.1732 Necedah

2) No birds were banded.

Appendix V. Survival rates for the entire state and each major banding area within the state for adult wood ducks 1959-75 estimated using Johnson's (1974) model.

Year	State		Upper Mississippi		Horicon		Crex Meadows		Necedah	
	Rate	S.E.	Rate	S.E.	Rate	S.E.	Rate	S.E.	Rate	S.E.
1959	0.5760	(0.0859)	0.5984	(0.0846)	*****	*****	*****	*****	0.3863	(0.2230)
1960	0.5197	(0.0500)	0.4942	(0.0518)	0.6776	(0.3912)	*****	*****	0.5732	(0.1532)
1961	0.6385	(0.0454)	0.6773	(0.0579)	0.5662	(0.1110)	*****	*****	0.5733	(0.0969)
1962	0.6245	(0.0383)	0.6090	(0.0530)	0.5410	(0.0647)	*****	*****	0.7433	(0.0929)
1963	0.4063	(0.0243)	0.4230	(0.0361)	0.4799	(0.0605)	0.4122	(0.1558)	0.6025	(0.0710)
1964	0.5582	(0.0338)	0.6035	(0.0463)	0.4453	(0.0704)	0.8492	(0.2002)	0.3454	(0.0493)
1965	0.5328	(0.0291)	0.5783	(0.0404)	0.4541	(0.0551)	1.1630	(0.2374)	0.5694	(0.0924)
1966	0.4477	(0.0259)	0.4355	(0.0316)	0.4149	(0.0559)	0.1334	(0.0471)	0.5012	(0.0860)
1967	0.5568	(0.0299)	0.5543	(0.0357)	0.5756	(0.0878)	0.4560	(0.1316)	0.7574	(0.1213)
1968	0.6149	(0.0339)	0.6475	(0.0438)	0.7787	(0.1316)	0.9244	(0.1563)	0.6704	(0.1150)
1969	0.4621	(0.0275)	0.4860	(0.0387)	0.3690	(0.0895)	0.4439	(0.0711)	0.4589	(0.0799)
1970	0.4668	(0.0324)	0.3136	(0.0312)	0.3758	(0.0862)	0.7025	(0.1352)	0.3512	(0.0536)
1971	0.4846	(0.0428)	0.6316	(0.0860)	0.5027	(0.1516)	0.2275	(0.0522)	1.3382	(0.2624)
1972	0.9609	(0.0916)	0.9382	(0.1522)			0.9688	(0.2166)		
1973	0.3154	(0.0404)	0.2850	(0.0570)			0.9682	(0.2500)		
1974	0.6700	(0.0938)	0.4215	(0.1126)						
Mean	0.5520	(0.1430)	0.5436	(0.1570)	0.5151	(0.1220)	0.6590	(0.3410)	0.6054	(0.2580)

Appendix W. Recovery rates 1959-75 for adult wood ducks calculated using program ESTIMATE (Brownie et al, 1978) Model 2, 1959-75.

Year	Recovery Rate	Standard Error	95 Percent Confidence Interval
1959	5.459	1.412	2.691-8.227
1960	5.514	0.872	3.804-7.224
1961	2.874	0.471	1.950-3.798
1962	4.885	0.482	3.911-5.798
1963	7.632	0.486	6.680-8.585
1964	4.472	0.451	3.587-5.357
1965	5.363	0.483	4.417-6.309
1966	7.467	0.532	6.424-8.510
1967	4.855	0.487	3.899-5.810
1968	4.533	0.557	3.442-5.625
1969	8.951	0.686	7.606-10.296
1970	7.506	0.669	6.195-8.818
1971	6.273	0.725	4.852-7.693
1972	4.854	0.702	3.479-6.229
1973	7.446	1.070	5.349-9.542
1974	4.111	0.821	2.501-5.721
1975	8.106	1.005	6.137-10.075
Mean	5.90	0.19	5.52-6.28
Survival =	51.75	0.96	49.88-53.62
Mean Life Span as an Adult =	1.52	0.04	1.44-1.60

Appendix X. Recovery rates for adult wood ducks for the entire state and each major banding area within Wisconsin 1959-75 determined using Johnson's (1974) model.

Year	State		Upper Mississippi		Horicon		Crescent Meadows		Necedah	
	Rate	S.E.	Rate	S.E.	Rate	S.E.	Rate	S.E.	Rate	S.E.
1959	0.0545	(0.0066)	0.0556	(0.0069)	***** <sup>1</sup>	*****	*****	*****	0.0415	(0.0240)
1960	0.0596	(0.0042)	0.0598	(0.0045)	0.1029	(0.0460)	*****	*****	0.0553	(0.0134)
1961	0.0298	(0.0029)	0.0296	(0.0035)	0.0300	(0.0083)	*****	*****	0.0344	(0.0073)
1962	0.0426	(0.0031)	0.0469	(0.0045)	0.0432	(0.0063)	*****	*****	0.0344	(0.0063)
1963	0.0651	(0.0032)	0.0642	(0.0043)	0.0779	(0.0075)	0.0573	(0.0203)	0.0600	(0.0063)
1964	0.0583	(0.0034)	0.0635	(0.0044)	0.0413	(0.0074)	0.0387	(0.0146)	0.0417	(0.0058)
1965	0.0561	(0.0030)	0.0562	(0.0037)	0.0555	(0.0071)	0.0732	(0.0126)	0.0479	(0.0092)
1966	0.0815	(0.0034)	0.0865	(0.0042)	0.0685	(0.0096)	0.0358	(0.0082)	0.0633	(0.0101)
1967	0.0591	(0.0028)	0.0622	(0.0032)	0.0823	(0.0135)	0.0467	(0.0156)	0.0341	(0.0080)
1968	0.0408	(0.0029)	0.0385	(0.0034)	0.0728	(0.0143)	0.0493	(0.0105)	0.0337	(0.0087)
1969	0.0748	(0.0035)	0.0662	(0.0043)	0.0827	(0.0150)	0.0480	(0.0079)	0.0506	(0.0097)
1970	0.0743	(0.0041)	0.0745	(0.0056)	0.0774	(0.0135)	0.0727	(0.0118)	0.0775	(0.0102)
1971	0.0676	(0.0053)	0.1033	(0.0118)	0.0770	(0.0187)	0.0466	(0.0090)	0.0859	(0.0183)
1972	0.0563	(0.0053)	0.0714	(0.0091)	0.0327	(0.0163)	0.0618	(0.0165)	0.0282	(0.0075)
1973	0.0381	(0.0040)	0.0350	(0.0055)	*****	*****	0.0448	(0.0120)	*****	*****
1974	0.0498	(0.0060)	0.0688	(0.0113)	*****	*****	0.0306	(0.0102)	*****	*****
1975	0.0689	(0.0059)	0.0866	(0.0119)	*****	*****	*****	*****	*****	*****
Mean	0.0576	(0.0141)	0.0629	(0.0191)	0.0650	(0.0224)	0.0505	(0.0135)	0.0492	(0.0175)

1) No birds were banded.

Appendix Y. Recovery and Survival rate estimates for adult and young wood ducks determined using Model HO2 of program BROWNIE (Brownie et al. 1978), 1959-75.

Year	Adult			Young		
	Recovery Rate	Standard Error	95 percent Conf. Interval	Recovery Rate	Standard Error	95 percent Conf. Interval
1959	0.0544	0.0141	0.0276-0.0820	0.0840	0.0108	0.0629-0.1051
1960	0.0571	0.0077	0.0420-0.0721	0.0939	0.0072	0.0798-0.1081
1961	0.0290	0.0038	0.0215-0.0365	0.0464	0.0061	0.0344-0.0584
1962	0.0494	0.0042	0.0413-0.0576	0.0576	0.0080	0.0419-0.0734
1963	0.0781	0.0045	0.0694-0.0869	0.0857	0.0072	0.0717-0.0998
1964	0.0479	0.0039	0.0402-0.0556	0.0958	0.0075	0.0811-0.1104
1965	0.0526	0.0040	0.0448-0.0605	0.0886	0.0065	0.0759-0.1012
1966	0.0775	0.0046	0.0685-0.0864	0.1283	0.0073	0.1140-0.1426
1967	0.0487	0.0038	0.0412-0.0562	0.0938	0.0053	0.0834-0.1043
1968	0.0416	0.0037	0.0343-0.0488	0.0556	0.0070	0.0420-0.0692
1969	0.0808	0.0052	0.0705-0.0910	0.1133	0.0079	0.0979-0.1288
1970	0.0693	0.0050	0.0594-0.0791	0.1154	0.0098	0.0962-0.1345
1971	0.0562	0.0051	0.0461-0.0663	0.1199	0.0199	0.0810-0.1589
1972	0.0480	0.0055	0.0372-0.0587	0.0850	0.0140	0.0576-0.1124
1973	0.0610	0.0074	0.0465-0.0756	0.0486	0.0109	0.0273-0.0700
1974	0.0430	0.0066	0.0302-0.0559	0.0816	0.0153	0.0516-0.1115
1975	0.0763	0.0083	0.0601-0.0926	0.1013	0.0132	0.0755-0.1272
Mean	0.0571	0.0019	0.0534-0.0608	0.0879	0.0025	0.0830-0.0929
Survival	0.0528	0.0078	0.5125-0.5431	0.3565	0.0151	0.3269-0.3860

Appendix Z. Wisconsin waterfowl hunting regulations and the number of active waterfowl hunters in Wisconsin, 1959-75.

Year	Opening Date	Season Length	October Days	Wood Duck Daily Bag Limit	Mallard Daily Bag Limit	Total Daily Bag Limit	Number of Active Hunters
1959	Oct. 7 <sup>1</sup>	50	25	1	3	3	92,885
1960	Oct. 7 <sup>1</sup>	50	25	1	3	3	95,969
1961	Oct. 14 <sup>2</sup>	30	18	1	2	2	79,750
1962	Oct. 13 <sup>2</sup>	25	19	2	1	2	63,520
1963	Oct. 5 <sup>2</sup>	35	27	2	2	4	75,916
1964	Oct. 10 <sup>2</sup>	40	22	2	2	4	86,276
1965	Oct. 9 <sup>2</sup>	40	23	2	2	4	92,692
1966	Oct. 8 <sup>2</sup>	46	24	2	2	4	94,662
1967	Oct. 7 <sup>2</sup>	30	25	1	2	4	95,069
1968	Oct. 12 <sup>2</sup>	30	20	2	1	3	88,561
1969	Oct. 4 <sup>2</sup>	40	28	2	1	4	110,740
1970	Oct. 3 <sup>2</sup>	55	29	2	2	6	131,404
1971	Oct. 2 <sup>2</sup>	50	30	2	4	4	135,504
1972	Oct. 7 <sup>2</sup>	50	25	2	4*	4	119,808
1973	Oct. 1 <sup>3</sup>	45	26	90 points	90 25	100	105,745
1974	Oct. 2 <sup>1</sup>	50	30	90 points	90 35	100	128,656
1975	Oct. 1 <sup>1</sup>	50	31	90 points	90 35	100	119,753

\* Only 1 hen during first 2 days.

- 1) Weekday opening.
- 2) Weekend opening.
- 3) Split season opened on a Monday (October 1) and Saturday (October 13).
- 4) Starting time on opening day was 12:00 hours.