A DECADE OF BIRD BANDING IN AMERICA: A REVIEW

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FREDERICK C. LINCOLN

Biologist, United States Biological Survey

FROM THE SMITHSONIAN REPORT FOR 1932, PAGES 327–351
(WITH 5 PLATES)

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From its inception in 1885, the study of North American birds by the Biological Survey of the United States Department of Agriculture has continued to be a major activity of this bureau. The distribution, migration, and economic status of birds have claimed the attention of its specialists for nearly 50 years, and the leadership of the bureau in these fields of research continues to be demanded. Since practically every method advocated for the development of new information has been thoroughly tested by the bureau, it is not surprising to find that, with the active cooperation of Canadian officials, it is directing one of the greatest studies of avian life ever attempted, namely, that conducted through a continental system of cooperative, volunteer, bird-banding stations.

In the Report of the Smithsonian Institution for 1927, under the title "Bird Banding in America" (pp. 331–354, 1928), the author presented a historical sketch and account of the development of the work during the preceding five years. Another 5-year period has now elapsed, and in concluding this full decade of intensive effort, it is fitting, in retrospect, to view the accomplishments.

Any new field of research is usually divisible into three periods: First, experimentation, when methods are developed; second, data accumulation; and third, interpretation and report. Properly speaking, none of these has an ending, as the perfection of technique and the testing of new methods and refinements continue indefinitely, as may also the collection of usable data. A starting point for the third period is, however, dependent wholly upon the successful prosecution of the other two, as obviously, no interpretation can be prepared until sufficient material has been obtained to permit proper evaluation. The banding work, as applied to North American birds, has only within the last few years entered this third period. During the 10 years many reports of more or less fundamental importance have been issued, but the data applicable to the larger ornithological

problems have only recently accumulated in adequate quantity, even for those species which from the beginning have received most attention.

As a means of illustrating the growth of the project—which reflects also the great interest in this means of investigation that has developed among the bird students of the continent—an examination of Table 1, showing the gross results, will be of interest. The fiscal years are those of the Federal Government, that is, beginning July 1 and ending June 30.

TABLE 1.—*Progress of bird banding in America*

Fiscal year	Number of cooperators	Number of birds banded	Number of returns [1]	Fiscal year	Number of cooperators	Number of birds banded	Number of returns [1]
1921	135	2,845	----------	1923	[2] 1,400	127,105	7,222
1922	490	5,940	149	1929	[2] 1,500	133,931	[2] 8,500
1923	851	25,068	668	1930	[2] 1,750	182,263	[2] 10,000
1924	890	40,432	1,924	1931	1,869	169,279	12,329
1925	1,100	64,253	3,187	1932	1,976	212,146	[3] 11,789
1926	1,134	68,418	3,351				
1927	1,296	91,848	4,445	Grand total	----------	1,123,523	63,564

[1] As applied to the bird-banding work a "return" is the record of a banded bird retrapped from the same or any other station during or following the succeeding migration period, and also banded birds that are killed, either accidentally or otherwise, regardless of the elapsed time since they were banded.

[2] Approximate.

[3] The reduced number of return records for the fiscal year 1932 is explained by the reduction of the shooting season for waterfowl from 3 months to 1 month in the fall of 1931.

When the work was started it was natural that those species to be banded in largest numbers should be the common frequenters of our dooryards, usually easily captured by the traps and methods then known. The results of the pioneer work of Dr. S. Prentiss Baldwin (1919) involved the use of traps originally developed by the Biological Survey for the control of English sparrows. His report became the first textbook and the foundation upon which the structure of future activities was laid. It was immediately obvious, however, that with our great and varied avifauna, there existed a vast field to tax the ingenuity of station operators in devising efficient means for bringing additional species within the scope of the work. The capture of the ground feeders, which respond readily to cereal baits is a comparatively simple matter, but the insect feeders and particularly those whose field of action is chiefly in the tree tops presented a much more difficult problem.

The large and interesting family of wood warblers for several years defied the efforts of station operators to trap them. Many elaborate traps were worked out and pulled high in the trees by means of endless ropes and pulleys, while bait items ran a long gamut, mostly without success. Finally it was discovered that "live" water, that is, water in a state of motion, had a potent at-

traction for these birds, and would frequently bring them to the ground (pl. 1 and pl. 2, fig. 1). With this knowledge, progress was rapid until now many stations are taking them in considerable variety and number. For example, a report recently received by the Biological Survey, following the spring migration of 1932, contained the banding records for 155 warblers of 19 species, while reports from other points show similar success.

Some of the author's early work in the field of banding had to do with the development of a satisfactory trap for ducks. The traps that had been used by market hunters were known, but generally these were found to be unsatisfactory for banding work. A short period of experimentation, however, resulted in the perfection of a simple trap that gave excellent results when used for mallards, black ducks, pintails, and other shoal-water species. Success here was somewhat discounted by the skeptics who openly declared that it would be a different matter when operations were begun with canvasbacks, redheads, scaups, and other deep-water species. It was a different matter, but already several thousands of these ducks have been banded (pl. 2, fig. 2, and pl. 3, fig. 1). In fact it is now a maxim with bird banders that "there is a way to trap everything if you can only solve the problem," and "you can trap any species for which you can discover an attractive bait."

The smaller tree climbers, such as the brown creeper and the black and white warbler, presented another problem. As these birds ascend the trunk of a tree it had been noticed that if they met any kind of an obstruction, they generally flew to another tree. It was found, however, that if the barrier slanted upward, the birds would continue to ascend, keeping a short distance away from the obstruction. Upon the basis of this observation, William I. Lyon, of Waukegan, Ill. (1924), worked out a highly successful trap for taking these birds (pl. 3, fig. 2, and pl. 4). A collar of wire netting, tacked to the trunk of the tree in an ascending spiral, serves to guide the climbing bird into the trap chamber.

GAME SPECIES—WATERFOWL

From the beginning of the project, the Biological Survey has given all possible attention to the banding of large numbers of migratory waterfowl, confidently believing the resulting data would be most useful in its administration of this important natural resource. Table 2 illustrates in part the success that has attended these efforts. With the data represented in this table available, valuable contributions may be made to the problems of conservation. The following summaries are based on studies already made or in progress.

TABLE 2.—*Banded waterfowl*

Species	Number banded	Number of returns	Species	Number banded	Number of returns
Mallard	40,369	8,036	Cinnamon teal	562	38
Black duck	14,346	2,883	Shoveler	346	63
Gadwall	671	113	Redhead	3,149	545
Baldpate	2,883	633	Ring-necked duck	2,083	241
Pintail	15,207	2,512	Canvasback	752	100
Green-winged teal	3,022	408	Lesser scaup	9,699	591
Blue-winged teal	2,741	332			

Migration.—Study of the distribution and migration of North American waterfowl continues to be a major project of the Biological Survey, and as will be noted from the data contained in Table 2 the number of banding records applicable to this subject is increasing rapidly.

A detailed investigation of the distribution and migration of the mallard and the black duck, two of the most important species of game waterfowl, is now in progress. Several thousand return records are at hand, which make it possible not only to present in full detail the intricate movements that make up the semiannual movements of these birds but also to portray graphically the way the flocks sweep across the country. While ornithologists and sportsmen have long understood the existence of migration flyways, along which birds are more or less concentrated, there has been a tendency to consider these lines of arterial traffic as narrow lanes, rather than as broad boulevards. The banding records show the general routes followed and also their approximate widths. From a study of these data a new type of migration map (fig. 1) has been devised to illustrate the advance and spread across the country of the ducks from any particular breeding or concentration area. Several maps of this type will show the movement of a species from different areas, and when these are superimposed on each other the resulting map should present an easily understood picture of the entire migratory flight for that species.

As will be seen from the map (fig. 1), ducks banded in the Prairie Provinces of Canada, in the autumn move both southeast and southwest. In fact, the great flocks of canvasbacks and redheads that winter on the Atlantic coast come chiefly from the interior breeding ground.

The banding work early showed that during the migratory season there is very little interchange of waterfowl between the eastern and the western halves of the country within the United States, even with those species that have a more or less general continental distribution. On the breeding grounds in central Canada the eastern and western ducks intermingle freely, but when the time comes for

migration they separate and each group adheres to its ancient flyways. The proof of this lies in the fact that very few ducks banded in the United States east of the one hundredth meridian (central North Dakota, South Dakota, and Nebraska, western Kansas, and central Texas) are killed west of this line while in the United States, and vice versa.

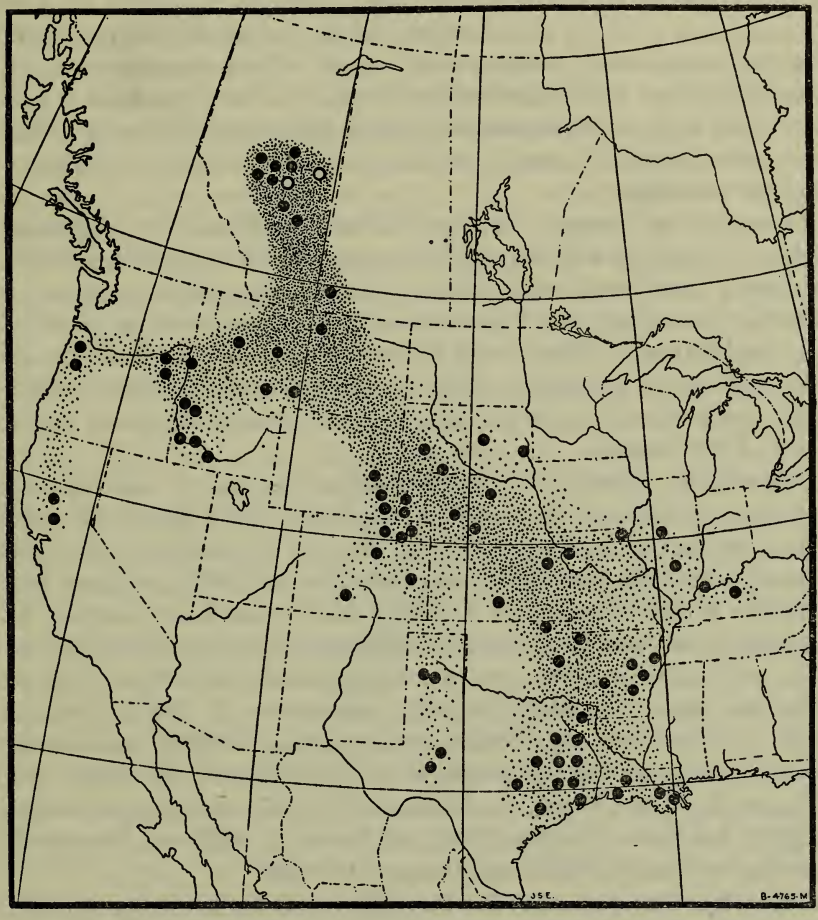

FIGURE 1.—The autumn migration of mallards from Alberta. Each large spot indicates the point of recovery of a banded duck while the shading shows the relative density of the flight in the different regions

The significance of this discovery will be more readily understood by reflecting upon the present condition of our wild waterfowl. During recent years drought conditions, disease, overshooting, and other unfavorable factors have been disastrous to these birds, chiefly those inhabiting the western part of the country. Some species (notably the diving ducks) that visit the eastern district have also been seri-

ously reduced, while others, such as the mallard and the pintail, that frequent the eastern plains region, the Mississippi Valley, and the Atlantic coast, have not been so much affected. It is easy to conceive that these conditions might become so acute that a complete cessation of wildfowl hunting would be imperative all through the West; possibly important species of migratory game birds might be virtually extirpated over vast areas in this part of the country, and at the same time be fairly abundant east of the one hundredth meridian. The banding records indicate that should such a disaster overtake these birds, those that migrate through and winter in the East would be very slow to overflow and repopulate the devastated areas in the West even though a complete recovery of natural habitat conditions might be achieved.

There are, of course, very well-defined northwest by southeast flights of ducks, best illustrated by considering the line of migration previously mentioned and which is followed by redheads and canvasbacks in reaching the Atlantic coast from their breeding grounds in central Canada. These birds follow the general line of the Great Lakes and thence overland to Delaware and Chesapeake Bays. Such flights are not to be confused with the more nearly north and south routes of the interior.

Nevertheless, occasionally ducks banded at eastern stations are recovered subsequently at points in the West as the following cases will illustrate: A mallard (231104) banded at Browning, Ill., on November 30, 1922, was killed near Sacramento, Calif., on December 24, 1923; a blue-winged teal (323756) banded at Lake Scugog, in southern Ontario, on September 24, 1925, was recovered in San Francisco Bay, Calif., on December 12, 1926; a pintail (367029) banded at Ellinwood, Kans., on March 4, 1925, was retaken in Butte County, Calif., on December 19, 1925; a greater scaup (204206) banded at Union Springs on Cayuga Lake, N. Y., on February 27, 1923, was killed at Big Lake, Wash., on December 7, 1927; and a lesser scaup (322327) banded at Oakley, S. C., on March 6, 1925, was recovered in Berkeley County, Calif., on January 13, 1926.

State dispersal of ducks.—In those States so fortunate as to have abundant waterfowl there are always centers of abundance, that is, areas of great importance to these birds as breeding grounds in summer or as feeding and resting grounds in winter. During the past 10 years many of these areas have supported active waterfowl-banding stations among which may be mentioned Lake Merritt, at Oakland, Calif., Lake Malheur, Oreg.; the National Bison Range, western Montana; the Bear River Marshes, at Great Salt Lake, Utah; Dawson, N. Dak.; the Cheyenne bottoms, Kansas; the marshes of the Illinois River, central Illinois; Cuivre Island and Portage des Sioux,

Mo.; Avery Island and the Paul J. Rainey Wild Life Refuge, La.; Waco, Tex.; Green Bay and the Moon Lake Wild Life Refuge, Wis.; Munuskong State Park and the Kellogg Bird Sanctuary, Mich.; Rochester and Long Island, N. Y.; Bar Harbor, Me.; Cape Cod, Mass.; the coastal marshes of South Carolina; and the lakes of southern Georgia. In Canada important stations have operated at Lac Ste. Anne and Leduc, Alberta; Muscow and Yorkton, Saskatchewan; and Kingsville and Lake Scugog, Ontario.

Sportsmen and conservation officials are keenly interested in knowing the dispersal of the ducks that concentrate at one season or another in these areas. Also, such information is highly practical from the viewpoint of game administration, in indicating the regions that may require special measures for their protection, such as the establishment of refuges. For example, during the time that the act which created the Bear River Migratory Bird Refuge in Utah was pending in Congress, some opposition developed from a group of California sportsmen who contended that the number of hunters concerned with this area was too small to justify expenditure of the funds that were contemplated. The records of ducks banded in these great marshes showed conclusively that the big flights of birds to California came through or from this section. When the data were shown on a map and made puplic, opposition quickly subsided. Similarly a map showing the dispersal of ducks banded in the Cheyenne Bottoms, Kans. (fig. 2), played an important part in the establishment of a Federal migratory-bird refuge at this point.

Calculating waterfowl abundance.—A major problem of sportsmen, naturalists, and conservation officials is the effect upon the supply of waterfowl of the annual kill by hunters. It is important to know whether the sportsman is merely harvesting the increase or whether he is also cutting into the breeding stock necessary for the perpetuation in adequate numbers of the different species. The many factors involved make the solution of this problem extremely difficult, and it will be apparent that the mere opinion of any single observer or group of observers can be accorded little weight unless it is known that all pertinent data have been taken into consideration. Nevertheless, it is believed that the most important factors may be calculated or at least estimated with accuracy sufficient for practical purposes. If this be true, then it appears that data from banded ducks will offer a reliable method for computing the annual fluctuation in the abundance of these birds. The basis of this belief is the constant relation that seems to exist between the number of ducks banded and the number of these killed during the first succeeding hunting season.

Briefly stated, the solution of this part of the problem may be found in the following postulate: Given a fairly accurate statement of the number of wild ducks killed in North America in any one season, the total number of ducks present on the continent for that

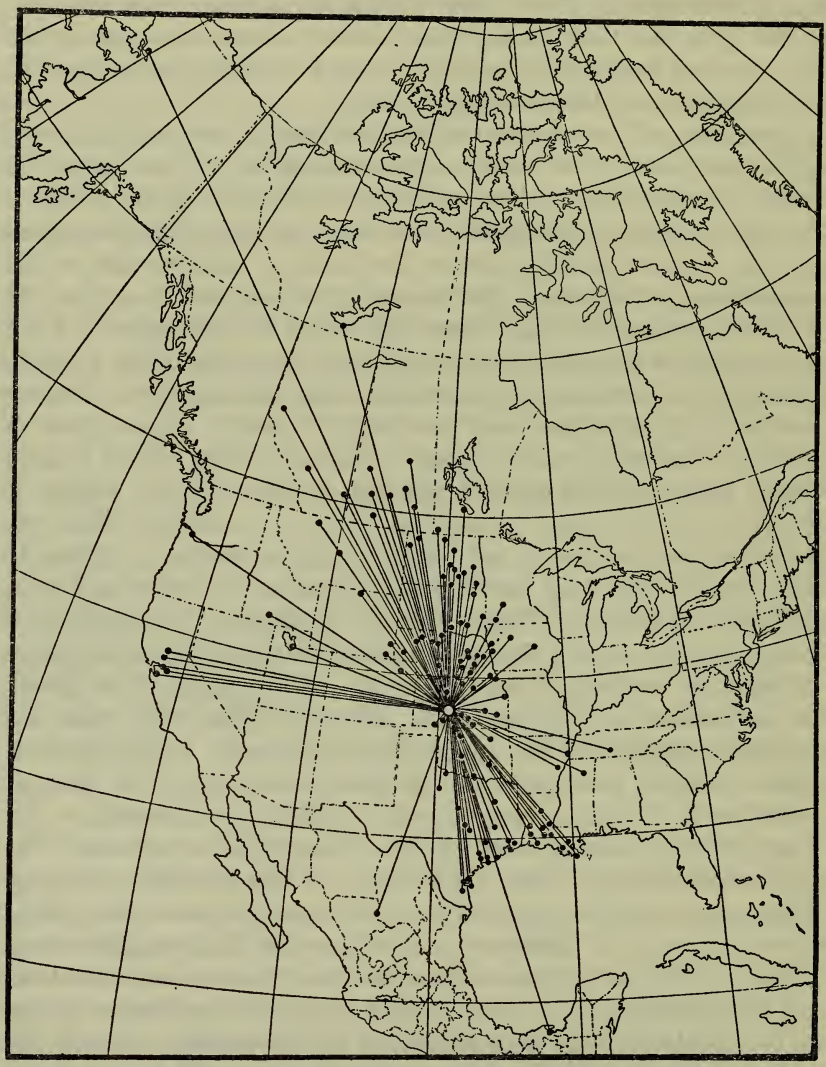

FIGURE 2.—The dispersal of banded ducks from the Cheyenne Bottoms, Kans.

season may be estimated by a percentage computation based upon the ratio that the total number of banded ducks killed during their first season as band carriers, has to the total number banded. (Cf. Lincoln, 1930.)

TABLE 3.—*Percentages of returns throughout the country of banded ducks during the shooting season immediately following their banding, 1920–1926*

Year	Number banded	Number of returns	Percentage	Year	Number banded	Number of returns	Percentage
1920	238	31	13.03	1925	1,795	214	11.92
1921	382	52	13.61	1926	4,891	444	9.08
1922	3,774	572	15.16				
1923	4,103	438	10.68	Total or average	17,449	2,083	11.94
1924	2,266	332	14.65				

Table 3 shows this relationship and the percentages based on the material available after seven years' work. The average of about 12 per cent is slightly increased when the results from the different banding stations are considered separately, the average first-season recoveries being between 12 and 13 per cent. Twelve per cent, however, is very close to a general average and may be accepted as a basis for computation, particularly when it is remembered that we are dealing with a problem in which the units are to be shown in millions. Disregarding other factors (which are, however, of decided importance), an illustrative case may be assumed as follows: If in one season, 5,000 ducks are banded and these yield the expected 600 first-season returns, or 12 per cent, and during that same season, the total kill is determined at 5,000,000, then the waterfowl population for that reason was approximately 42,000,000. To assume further: If during the following season (both seasons of equal length), the total kill is estimated at 500,000 birds less, then the total duck population for that year would be about 37,500,000, or an approximate decrease of 4,500,000 in the continental waterfowl population.

Such figures naturally should be considered only as approximations but they would at least have the merit of being based on factors appearing to have a definite relationship. As the work continues, additional data are being accumulated so it should be possible ultimately to arrive at an average percentage in which the margin of error will be reduced to a negligible quantity.

Sex ratio.—It is common knowledge among sportsmen that the average bag of ducks is likely to contain more males than females. This, however, is not surprising, since it is fairly obvious that in a mixed flock of both sexes the aim of the shooter would unconsciously be directed toward the males because of their more striking and conspicuous plumage.

But it would seem that the large cage traps used to capture ducks for banding can not be selective as regards sex. As a matter of fact, observations of the author on one species, the pintail, indicate the

females to be less suspicious than males, which are frequently led into the traps by their consorts. Nevertheless, as early as 1922, while experimental work to develop a satisfactory duck trap was in progress a total "catch" of 388 mallards was divided into 248 males and 140 females, or a ratio of a little less than two to one. Personal experience since that time in other regions, at other seasons and with other species has indicated a corresponding preponderance of males over females. Also, the operators of other waterfowl banding stations frequently have commented upon the relatively large numbers of males that were trapped in proportion to the females.

Generally speaking, all birds are naturally monogamous, so theoretically it would seem logical to assume a reasonably perfect numerical equality of the sexes. This condition has been borne out by investigators who have studied the sex ratio of the domestic fowl. For example, Darwin worked out the ratio as 48.64 to 51.36 in favor of the female, while more recently Prof. Raymond Pearl, of Johns Hopkins University, working on a basis of 22,000 chicks, obtained a ratio of 48.57 to 51.43 males to females, thus giving almost perfect confirmation to the pioneer results of Darwin. The apparent situation among our waterfowl appears, therefore, to warrant serious study.

As a contribution to the subject the author has made (1932) a statistical analysis of the banding data for certain species of ducks. The material available for study consisted of banding records from about 50 trapping stations located geographically from Maine, Connecticut, and South Carolina, west to California and Oregon, and from Alberta, Saskatchewan, and Michigan, south to Georgia, Louisiana, and Texas. The data represented 10 of the most important species of game waterfowl and totaled 40,904. This was only a little more than half of the grand total of banded ducks, but certain lots of records were considered ineligible for inclusion in the study for various reasons. Among these were the unknown ability of some operators to sex their birds, particularly in late summer and early fall when the plumage of immature birds closely resembles that of the females. In other words, all data that in any way might be considered as open to question were excluded from the study.

The proportion of sexes in the total number was 24,411 males to 16,493 females, or about three males for every two females. The detailed comparison shown by species is well illustrated in Table 4.

The results shown in the gross numbers are similarly borne out by the records from the individual stations, in some cases the proportion being even greater. For example, of 415 mallards banded at Dawson, N. Dak., in the autumn of 1926, 309 were males and 106 were females, or a ratio of nearly 3 to 1.

TABLE 4.—*Percentage of males in banded ducks*

Species	Males	Females	Percentage of males	Species	Males	Females	Percentage of[1] males
Wood duck	391	367	52	Lesser scaup	2,633	1,444	65
Mallard	12,386	9,572	56	Blue-winged teal	765	411	65
Black duck	477	344	58	Green-winged teal	357	95	79
Baldpate	413	251	62	Ring-necked duck	455	123	79
Pintail	6,308	3,759	63				
Canvasback	226	127	64	Total	24,411	16,493	59

[1] In the computation of percentages the figures have been carried to the second decimal, and the remaining fraction, if less than 0.5, has been dropped, while if more than 0.5 the next higher unit has been adopted.

It will be observed that in the case of the wood duck, there is a more normal representation of what might be properly expected as a sex ratio. As this handsome bird for 16 years has enjoyed comparative immunity from shooting, the conclusion seems to be fairly well justified that overshooting has been responsible for the disproportionate ratios in the other species. Possibly this is the correct solution, but further study of the problem will be required before the full significance of the data will be apparent. Nevertheless, despite the seeming truth of the hypothesis that more males than females are killed by hunters, it appears obvious the drakes now outnumber the hens in a proportion that does not auger well for the successful rearing of broods of ducklings.

NONGAME SPECIES

Banding problems dealing with nongame species, and which engage the attention of the Washington staff of the Biological Survey, relate almost entirely to distribution and migration. Contributions to this subject by individual station operators obviously can have only local significance for the reason that interpretation of the data assembled from points over the entire hemisphere can be satisfactorily made only at the central office. There are, however, exceptions, as occasionally a station operator will obtain an adequate quantity of data from his own birds, or he may be able to coordinate the activities of several widely scattered stations and so be placed in possession of sufficient material to warrant interpretation. The following examples, dealing with the evening grosbeak and the Harris sparrow, illustrate the case in point.

East and west migration.—The general (and usually correct) conception of bird migration is of a north and south movement. In addition, for many years we have been familiar with what is known as "vertical migration" whereby mountain-dwelling species obtain latitudinal changes in habitat by the simple expedient of moving down the mountain sides in the autumn and back again in

the spring. It now appears, however, that some birds make east and west trips with the same regularity of others in their journeys between the North and the South. The evening grosbeak (*Hesperiphona vespertina*) is an excellent example.

This large finch breeds almost entirely in the Canadian Zone, and while it is a notorious wanderer, it is detected only occasionally as far south as Missouri, Kentucky, and Maryland. At one banding station, operated at Sault Ste. Marie, Mich., it is plentiful, and many are banded each year. From these, several return records are available, the points of recovery extending west to Karlstad, Minn., and east to eastern Massachusetts and Connecticut (Magee, 1930). Altogether some 9 or 10 records indicate the remarkable "sidewise" movement of this bird. In addition to those banded at the Michigan station and recovered at eastern and western points, one was there recaptured which had been banded at Hanover, N. H.

Banding records for other species indicate that east and west movements may not be as unusual as has been believed.

A coot (A515245), banded at Green Bay, Wis., on October 22, 1930, was killed at Essex, Conn., on November 5, 1930.

A duck hawk (A701032), banded at Mohonk Lake, N. Y., on June 18, 1929, was recaptured at Grand Island, Nebr., on September 26, 1929.

A chimney swift (A37826), banded at Thomasville, Ga., on October 3, 1925, was captured at Claremore, Okla., on June 6, 1928, and again on May 8, 1929.

A blue jay (A346309), banded at Hubbard Woods, Ill., on May 13, 1930, was recovered at Bluevale, Ontario, on February 24, 1931.

A purple finch (A124752), banded at Katonah, N. Y., on April 23, 1930, and another (C69545), banded at Sault Ste. Marie, Mich., on August 17, 1930, were retrapped together at Milton, Mass., on February 14, 1931.

Another purple finch (A54292), banded at Cohasset, Mass., on January 30, 1927, was retrapped at Pickford, Mich., on March 10, 1929.

A junco (84691), banded at Crystal Bay, Minn., on October 13, 1923, was retrapped at Demarest, N. J., on January 9, 1926.

Another junco (A61943), banded at Paoli, Pa., on November 6, 1927, was retrapped at Jamestown, N. Dak., on April 23, 1928.

Harris sparrow.—An important contribution to our knoweldge of this little-known species has been made by Swenk and Stevens (1929). The junior author, himself the operator of one of the larger banding stations, established contact with six other stations where Harris sparrows were common and so added greatly to the data for his study. The records from one station (Fairbury, Nebr.) showed a

remarkably large percentage of these birds returning to winter in the same place. For example, of 13 birds banded in February, 6, or 46.1 per cent, returned the following year. Data obtained at Fargo, N. Dak., indicated that the southward migration of the adults is more rapid than that of the immatures. In 1928, 38 adults stayed in the vicinity of the banding station for an average of only 2.4 days, while the immature birds made stop-overs averaging 8.7 days.

The return to exact winter quarters of certain birds has been demonstrated on several occasions, perhaps the best example being a small group of banded white-throated sparrows that returned year after year to a patch of ornamental shrubbery on a plantation at Thomasville, Ga. (Cf. Baldwin, 1922.) Other stations have had similar experience with juncos, chipping sparrows, and other finches. This habit appears to be fairly well established for several birds, but it also appears that all individuals may not make the same stops while on their migratory journeys. The best evidence of this comes from a banding station at Waukegan, Ill., where more than 6,000 white-throated sparrows have been banded. A few return records for these birds have been reported from other points, but up to the present time (July, 1932) the operator of this station has not recaptured in a successive season a single banded white-throat.

Studies at banding stations.—Among the published reports of the past few years there are intimate studies dealing with local movements and other habits of certain birds, some of which are usually considered to be more or less resident in their respective areas. It is in investigations of this kind that the individual station operator comes "into his own," as it is practical for him to work out his entire problem without the necessity for access to data from other points. To be sure, before the results obtained in one area can be considered as being applicable to the species over its entire range, a certain amount of repetition must take place in other sections, but this in no way militates against the completion by a single worker of a definite piece of research.

The species that have been accorded this treatment include the song sparrow, the house wren, the white-breasted nuthatch, the tufted titmouse, and the chickadee. In some of these studies the permanent registration of the numbered aluminum band has been supplemented by second bands of colored celluloid which enabled the investigator to keep individual birds under more or less continuous observation, without the necessity for frequent retrapping.

Dr. Wilbur K. Butts (1930 and 1931), after much experimental work involving the use of stains, dyes, and enamels, devised a method for the manufacture of small celluloid bands. These are now stocked regularly by the Biological Survey. Doctor Butts conducted an

exhaustive inquiry into the local movements of the chickadee (*Penthestes atricapillus*) and the white-breasted nuthatch (*Sitta carolinensis*) on the Cornell University campus and the nearby Louis Agassiz Fuertes Bird Sanctuary. The study was begun in the autumn of 1924 and continued (with interruptions of a few months at a time) to 1929. During this period practically all of the chickadees and nuthatches within the area were banded both with a numbered aluminum band and a colored celluloid band.

It was found that during the winter season there were four or five times as many chickadees present as during the breeding season, which possibly indicates a migration of certain individuals, although the breeding birds of the area were all, or nearly all, permanent residents. The influx of birds from other regions occurred between August and January 1, while most of these transients left in March and April. Chickadees are known to wander in small flocks, but it was ascertained that these were not, as might be otherwise expected, family parties. Nevertheless, the flocks behaved as semipermanent units and had definite restricted feeding territories of from 40 to 70 acres. When nesting it was found that the birds ranged about 100 yards from the nest, although most of the food was obtained much nearer. When one member of a mated pair suffered an accident or disappeared for any reason, the survivor frequently obtained a new mate, and it was determined that the fact of an adult raising a brood of young could not be accepted as prima facie evidence that it was caring for its own offspring. In this species at least, the young finally disperse widely from the nest.

In the case of the nuthatch Doctor Butts found that there was no evidence of migration in the region of Ithaca, N. Y., and that the birds he studied were permanent residents. These birds ranged in both summer and winter over areas approximately equal in size, but they showed no hesitation in changing the scene of their operations in the different seasons. In addition to mated pairs which have established their territories, there are usually a number of wandering unmated birds which may take the place of one member of a pair if for any reason it disappears. It was also found that the parents had little difficulty in finding ample food for their broods close to the nests and Doctor Butts concluded that feeding the young is not as severe a task as it is commonly supposed to be.

A somewhat similar study has been made of the tufted titmouse (*Baeolophus bicolor*) by Mrs. Mabel Gillespie (1930). Field observations, supplemented by banding data over a period of 12 years in the vicinity of Glenolden, Pa., resulted in an important accumulation of data. In recent years the possible influence of the sun-spot

cycle on population density and scarcity among various forms of life has received much attention from some biologists. According to the theory of Julian Huxley (1927) meteorological conditions of the earth which are caused periodically by sun-spot maxima result in conditions favorable for increased productivity of plant life, and, therefore, of herbivorous animals and their predators. Epidemic disease then causes numerical reduction to the minimum when the cycle is repeated. It has been found that the average length of this cycle is either a little more than 11 years, or else is one-third of this, and Mrs. Gillespie finds in her data a striking suggestion of a 4-year cycle for abundance in the tufted titmouse. In the words of Mrs. Gillespie: "The results of 12 years' observations show a tendency toward alternate years of presence and absence about the banding station or near vicinity; and a peak of population density every four years, followed by a scarcity of numbers."

The song sparrow (*Melospiza melodia*) is not only one of the most widely distributed of our native birds, but also one of the sweetest singers. Added to these qualities is its general willingness to associate with human habitations. Taking advantage of a local concentration of this species, Mrs. Margaret Morse Nice (1930, 1931, and 1932) has conducted a most interesting and important investigation at Columbus, Ohio.

In the region under consideration the song sparrow attempts to raise three broods, sometimes producing a fourth set of eggs if one or more nests meet with disaster. During the incubation period the average routine for the female is between 20 and 30 minutes on the eggs, alternated with feeding periods of 7 to 9 minutes. There does not appear to be any set time, however, as either period may be longer or shorter.

One of the features of this study has been a careful investigation of the territory requirements and its occupation. In the vicinity of Columbus it was found that about half of the males are permanent residents which appear to spend their entire adult lives within the space of a few acres. These birds might be said to guard their nesting territory throughout the year, although there seems to be no exhibition of this other than in the breeding season. The other males and females move southward for the winter, but are likely to return to their territory of the preceding season, which is then occupied for six or eight months. In the conduct of its nesting duties, the song sparrow apparently requires about two-thirds of an acre and does not usually occupy more during one nesting. In 1931, however, several banded males that returned to their territories, were observed to spread out to some extent and include larger areas in their domains. A reduced number of birds was the apparent answer

to this move rather than the existence of any special condition that made additional territory necessary. In no case was a male bird found mated with his partner of the preceding year.

The song sparrow is a home-lover and an individualist. Mrs. Nice concludes that it is "not over fond of flocking, even in the winter, and not of migrating en masse. The same bird may arrive at very different times in successive years, some of the females come before some of the males, and some of the adults come later than the juveniles."

Baldwin Bird Research Laboratory.—Detailed and extensive studies of the life history of the house wren (*Troglodytes aëdon*) (pl. 5) have been intimately associated with the Baldwin Bird Research Laboratory at Gates Mills, Ohio. Elaborate and highly technical apparatus has been developed to further the investigations and it is a fair statement that no other small bird has ever received the close attention that Doctor Baldwin and his associates have accorded this species.

Baldwin (1921) had already pointed out that house wrens not infrequently change mates between their first and second broods and, while of infrequent occurrence, had indicated that polygamy was not unknown. The species is unusually abundant in and around the Chagrin Valley, near which the laboratory is located, and many wrens have returned year after year to nest in the locality. Literally hundreds of young have been banded, but strangely enough very few of these have returned to breed in their natal areas. It is well known that juvenile mortality is very heavy, ornithologists generally accepting the theory that on an average each pair of adult passerine birds will raise but two nestlings to maturity. Nevertheless, since the different species remain practically numerically constant, it would seem that there must be a larger percentage of survival of the young than is indicated by the few return records of yearling birds.

In an effort to answer this question, an intensive study was made in 1926 and 1927. (Cf. Baldwin and Bowen, 1928.) A laboratory assistant was assigned to the task, and during the two seasons the entire wren population of this large area was under almost constant observation. Most of the nesting birds were repeatedly trapped and handled. While a few birds were captured that had been banded in previous seasons, in almost every instance the record showed that they were adult at the time of banding. The problem as to what becomes of the young birds is still one that challenges the efforts of the investigator.

In a study to determine the relation between the time that the adult wrens spend at their nesting activities and the time that they spend in seeking food and rest for themselves, Doctor Baldwin and

his assistants invoked the aid of thermoelectricity. (Cf. Baldwin and Kendeigh, 1927.) A thermocouple, made of copper and constantan, was installed in the nest, the thin, flexible wire passing just above the eggs with the junction of the two metals at the middle of the nest. Wires were carried from the thermocouple to a recording potentiometer in the laboratory. Here the recording pen rested on a strip of paper marked in degrees of temperature, and this paper was rolled past the pen at a constant speed. When the female was on the nest the thermocouple came in contact with her body, resulting in an electromotive force sufficient to move the pen in the potentiometer. In fact, so sensitive was this apparatus that a record was made on the moving paper every time the bird stood up and turned around in the nest.

During the summer of 1926 a record some 250 feet in length was obtained representing 91 days and nights. Four nests of the house wren and one of the robin received similar attention. As would be expected with these species the differentiation between the periods of attentiveness when the bird is actually on its nest, and the periods of inattentiveness, when feeding or resting, is best developed with the female, but nevertheless, the same relation applies also to the male.

In one case a female wren (71653) was found to incubate during the day for average periods of 14.3 minutes, alternated with 6-minute intervals when she was away feeding. During the incubation period she spent every night but one in the nest. On this one occasion she left her nest at 8.50 p. m. and did not return until 1.04 the next morning.

One more example, illustrating further the character of the researches conducted at the Baldwin laboratory, has to do with the temperature variation in young birds. (Cf. Kendeigh and Baldwin, 1928.) Again the house wren was the subject and mercury thermometers, and the thermocouple were employed to obtain the necessary data.

Among ornithologists it is now a well-known fact that while the average temperature of adult birds is relatively high there is some variation in this condition. In fact, differences in body temperature of 4° or 5° may occur within a very few minutes. Unusual excitement or merely the natural metabolism may be sufficient to effect these variations. The variable temperature of adult birds does not seem, however, to be in any way correlated with atmospheric temperature.

In the case of young birds (that is, nestlings), the situation is different. Their temperature is extremely variable and were they dependent upon their own resources they would be truly "cold-

blooded" or with a body temperature equal to the surrounding air. This explains why brooding of newly hatched birds by the parent is so necessary for their proper development. During its life in the nest, however, the fledgling evolves an efficient control system so that when it is ready for separation from parental care its body temperature is more nearly uniform.

The young bird accordingly may be considered as a cold-blooded organism that develops into one with warm blood. This fact is of significance as supporting evidence that the immediate preavian ancestors were cold-blooded, which, of course, fits in with the modern view of the reptilian ancestry of birds.

The O. L. Austin Ornithological Research Station.—This station, located at North Eastham, Cape Cod, Mass., was established as recently as 1930, but the research program already prepared should result in important contributions to our knowledge of North American birds. The director, Dr. Oliver L. Austin, sr., has assigned himself the task of ascertaining causes, symptomatology, and curability of the many diseases of birds. Already he has published (1931) a short paper based upon many dissections, from which he concludes that injuries resulting from their own activities or from violence from other organisms and forces are the principal causes of death in birds.

Introduced species.—Investigations of the Biological Survey through the banding method are confined to native birds although exceptions are made when some special study of an introduced species is contemplated.

The remarkable increase and spread of the European starling (*Sturnus vulgaris*), since its introduction in New York City in 1890 and 1891, has been watched with much apprehension by students of birds. Because of the obvious potentialities of this bird for good or bad, the Survey early authorized and urged its cooperators to band them at every opportunity. As a gross result many thousands are now wearing numbered bands. Centers of starling banding activity have been Washington, D. C., and Columbus, Ohio. During the winters of 1927–28 and 1928–29, the author in company with other Washington ornithologists conducted a banding campaign that resulted in the marking of more than 4,500 of these birds. The work was instituted under the direction of E. R. Kalmbach, of the Biological Survey, who (1932) has described how the banding operations so discouraged the birds that they have not since resorted in large numbers to the church towers where so many of their fellows were ignominiously treated.

About 125 of these birds have since been reported as returns. Seventy or more of these have been from points less than 20 miles

from the point of banding, 28 being recaptured during subsequent breeding seasons. It therefore appears, as Mr. Kalmbach has pointed out (loc. cit., p. 68), that "something more than 23 per cent of the wintering starlings of Washington were essentially resident birds." Determination of this fact is of much importance in planning control measures against the large winter roosts.

Another contingent apparently has developed or is developing migratory habits, as many of the Washington birds have been reported from northern points, mostly from Pennsylvania and New York. Recoveries at Wallingford, Vt., Cape Vincent, N. Y., and Cornwall and Elgin, Ontario, constitute the most northern points from which these birds have been recovered.

In subsequent winters a few returns were received from points as far south of Washington as southeastern Virginia. It is possible that these represent some of those that had developed the migratory habit, had nested north of Washington, and had merely gone on past the Capital when on their autumnal migration. Additional evidence of such a migratory flight is contained in the record of a starling (A200521) banded November 20, 1928, at Norristown, Pa. where it was apparently a winter resident, and recovered at Palatka, Fla., in December, 1930.

Long-range returns.—Banded birds recovered at long distances from the points of banding, are naturally of exceptional interest. Through the friendly cooperation of correspondents in many regions these records are increasing rapidly. Particularly is this true of South and Central American and Caribbean countries, while there are now three records of American banded birds (Arctic terns) that were recovered in the Old World.

The migration route of the Arctic tern (*Sterna paradisaea*) has long been one of the unsolved ornithological problems. Its breeding range is circumpolar, while in winter it has been found south to the Antarctic Continent. The problem has been to determine the path followed by those birds that breed in northeastern North America. Austin (1928) points out that while south of Long Island, N. Y., the species is practically unknown on the Atlantic coast of either North or South America, large numbers of these birds have been observed during the latter part of August, between Newfoundland and the Irish coast.

During the summers of 1927 and 1928 Doctor Austin was engaged in ornithological investigations on the coast of Labrador where he banded several hundred of these terns. One (548656), banded as a nestling in Turnevik Bay on July 22, 1927, was found dead near La Rochelle, Charente-Inferieure, on the west coast of France, on October 1, 1927. Another (548138), also banded as a chick on July

23, 1928, was picked up dead on the beach at Margate, 15 miles southwest of Port Shepstone, Natal, on the east coast of South Africa, on November 14, 1928. This last is the longest flight on record for any banded bird as the shortest possible distance from point of banding to point of recovery is 8,000 miles, while 9,000 miles is a conservative estimate for the entire flight, considering the course that the bird must have followed. For a bird not more than three months old, it is a truly remarkable journey. One other African return record is available: A tern (A. B. B. A. 1258), banded on July 3, 1913, at Eastern Egg Rock, Me., was found dead at the village of Ikibiri, South Nigeria, West Africa, in August, 1917. At the time of banding this bird was identified as the common tern (*Sterna hirundo*), but it is now believed that it was the Arctic species which does nest in small numbers on the New England coast. The chicks of the two species are much alike and even the adults might be confused.

In the light of these three records it now appears that the route of the Arctic tern from its breeding grounds in northeastern North America is eastward across the ocean, probably by way of the British Isles, to the coast of Europe, where, joining forces with those that breed in the northern part of that continent, they turn southward and follow the coasts of Europe and Africa to their winter quarters (fig. 3).

As above stated, it is now believed that there is no authentic record of a banded American common tern (*Sterna hirundo*) crossing the ocean. Nevertheless, there are many long range returns for this bird. Colonies in the Great Lakes and on the coast of New England have been the scene of much banding activity, and more than 80,000 have been banded. Two have been reported from Puerto Rico, 3 from eastern Mexico, 1 from the Republic of Haiti, 2 from the Dominican Republic, 1 from Panama, 7 from the island of Trinidad off the northern coast of South America, 3 from Venezuela, and 2 from the northeastern coast of Brazil.

A laughing gull (*Larus atricilla*) (A518811) banded at Muskeget Island, off the coast of Massachusetts, on July 13, 1930, was killed January 26, 1931, in Acajutla Bay, Salvador. This bird had not only flown more than 2,000 miles but it had crossed from the Atlantic coast to the Pacific coast.

Four Caspian terns (*Sterna caspia*) banded at their breeding colonies in northern Lake Michigan, have been reported more than 2,500 miles southeast, at the mouth of the Magdalena River, Colombia, while a fifth was recaptured at San Cristobal, Cuba.

A large colony of black-crowned night herons at Barnstable, Mass., was visited regularly for several seasons, and more than 2,500 were banded. (Cf. May, 1926.) From this work return records

were obtained from points to the north, west, and south, the most distant being a bird (233743) recovered on the Island of Jamaica,

FIGURE 3.—Distribution and migration of the Arctic terns of eastern North America. Solid spots represent breeding colonies, those marked with crosses being banding localities; the crosses in France and Africa show points of recovery of banded birds; triangles show winter quarters; arrows indicate migration route as now understood

some 1,750 miles nearly due south of the point of banding. Another bird of this species (368306) banded at Indian Head, Sask., on

June 20, 1925, flew about 2,300 miles southeast to Alvarado, Vera Cruz, Mexico, where it was killed on November 15, 1925; while a third (A675440) made a trip of similar length and in the same direction, from Webster, S. Dak., to a point near Habana, Cuba.

The great blue heron (*Ardea herodias*) also makes long flights. Two of these birds banded at Waseca, in southeastern Minnesota, were recaptured almost due south in Central America. The first (334487) was taken 1,900 miles distant at El Hule, State of Oaxaca, southern Mexico, while the other (334402) was killed after a flight of 2,600 miles to Gatun Lake, Panama. Still a third bird of this species (204206), banded at Hat Island, in Green Bay, Wis., flew southeast nearly 1,700 miles to the southern coast of Cuba, its capture forming the first record for the race in that country.

A long-billed curlew (*Numenius americanus*) (531112) banded at Brigham City, Utah, flew southwest about 800 miles and was recaptured in northwestern lower California.

Among the ducks the pintails (*Dafila acuta*) and blue-winged teals (*Querquedula discors*) have made the longest flights. A pintail (367451) banded at Ellinwood, Kans., flew northwest more than 3,300 miles to the mouth of the Kobuk River, Alaska; another (227609) banded at Keno, Oreg., in September, was killed 2,800 miles to the southeast, near Belize, British Honduras; two others (A638860 and A647295), both banded on the same day, one at the Bear River Marshes in Utah, and the other at Dawson, N. Dak., were killed on the same day by the same man at Toluca, near Mexico City, Mexico. A blue-winged teal (A510183) banded at Ellinwood, Kans., flew 1,800 miles southeast to Corocito, Honduras, while another (531961), banded at the same place, traveled more to the eastward and was recaptured near Elia, Camaguey, Cuba. One of these little ducks (363850), banded at Kearney, Nebr., flew southeast about 2,600 miles to Santa Marta, Colombia, and another (4576), banded at Lake Scugog in southern Ontario, was recovered after a flight of about the same length, on the Island of Trinidad, off the north coast of South America.

Although not a large number of hawks have been banded, they have yielded several return records of unusual interest. Among these are a ferruginous rough-leg (*Buteo regalis*) (A709881), banded at Rosebud, Alta., and killed 1,700 miles south at Alpine, Tex.; a duck hawk (*Falco peregrinus*) (310753), banded at King's Point, Yukon Territory, was killed at Duchesne, Utah, more than 2,000 miles south; a red-tailed hawk (*Buteo borealis*) (655444), banded at Hepburn, Sask., flew south about 1,800 miles to Flatonia, Tex.; and a marsh hawk (*Circus hudsonius*) (A697063), banded at

Argusville, N. Dak., flew 1,100 miles in a southeasterly direction and was killed at Guantanamo, Cuba.

The number of small birds recovered after long flights is not so large, but considering the size of the birds, some of the distances traveled are none the less remarkable. For example, the family of sparrows and finches are not usually considered as birds of powerful flight, but a purple finch (*Carpodacus purpureus*) (A127258), banded at Hyde Park, Mass., was recaptured more than 1,400 miles to the southwest, at Nacogdoches, Tex., and another individual of this same species (77230), banded at Peterboro, N. H., flew nearly 1,500 miles to Thornton, Tex.

A tree sparrow (*Spizella arborea*) (38765), banded at Berlin, Mass., was recovered at Hardin, Tex.; a fox sparrow (*Passerella iliaca*) (643516), banded at Rhinebeck, N. Y., on March 18, 1929, was killed by a cat at Port au Port, Newfoundland, on April 30, 1929; a chipping sparrow (*Spizella passerina*) (C79688), banded at North Eastham, Mass., was recaptured at Grand Crossing, Fla.; a white-crowned sparrow (*Zonotrichia leucophrys*) (A196315), banded at Woodland, N. Y., was retaken at Moody, Tex.; a snow bunting (*Plectrophenax nivalis*) (C98323), banded at McMillan, Mich., on February 17, 1931, was killed by an Eskimo at Igdlorpait, Julianehaab District of southern Greenland, on March 30, 1931; a mourning dove (*Zenaidura macroura*) (306053), banded at Fort Riley, Kans., was killed at Apipilulco, State of Guerrero, Mexico; a catbird (*Dumetella carolinensis*) (392781), banded at Schoharie, N. Y., was recovered at Tela, Honduras; and a robin (*Turdus migratorius*) (273933), banded at Crystal Bay, Minn., was recaptured at Pachuca, State of Hidalgo, in southern Mexico.

CONCLUSION

Considering the material now assembled, it is proper to ask: Of what value are these data? The answer is, that for the first time in the history of ornithology there exists a mass of definite, precise information, obtained from living birds, which deals with the complicated movements of the individual birds that go to make up migration. Previously the study of this subject involved the use of data that were obviously incomplete, in most cases being little more than observations of the arrival and departure of the various species in different localities. The movements of the birds that make up the flocks could be only surmised, and the guess of one man was as good as that of another. Second, we are now rapidly accumulating a wealth of information showing how a bird develops, the transition of its plumages, its identification with the same or different mates in

successive seasons, its diseases, food preferences, and many other subjects that in the past could not be adequately studied or at best were but imperfectly known.

Not only does bird banding make it possible to make definite contributions to an increase of knowledge, but in some important instances the material is being applied to pertinent administrative and economic problems relating to our native birds.

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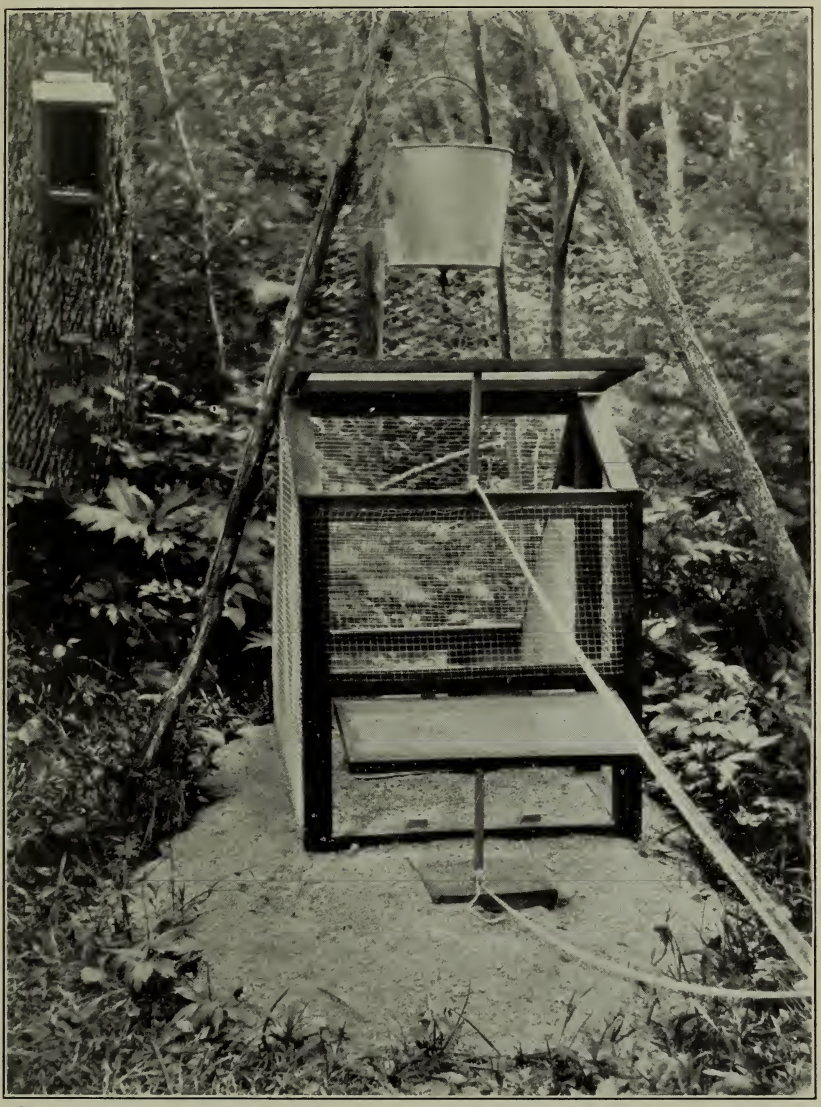


Photograph by Karl Christofferson

A COMBINATION TRAP BAITED WITH WATER DRIPPING FROM THE PAIL INTO A SHALLOW BASIN WHICH IS ALMOST CONCEALED BY THE LOWER DOOR

The doors are released simultaneously.

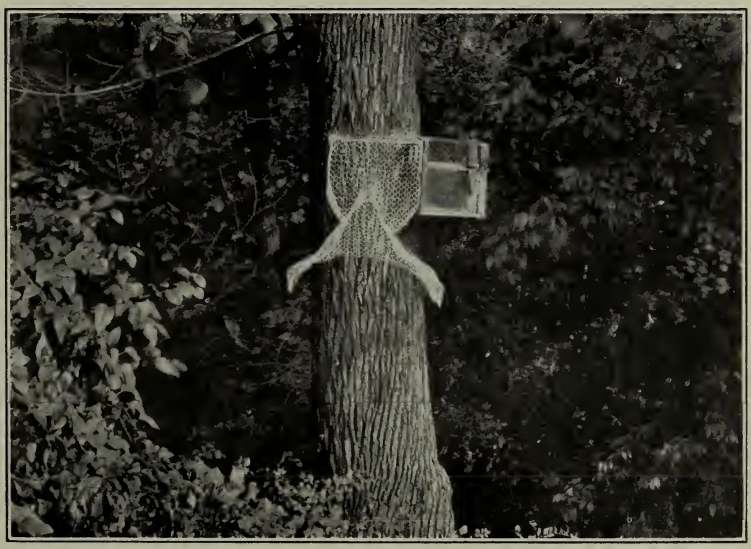
Photograph by M. J. Magee

1. AN EFFICIENT WARBLER TRAP SET OVER A DRINKING FOUNTAIN UNDER AN APPLE TREE

2. TRAP HOLDING NEARLY 250 LESSER SCAUP DUCKS

Paul J. Rainey, Wild Life Refuge, near Abbeville, La.

1. TRAP HOLDING A LARGE CATCH OF DUCKS AND A FEW CANADA GEESE
Lake Malheur bird reservation, Voltage, Oreg.



2. INLAND CREEPER TRAP
The collar of wire netting below the trap chamber encircles the tree trunk spirally.

A CATCH OF BLACK AND WHITE WARBLERS MADE WITH THE INLAND CREEPER TRAP

BANDED HOUSE WREN