ANALYSIS OF RECORDS OF LOUISIANA-BANDED WOODCOCK

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INTRODUCTION

From winter 1948-49 to winter 1968-69, 17,176 American woodcock (*Philohela minor*, Gmelin) were banded in Louisiana by staff and students in wildlife management at Louisiana State University, and by personnel in the Louisiana Wild Life and Fisheries Commission.

This paper is an analysis of these banding records, and is a revision of a thesis recently completed by Williams (1969). Objectives were to determine location and time of hunting-season kill, breeding-ground origin of wintering birds, causes of mortality, and annual mortality rates.

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METHODS

Location of Capture

Woodcock have been banded in a number of Louisiana parishes. However, most activity has centered in south-central parishes of Iberville, Pointe Coupee, and St. Landry. Within these parishes, banding has been confined to pastures and croplands used by woodcock at night.

The ratio of timberland to agricultural land varies among parishes where banding was concentrated. However, at least 50 percent of the land area contains bottomland hardwoods, largely cypress-gum-oak swamps. Crops are usually grown on well-drained land, gradually yielding to pastures nearer the swamps. Traditionally, the most important crops have been sugar cane, cotton, and corn. In recent years, however, much cultivated and timbered land has been placed in soybean production.

Capture Technique

Glasgow (1953, 1958) has described the capture technique. The most effective method is with headlamps and hand nets. The ideal light is a hunter's headlamp. The battery is carried in a canvas bag, leaving both hands free to handle the bamboo pole and net.

Two to six workers are best for banding. The workers traverse a field, keeping abreast of each other. When a woodcock's eye is reflected, usually as a reddish glow, the worker quickly but quietly nets the bird. The birds are carried in cloth sacks. When a field has been searched, or when bags are filled, the birds are banded and released.

An ideal night for banding follows a day or two of rain, has an overcast sky, slight mist, and no wind. On such a night, January 2, 1968, six experienced workers captured 391 woodcock in a 6-hour period.

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Age and Sex Determination

From 1948 to 1961, sex of captured woodcock was determined by bill length (Mendall and Aldous, 1943). Since 1961, sex has been determined by width of the outer three primaries, a method developed by several workers, and described by Martin (1964). Use of this method has almost eliminated the unknown sex category, which reduced the value of earlier bandings. With practice, sex can be determined quickly and accurately without use of a measuring device.

After 1961, age of increasing numbers of birds has been determined by differences in pattern and color of secondaries (Martin, 1964). During the last two winters (1967 and 1968), age was determined for nearly all banded birds.

RESULTS AND DISCUSSION

Age and Sex Composition of Banded Samples

Table 1 shows the number and sex of woodcock banded from 1948-49 to 1968-69. Birds banded in the last two winters are the only samples in which both age and sex determinations are considered reliable. Age and sex ratios of these birds follows:

Winter Period	Number Banded	Immatures per Adult Female	Immature Females per Adult Female	Adult Males per Adult Female	Immature Males per Immature Female
1967-68	1,041	2.51	1.19	0.72	1.11
1968-69	771	2.30	0.95	0.94	1.42

Various studies of woodcock captured in banding operations or shot during the hunting season have indicated a preponderance of females (Mendall and Aldous, 1943; Greeley, 1953; Blankenship, 1957; Martin, Geis, and Stickel, 1965; Sheldon, 1967; Goudy, Kletzly, and Rieffenberger, 1969). The overall sex ratio in Louisiana-banded birds was 0.9 male per female. If results of the last 2 years of banding are representative of earlier years, banded samples contained more adult females than adult males, but more immature males than immature females.

Age and Sex Differences During the Winter

Table 2 shows the sex composition of banded birds by time periods within the winter. Females formed 63.5 percent of birds banded in November. This larger fraction of females is highly significant. The sexes were banded in nearly even numbers throughout December and the first half of January. Birds banded after mid-January again showed a highly significant preponderance of females, increasing from 54.2 percent in the last half of January, to 67.5 percent in February.

These results suggest that female woodcock arrive earlier in the winter and remain longer than do males. Limited information gathered in the last 2 years of banding suggests that the higher proportion of females in early winter is caused by later arrival of adult males. Similarly, the higher percentage of females in late winter may result from earlier departure of adult males.

Geographical Distribution of Harvest

Distribution by States and Provinces

Indirect recoveries of birds reported shot were used to determine geographical distribution of hunting-season kill. These 284 recoveries represented birds that were banded in Louisiana, survived the winter, returned north the following spring, and were harvested in subsequent hunting seasons.

Michigan accounted for the largest number of recoveries (28.9 percent of the total). Louisiana was second (17.6 percent), followed by Wisconsin (10.9 percent). Pennsylvania (5.3 percent) and New York (3.9 percent) were leading eastern states (Table 3). The comparatively large number of recoveries in Alabama, Arkansas, Louisiana, and Mississippi indicates that shooting pressure on woodcock in these states is much higher than previously was suspected.

Distribution by Regions

For comparison purposes, recoveries were assigned to three regions: (1) Eastern, which included all recoveries east of Ohio and Ontario and north of West Virginia and Maryland; (2) Western, which included recoveries west of the Eastern Region and north of Kentucky and West Virginia, and (3) Southern, which included recoveries south of the other two regions.

Comparatively few woodcock wintering in Louisiana were shot later in the Eastern Region. Most were harvested in the Western Region. This region, together with the Southern, accounted for 81.3 percent of all recoveries.

Sex Differences in Distribution

Indirect recoveries were examined to determine if there were differences between adult males and females in distribution of harvest in the northern and southern segments of the range. Sixty-three percent of adult male recoveries were reported from northern states and provinces. For adult females, this value was 68.7 percent. The difference is not statistically significant.

The recoveries also were examined by time periods within combined hunting seasons. Only 180 recoveries had necessary information on date and location of kill (Table 4).

Of 45 males shot north of 40° latitude, 17 (37.8 percent) were recovered before October 16. Twenty-four (30.4 percent) of 79 females were shot there during the same time span.

Sixty-two percent of the reported kill of males in the north occurred after October 16. Seventy-six percent of the female recoveries from the north occurred in this time interval. Again, differences were not statistically significant.

Results of wing-collection surveys conducted by the Bureau of Sport Fisheries and Wildlife have indicated that comparatively more adult males than adult females are shot in northern states late in the hunting season (Martin, Geis, and Stickel, 1965). More recoveries are needed to clarify this question.

Breeding-Ground Origin

Woodcock in the two northern regions probably were produced in the same region where they were shot. The importance of the Southern Region as a breeding ground is not known, but production there probably is small in comparison with the other regions. Therefore, some recoveries in the Southern Region represented birds produced elsewhere that were shot en route to Louisiana. Although the exact contribution of each northern region to the Southern Region is not clear, the pattern of recoveries suggests that most birds shot in the Southern Region were produced there or in the Western Region (Figure 1).

The best indication of breeding-ground origin of woodcock wintering in Louisiana probably comes from the percentage distribution of banded birds reported shot in the Eastern and Western Regions. Distribution of these recoveries was as follows:

Region	Number of Recoveries	Percentage of Total Recoveries
Eastern	53	27.5
Western	140	72.5
Total	193	100.0

Although about three-fourths of the recoveries occurred in the Western Region, this does not mean that three-fourths of the wintering population came from this region. For this to be true, the harvest rate (i. e., proportion of birds in each region that is shot) must be the same.

To gain insight into this problem, we weighted recoveries in each region by hunter-kill figures for 1965 (Goudy, 1966) and by breeding-population indices derived from singing-ground counts made in 1969 on randomly-selected routes (unpublished information provided by E. Clark). The weighting procedure and results are shown below:

Region	No. Recoveries	Estimated Kill (Thousands)	Percent of Breeding Pop.Index	Population-Kill Index (Recoveries ÷ Kill x B.P. Index)	Percentage Contribution to Louisiana
Eastern	53	340	45.0	7.02	25
Western	140	360	55.0	21.40	75
				28.42	

Weighted results were similar to the unweighted percentage distribution of recoveries. This is because the estimated harvest rate was about the same in each region. The information used in weighting is crude. Therefore, the findings are tentative.

These results suggest, however, that the Western Region contributes 75 percent of the woodcock wintering in Louisiana. When the Southern Region is considered, it appears that more than 80 percent of the Louisiana population is produced west of the Appalachian Mountains.

Migration Routes

Woodcock wintering in Louisiana seem to follow migration paths described by Glasgow (1958) and Sheldon (1967). There was a striking absence of both shot and non-shot recoveries in states along the South-Atlantic coast (Figures 1 and 2). According to Sheldon (1967), more than 90 percent of 100 recoveries from woodcock banded in Maine, Massachusetts, and New Brunswick occurred in these coastal states.

Few recoveries were reported from Kentucky and southern portions of Ohio, Indiana, and Illinois (Figures 1 and 2). Evidently, woodcock pass through this region rapidly. However, hunting seasons in these states may be set too late to harvest many woodcock.

Band-Recovery Rates and Causes of Mortality

Band-Recovery Rates

The band-recovery rates for woodcock reported shot in the first hunting season after banding were low. These rates averaged 0.85 percent for males and 0.95 percent for females.

Causes of Death

Shot recoveries formed 76.5 percent of the 412 recoveries reported to the Bird-Banding Laboratory through the 1966-67 hunting season. The cause of death of most non-shot recoveries was not clear. However, at least 11.3 percent of these recoveries represented deaths from collision (flying into objects, hit by automobiles, found dead on highway, etc.). When this minimal estimate is compared with the 0.14 percent of total non-hunting mortality caused by collisional death in waterfowl (Stout, 1967), this single cause of natural death in woodcock assumes added importance.

The probability of finding a banded woodcock that died of natural causes most likely is much lower than the probability of a hunter reporting a banded bird which he shot. Since non-hunting mortality represented 23.5 percent of all recoveries, it seems likely that most woodcock die from causes other than shooting. Although information is

lacking on percentage of banded birds retrieved and reported by hunters, as well as crippling loss, the low recovery rates also suggest that shooting is not a major cause of mortality in the overall population. These rates could be misleading, however. Some birds were shot during the winter of banding, and many more must have died during the long interval between banding and the next hunting season. The effects of shooting on total mortality can be answered best by bandings on the breeding ground shortly before the hunting season. Such bandings would also provide important information on the extent to which each age and sex is likely to be shot.

Annual Mortality

Mortality Rates of Males and Females

The 212 indirect recoveries reported shot through the 1966-67 hunting season were used to calculate average annual mortality rates. The three methods used were composite dynamic (Geis and Taber, 1963), Haldane extension of the dynamic (Haldane, 1955), and relative-recovery rates (Miller, Dzubin, and Sweet, 1968).

The composite-dynamic life table indicated average annual mortality rates of 40 percent for adult females and 59 percent for adult males (Tables 5 and 6). These rates were essentially the same when banded samples of less than 100 birds were excluded, and when non-shot recoveries were included with shot recoveries.

The Haldane method (with 95 percent confidence limits) also indicated higher mortality in adult males. Using all banded samples, the rates were 39 ± 7 percent for females and 58 ± 10 percent for males. Since the confidence limits do not overlap, this method suggests a real difference in mortality rates of adult males and females.

Relative-recovery rate estimates of adult female mortality agreed with dynamic estimates; when banded samples of less than 75 birds were excluded, the calculated mortality rate was 43 percent. The adult male mortality rate (47 percent) was much lower than the dynamic estimate (Tables 7 and 8).

Reliability of mortality calculations probably was affected by random error due to the small samples. The several methods used suggest, however, that the average annual mortality rate of adult females is approximately 40 percent. The number of recoveries probably is inadequate to measure mortality of adult males, but their rate of loss seems to exceed female mortality.

SUMMARY AND CONCLUSIONS

From 1948 to 1968, 17,176 woodcock were banded on the Louisiana wintering ground. Birds were captured from November to February, but most were banded in December and January. Females arrived earlier and remained longer than males.

The overall sex ratio was 0.9 male per female. If the age and sex composition of birds banded in the last two winters is representative of earlier years, banded samples contained more adult females than adult males, but more immature males than immature females.

Band recoveries were reported obtained in 15 ways. Shooting formed 76.5 percent of all recoveries. Collision was an important cause of natural loss. The average annual mortality of adult females was approximately 40 percent. A mortality rate was not determined for adult males, but it appeared to exceed female loss. The recovery rate of birds shot in the first hunting season after banding was only 1 percent, and suggests that shooting probably is not a major cause of mortality in the overall population.

Birds were reported shot in 23 states and 4 Canadian provinces, but Michigan, Louisiana, and Wisconsin accounted for more than half of the recoveries.

The distribution of recoveries suggests that more than three-fourths of the woodcock wintering in Louisiana are produced west of the Appalachian Mountains. Michigan and Wisconsin are especially important breeding grounds.

There was a striking absence of both shot and non-shot recoveries in states along the South-Atlantic coast, a region which winters most woodcock produced in New England and the Maritime Provinces. Evidently, birds wintering in Louisiana form a population distinctly apart from most woodcock produced in the Northeast.

Recognition of these different populations may have important management implications. Management units could be established, and different federal and state regulations could be set in each unit.

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TABLE 1. Number and sex of woodcock banded in Louisiana, 1948-49 to 1968-69

Winter Period	Number Banded				Percent		Sex Ratio
	Male	Female	Unknown Sex	Total	Male	Female	Males per Female
1948-49	8	17	8	33	32	68	0.47
1949-50	97	123	26	246	44	56	0.79
1950-51	215	278	96	589	44	56	0.77
1951-52	339	441	468	1,248	43	57	0.77
1952-53	322	160	199	681	67	33	2.01
1953-54	387	539	288	1,214	42	58	0.72
1954-55	145	251	383	779	37	63	0.58
1955-56	600	721	480	1,801	45	55	0.83
1956-57	350	609	320	1,279	37	63	0.57
1957-58	38	44	16	98	46	54	0.86
1958-59	286	209	219	795	50	50	0.98
1959-60	156	198	172	526	44	56	0.79
1960-61	...	...	...	...	..	..	...
1961-62	220	232	172	624	49	51	0.95
1962-63	96	95	214	405	50	50	1.01
1963-64	135	187	299	621	42	58	0.72
1964-65	1,099	1,211	86	2,396	48	52	0.90
1965-66	568	632	3	1,103	52	48	1.07
1966-67	541	381	0	922	59	41	1.42
1967-68	503	538	4	1,045	48	52	0.94
1968-69	416	355	0	771	54	46	1.17
Total	6,521	7,202	3,453	17,176	48	52	0.90

TABLE 2. Sex composition fluctuations in Louisiana-banded woodcock by 15-day time periods during the winter, 1948-49 to 1968-69

Time Period	Number Banded		Total Known Sex	Percent of Known Sex		Unknown Sex	Total Banded
	Male	Female		Male	Female		
Nov. 1-30*	69	120	189	36.5	63.5	102	291
Dec. 1-15	1331	1341	2672	49.8	50.2	488	3160
Dec. 16-31	1794	1699	3493	51.4	48.6	630	4123
Jan. 1-15	1401	1328	2729	51.3	48.7	768	3497
Jan. 16-31	1439	1702	3141	45.8	54.2	1001	4142
Feb. 1-15	468	934	1402	33.4	66.6	398	1800
Feb. 16-28	19	78	97	19.6	80.4	66	163
Total	6521	7202	13,723	...	...	3453	17,176

* November time periods were combined because only 52 woodcock were banded during the first 15-day period.

TABLE 3. Geographical distribution, by sex, of all indirect shot woodcock recoveries.

State or Province	Number and Percent of Recoveries						
	Number of Males	Percent Male	Number of Females	Percent Female	Number of Unknown	Total	Percent of Total
Alabama	4	5.0	3	2.3	3	10	3.5
Arkansas	6	7.4	2	1.5	..	8	2.8
Connecticut	..	..	..	..	2	2	.7
Illinois	..	..	2	1.5	..	2	.7
Iowa	..	..	1	.8	0	1	.3
Kentucky	5	6.2	2	1.5	..	7	2.5
Louisiana	11	13.6	24	18.3	15	50	17.6
Maine	..	..	2	1.5	2	4	1.4
Massachusetts	1	1.2	3	2.3	..	4	1.4
Michigan	17	21.0	43	32.8	22	82	28.9
Minnesota	3	3.7	1	.8	3	7	2.5
Mississippi	2	2.5	8	6.1	2	12	4.2
Missouri	1	1.2	1	.8	3	5	1.8
New Brunswick	..	..	..	..	1	1	.3
New Hampshire	4	5.0	1	.8	2	7	2.5
New Jersey	..	..	2	1.5	..	2	.7
New York	3	3.7	4	3.0	4	11	3.9
Nova Scotia	1	1.2	..	..	1	2	.7
Ohio	..	..	2	1.5	1	3	1.0
Ontario	3	3.7	3	2.3	3	9	3.2
Pennsylvania	6	7.4	7	5.3	2	15	5.3
Quebec	1	1.2	1	.8	..	2	.7
Tennessee	1	1.2	1	.8	..	2	.7
Texas	..	..	..	..	1	1	.3
Vermont	2	2.5	1	.8	..	3	1.1
West Virginia	1	1.2	..	..	..	1	.3
Wisconsin	9	11.1	17	13.0	5	31	10.9
Total	81	100.0	131	100.0	72	284	100.0
Percent	28.5	..	46.1	..	25.4	100.0	..

TABLE 4. Chronological distribution of indirect shot recoveries of male and female woodcock by 15-day time periods above and below 40° latitude.

Time Period Shot	Males (70 Recoveries)		Females (110 Recoveries)	
	Number Above 40°	Number Below 40°	Number Above 40°	Number Below 40°
Sept. 16-30	0	0	1	0
Oct. 1-15	17	0	23	0
Oct. 16-31	23	2	42	0
Nov. 1-15	5	0	12	1
Nov. 16-30	0	4	1	4
Dec. 1-15	0	6	0	4
Dec. 16-31	0	4	0	12
Jan. 1-15	0	4	0	8
Jan. 16-31	0	5	0	1
Feb. 1-15	0	0	0	1
	45	25	79	31

TABLE 5. Estimate of mortality rate by composite-dynamic method for adult male woodcock

Season Banded	Number Banded	Number of Recoveries by Hunting Season 1	2	3	4	Total
1948-49	8	2	0	0	0	
1949-50	97	0	0	0	0	
1950-51	215	1	1	0	0	
1951-52	339	5	4	0	0	
1952-53	322	0	1	2	0	
1953-54	387	2	1	0	0	
1954-55	145	0	0	0	0	
1955-56	600	5	4	3	0	
1956-57	350	4	3	0	0	
1957-58	38	0	2	0	0	
1958-59	286	2	2	2	1	
1959-60	156	4	1	0	0	
1960-61	...	..	..	..	..	
1961-62	220	1	2	0	0	
1962-63	96	0	1	0	0	
1963-64	135	1	1	1	..	
1964-65	1,099	10	6	..	..	
1965-66	568	6	..	..	..	
Total	5,061	43	29	8	1	81
Number Available		5,061	4,493	3,394	3,259	..
Percent Reported Shot		.85	.64	.24	.03	1.76
Percent Alive at Start		1.76	.91	.27	.03	2.97

$$\text{Average annual mortality rate} = \frac{1.76}{2.97} = .59$$

TABLE 6. Estimate of mortality rate by composite-dynamic method for adult female woodcock.

Season Banded	Number Banded	Number of Recoveries by Hunting Season 1	2	3	4	5	6	7	8	9	Total
1948-49	17	0	0	0	0	0	0	0	0	0	...
1949-50	123	1	0	0	0	0	0	0	0	0	...
1950-51	278	1	0	1	0	1	0	0	0	0	...
1951-52	441	4	3	1	1	0	0	0	0	1	...
1952-53	160	2	1	1	0	0	0	0	0	0	...
1953-54	539	3	1	1	3	0	1	0	0	0	...
1954-55	251	4	3	0	2	0	0	0	0	0	...
1955-56	721	5	4	2	2	0	1	0	1	0	...
1956-57	609	5	6	3	2	0	2	0	1	0	...
1957-58	44	1	1	0	0	0	0	0	0	0	...
1958-59	290	2	3	3	0	1	1	0	0	.	...
1959-60	198	1	3	0	0	0	0	0	.	.	...
1960-61	...	..	..	..	..	..	..	..	..	..	...
1961-62	232	1	4	1	1	0	..	..	..	..	...
1962-63	95	3	..	1	0	..	..	..	..	..	...
1963-64	187	2	2	1	..	..	..	..	..	..	...
1964-65	1,211	15	7	..	..	..	..	..	..	..	...
1965-66	532	7	..	..	..	..	..	..	..	..	...
Total	5,928	57	38	15	11	2	5	0	2	1	131
Number Available		5,928	5,396	4,185	3,998	3,903	3,671	3,671	3,473	3,183	...
Percent Reported Shot		.96	.70	.36	.28	.05	.14	.00	.06	.03	2.58
Percent Alive at Start		2.58	1.62	.92	.56	.28	.23	.09	.09	.03	6.40

$$\text{Average annual mortality rate} = \frac{2.58}{6.40} = .40$$

TABLE 7. Estimates of mortality by relative recovery rate method for adult male woodcock. Method utilizes only those years in which 75 or more were banded.

Winter Period Banded	Number Banded	Number of Recoveries*		Recovery Rates	
		HS_1-HS_j	HS_2-HS_j	HS_1-HS_j	HS_2-HS_j
1949-50	97	0	0	....	.0000
1950-51	215	2	1	.0093	.0046
1951-52	339	9	4	.0265	.0118
1952-53	322	3	3	.0093	.0093
1953-54	387	3	1	.0078	.0026
1954-55	145	0	0	.0000	.0000
1955-56	600	12	7	.0200	.0117
1956-57	350	7	3	.0200	....
1957-58	...	..	..	....	....
1958-59	286	7	5	....	.0175
1959-60	156	5	1	.0320	....
1960-61	...	..	..	....	....
1961-62	220	3	2	....	.0091
1962-63	96	1	1	.0104	.0104
1963-64	135	3	2	.0222	.0148
1964-65	1,099	16	6	.0146	.0054
1965-66	568	6	0	.0106	....
Total				.1827	.0972

$$\text{Average annual survival} = \frac{.0972}{.1827} = 0.53$$

Average annual mortality rate = 1 - 0.53 = 0.47

TABLE 8. Estimates of mortality by relative-recovery rate method for adult female woodcock. Method utilizes only those years in which 75 or more were banded.

Winter Period Banded	Number Banded	Number of Recoveries*		Recovery Rates	
		HS_1-HS_j	HS_2-HS_j	HS_1-HS_j	HS_2-HS_j
1949-50	123	1	0	....	.0000
1950-51	278	3	2	.0108	.0072
1951-52	441	10	6	.0227	.0136
1952-53	160	4	2	.0250	.0125
1953-54	539	9	6	.0167	.0111
1954-55	251	9	5	.0359	.0199
1955-56	721	15	10	.0208	.0139
1956-57	609	19	14	.0312	....
1957-58	...	..	..	....	....
1958-59	290	10	8	....	.0276
1959-60	198	4	3	.0202	....
1960-61	...	..	..	....	....
1961-62	232	7	6	....	.0259
1962-63	95	4	1	.0421	.0105
1963-64	187	5	3	.0267	.0160
1964-65	1,211	22	7	.0182	.0058
1965-66	532	8	0	.0150	....
Total				.2853	.1640

$$\text{Average annual survival rate} = \frac{.1640}{.2853} = 0.57$$

Average annual mortality rate = 1 - .57 = 0.43

* HS = hunting season of recovery; HS_1 = first hunting season; HS_2 = second hunting season; HS_j = last hunting season for which recoveries are available.

Figure 1. Geographical distribution of 284 indirect shot woodcock recoveries (male, female, and unknown) by degree block of recovery. Heavy lines denote eastern, western, and southern regions.

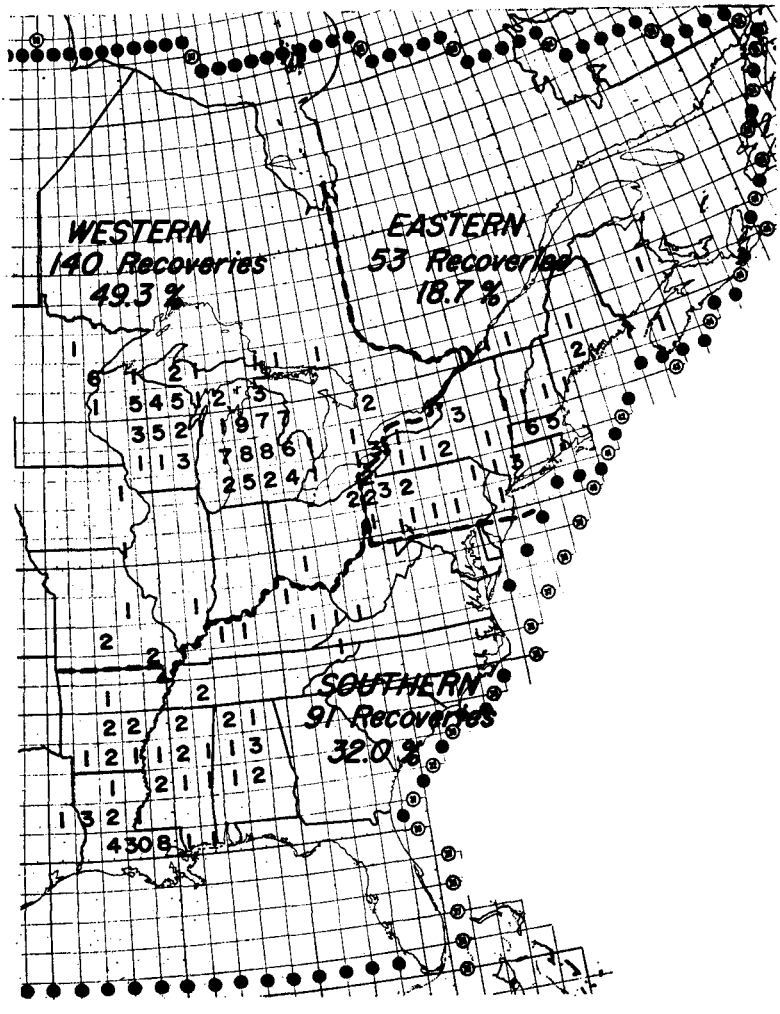

Figure 2. Geographical distribution, by degree block, of 412 woodcock recovered from all causes.