THE IMPORTANCE OF BEAVER IN WATERFOWL MANAGEMENT AT THE SENEY NATIONAL WILDLIFE REFUGE [1]

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EDITOR'S NOTE: Articles which will occupy more than 20 pages in the *Journal* are not usually accepted for publication by The Wildlife Society. Occasionally, more lengthy papers can be published when authors pay the cost of the pages exceeding 20.

This article is the result of a long study by Mrs. Beard. It will be of much interest to persons concerned with wildlife ecology and management. Publication has been made possible in the *Journal* by a subsidy from the *Wildlife Management Institute*. Appreciation is expressed by the Society to the Institute, and particularly to Ira N. Gabrielson and C. R. Gutermuth.

INTRODUCTION

The praises of the beaver as nature's engineer are frequently sung, and the use of beaver ponds by wildlife, especially ducks, is asserted to be both common and widespread. A search of wildlife literature, however, reveals no detailed studies that substantiate such assertions. This fact is emphasized by Evans (1948). Recognition, however, is paid the beaver as creator of desirable waterfowl habitat by Bradt (1947), Bump (1941), Carr (1940), Cook (1940), Foote (1945), Grasse and Putnam (1950), Moore and Martin (1949), Salyer (1935), Shaw (1948), Swank (1949), and others.

The three-fold purpose of this report, based on field work carried on at intervals over three years at the Seney National Wildlife Refuge, is: (1) to demonstrate that the beaver is entitled to praise as a wildlife engineer and that beaver ponds in marsh country such as that at the Seney Refuge are intensively used by waterfowl; (2) to ascertain the

[1] Field data were largely obtained during the writer's term of employment with the Fish and Wildlife Service in 1947-1949.

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factors responsible for the attractiveness of beaver areas to waterfowl; and (3) to suggest measures to ensure the continued presence of beaver ponds and to aid artificially in establishing similar areas.

SITE OF STUDY

The Seney National Wildlife Refuge is located in Schoolcraft County in the eastern part of the Upper Peninsula of Michigan. Its 96,000 acres contain a major portion of the extensive Seney marshes.

The passage of time has left slight impression on much of this marshland. It remains little changed from its original condition. According to Harvey Saunders, who began cruising this country in 1900 and who has been on the staff of the Seney Refuge for many years, much of the big pine has gone, but the marsh now, as then, extends vast and undisturbed, broken only by numerous pine-covered sandy knolls and ridges. The long axis of the marshes, of the ridges, and of the six creeks that flow through parts of the refuge lie with rather marked conformity in a northwest-southeast direction. Sedges characteristic of semi-dry soils continue to be the dominant vegetation. Their growth is rank and dense. With the exception of the streams, originally there was little open water. Conditions varied with the annual precipitation, but, in general, few openings occurred in the lush sedge vegetation. Because of this, waterfowl and beaver were scarce. The few beaver usually lived in banks along the creeks. Sometimes their dams across these streams formed small ponds, which were utilized by small numbers of waterfowl.

In 1935 the Fish and Wildlife Service acquired this marshland for a wildlife refuge. One of the first acts was to divert water from streams, such as the Driggs River, to the dry marshes. Dikes were built to impound pools of varying size. Nineteen pools, totaling approximately 6,500 water acres, were constructed during a six-year period. This development (with the exception of one pool) has been confined so far to the eastern third of the refuge comprising Units 1 and 2. The remaining 66,000 acres, (known as Unit 3) are still undeveloped and unchanged.

In Units 1 and 2 the effect of the pools and of the increased amount of water spreading gradually outward has become noticeable. The marshes have begun to change. Sedge here and there is being replaced by cattail; bulrush has commenced to appear. Little by little the old semi-dry sedge marsh is becoming wet marsh. In response to this changed environment waterfowl populations have expanded with increasing rapidity with passing years. Beaver have established themselves over much of this newly-flooded area. Now (1949) waterfowl and beaver occupy the suitable portions of Units 1 and 2 in significant numbers.

PLAN AND OBJECTIVES OF STUDY

In the spring of 1947 the author was assigned to the Seney Refuge to investigate use by waterfowl of the various types of habitat. It was thought that if the environmental types most favored by waterfowl and the reasons for such preference could be determined, management efforts could then be directed toward increasing the acreage of preferred types.

It was soon discovered that certain

types of marshes and small ponds were preferred by ducks during spring and early summer for breeding activities. It was also quickly realized that these types of marshes and small ponds were almost always the result of past or present beaver activity.

In order to investigate the relation of beaver to habitat receiving intensive use by waterfowl, four areas typical of refuge habitat and embodying different stages in beaver activity were selected for detailed study.

The general plan of procedure was three-fold: (1) every attempt was made to keep these areas under close observation to determine their use by waterfowl; (2) physical characteristics of the areas were very carefully analyzed to determine the important factors responsible for their attraction to waterfowl; (3) management recommendations were designed to maintain a desirable number of such beaver ponds and marshes.

STUDY METHODS AND TECHNIQUES

From favorable sites on natural ridges and dikes that bordered and overlooked the study areas, direct observations with 8x binoculars and 20x spotting 'scope were made of the ducks' activities. Early morning or late afternoon was found to be best for watching, since the ducks were then most active. A daily record was kept of data on species, number of individuals, size of broods, age class of young, behavior of young, and behavior of adults. To facilitate observations on Study Area IV, a platform was constructed at a height of about 30 feet in a red pine. This permitted a view of the entire marsh.

Rough maps, based on aerial photos when possible, were drawn of each study area, and field data sheets were prepared, so that measurements and other information could be quickly recorded. Stakes were driven and cord strung to form transect lines across each area. There were four or five of these lines (depending upon the size of the marsh or pond) erected parallel to each other, locations being plotted on the field maps. At regular intervals along each line (usually four to six, depending upon the length of the line) the following measurements and samples were taken and recorded on the field data sheets: (1) depth of water; (2) sweep of insects on emergent vegetation; (3) sweep of insects in water and on marsh or pond bottom; and (4) amount and kind of submerged aquatic plants. The space occupied by emergent vegetation and by open water along the length of the transect line was measured to the nearest half-foot.

The density of emergent vegetation was also recorded. Based on the ease with which ducks could penetrate it, three degrees of density (sparse, medium, and dense) were set up. A series of 32 stem counts, each along a 36-inch line, were made at random in several marshes. Growth which offered no hindrance and only scant cover to waterfowl was labeled sparse. Stem counts taken in such areas ranged from 0 to 160. Vegetation which allowed easy penetration by waterfowl and which provided abundant escape cover was classified as medium, with stem counts from 160 to 290, but with the majority between 240 and 265. Vegetation with stem counts above 290, which could not be penetrated by waterfowl, was called dense. With a little practice, it was possible to classify the degree of density of the emergents with

reasonable accuracy, so that it was not necessary to make stem counts, except occasionally for checking estimates.

The presence of other forms of wildlife and the plants along the periphery of these marshes and ponds were noted and all important species were recorded with estimated densities.

As a further aid in analyzing these four marsh areas, enlargements of air photos taken in 1938 were used for comparison with air photos of the same locations taken in 1949 by the author. In addition, pictures were taken from the ground to show various types of cover interspersion, beaver activities, etc.

WATERFOWL USE OF STUDY AREAS

It was soon established that waterfowl were using the four study areas quite intensively. This heavy usage, although it varied somewhat in response to changes in local conditions, continued throughout the entire period.

STUDY AREA I was a sedge marsh which had been abandoned by beaver for either three or four years. Its record of waterfowl use for the three-years' study follows.

Nesting. No nests around the periphery of this marsh were discovered. One brood each of very young black ducks, blue-winged teal, and hooded mergansers, suggest that nests were nearby.

Broods. Table 1 summarizes the brood observations for this area over the three-year period.

The most numerous broods were of black duck, blue-winged teal, and mallard. Total duckling production for the marsh was 108.

The ease and speed with which broods disappeared into the nearby sedge at the approach of any would-be observer, demonstrated its adequacy and effectiveness as escape cover.

The length of time which individual broods remained in the marsh was difficult to determine, for none of the ducklings were marked. Sometimes it was possible, however, to identify broods with reasonable accuracy. Observations of these showed that they remained in the marsh from two to four weeks. One brood of black ducks first seen on May 27 as downy young was later recorded May 28, June 2, June 23 and June 30. A brood of blue-winged teal was followed through from July 5 to July 22, and another from July 19 to August 2.

Adult activities. The number of adult ducks (omitting hens accompanied by their broods) using this area for the

TABLE 1.—NUMBER OF DUCK BROODS USING STUDY AREA I (SEEPAGE MARSH ABANDONED BY BEAVER)

Species	1947		1948		1949		Total	
	No. broods	No. young	No. broods	No. young	No. broods	No. young	No. broods	No. young
Mallard	2	9	1	7	1	7	4	23
Black duck	5	34	1	5	0	0	6	39
Blue-winged teal	3	22	2	12	1	6	6	40
Hooded merganser	1	6	0	0	0	0	1	6
Total	11	71	4	24	2	13	17	108

three-year period is summarized in Table 2.

TABLE 2.—NUMBER OF ADULT DUCKS USING STUDY AREA I
(SEEPAGE MARSH ABANDONED BY BEAVER)

Species	1947	1948	1949	Total
Mallard	52	18	16	86
Black	88	64	20	172
Baldpate			3	3
Pintail	1			1
Green-winged teal	22		2	24
Blue-winged teal	57	43	20	120
Wood duck		4		4
Ring-necked duck	7		2	9
Hooded merganser	16	2	1	19
Total	243	131	64	438

Black ducks, blue-winged teal and mallards were the ducks most commonly seen in the marsh in each of the three years. They accounted for about 85 per cent of the total of 438 observed.

A variety of activities was engaged in by these ducks. In late spring, territorial activity of male mallards, blue-winged teal, hooded mergansers and black ducks was noted. During this period, drakes of these species were frequently observed loafing or feeding in parts of the marsh.

Throughout June and July, in addition to hens with broods, small numbers of ducks were often seen feeding in the marsh. By September and October as many as five to ten at a time of mallards, blacks, or blue-winged teal were feeding there. Green-winged teal and ring-necks were not seen in Area I after the middle of June.

No evidence of the use of this marsh by moulting adult ducks during their flightless period was discovered.

STUDY AREA II was a sedge marsh flooded by a beaver dam across the creek which runs through the area. Its record of waterfowl use for the last two years of the study period follows.

Nesting. On May 30, 1949, a hen wood duck was flushed from a nest with 9 eggs in a keg nailed to a dead jack pine (*Pinus banksiana*) standing in the marsh about 75 feet from shore. On June 9, all but two eggs had hatched. When opened, these contained embryos almost fully-developed. Another nesting keg in a dead jack pine standing in the marsh about 300 feet from shore contained a great deal of down, but no eggs. This may have represented an earlier nest of wood ducks that was broken up, or might have been the successful nest of another tree-nesting species, such as hooded merganser.

One brood each of very young blue-winged teal and hooded mergansers was seen, indicating nests in the immediate vicinity.

Broods. Table 3 summarizes the brood observations for this area over a two-year period (1948 and 1949).

TABLE 3.—NUMBER OF DUCK BROODS USING STUDY AREA II
(RIVER MARSH DAMMED BY BEAVER)

Species	1948		1949		Total	
	No. broods	No. young	No. broods	No. young	No. broods	No. young
Black duck	1	5	1	10	2	15
Blue-winged teal	1	3			1	3
Wood duck	2	14			2	14
Hooded merganser	1	1	2	18	3	19
Unknown	1	5			1	5
Total	6	28	3	28	9	56

Broods of hooded merganser, black duck and wood duck were found in the marsh in the greatest number. The total production of ducklings for the two years was 56.

Adult activities. The number of adult ducks (omitting hens accompanied by their broods) using this area for the two-year period is summarized in Table 4.

TABLE 4.—NUMBER OF ADULT DUCKS USING STUDY AREA II
(RIVER MARSH DAMMED BY BEAVER)

Species	1948	1949	Total
Black duck	1	11	12
Blue-winged teal		1	1
Wood duck	6	23	29
Ring-necked duck	5	16	21
Hooded merganser		3	3
American merganser		2	2
Total	12	56	68

Wood ducks and ring-necked ducks were commonest in this river marsh for the two-year period. Together they accounted for more than two-thirds of 68 ducks seen.

During the late spring the repeated presence of single black ducks, wood ducks and hooded mergansers loafing and feeding in the area suggested that territories had been set up. Pairs of ring-necks were observed in the area feeding and loafing during the first half of May. On three occasions (June 28, July 12 and 22) a total of 12 flightless adult black ducks and wood ducks were observed.

STUDY AREA III was an open-water beaver pond which has been maintained off and on by beaver for many years. Its record of waterfowl use for the three-year study period is given below.

Nesting. One brood of downy black ducks and two of ring-necks, indicate nesting in the immediate vicinity.

Broods. Table 5 summarizes the brood observations for this area over the three-year period.

Black duck, ring-necked duck, and hooded merganser broods were each present in equal numbers in this beaver pond for the three-year period. They accounted for three-quarters of the total number of broods seen. The duckling production for this pond was 102.

A series of observations of individual broods that could be identified indicated that these remained in the pond from one and one-half weeks to six weeks. One black duck brood was recorded four times, between June 14 and July 28. A ring-necked brood was seen July 8 to July 18 and a hooded merganser brood from June 14 to July 8.

TABLE 5.—NUMBER OF DUCK BROODS USING STUDY AREA III
(OPEN-WATER BEAVER POND)

	1947		1948		1949		Total	
Species	No. broods	No. young	No. broods	No. young	No. broods	No. young	No. broods	No. young
Mallard					1	3	1	3
Black duck	2	15	3	23			5	38
Blue-winged teal					1	6	1	6
Wood duck	2	9					2	9
Ring-necked duck	3	20			2	7	5	27
Hooded merganser	2	8	1	2	2	8	5	18
American merganser					1	1	1	1
Total	9	52	4	25	7	25	20	102

Adult activities. The number of adult ducks (omitting hens accompanied by their broods) using this pond for the three-year period is summarized in Table 6.

TABLE 6.—NUMBER OF ADULT DUCKS USING STUDY AREA III (OPEN-WATER BEAVER POND)

Species	1947	1948	1949	Total
Mallard	2	11	11	24
Black duck	15	29	19	63
Pintail			6	6
Green-winged teal		15	8	23
Blue-winged teal	7	19		26
Wood duck	1		3	4
Ring-necked duck	15	18	7	40
Hooded merganser	3	8	5	16
Total	43	100	59	202

Black ducks and ring-necks were the commonest ducks in the beaver pond for the three-year period. They accounted for half of 202 ducks seen.

The presence of pairs or singles of black ducks, blue-winged teal, ring-necks, and hooded mergansers during May and June indicated that territories had been set up.

During the early part of May this pond was used by small numbers of migrating pintails, green-winged teal, ring-necks and mallards. From the end of July to September, mallards, blacks, blue-winged and green-winged teal flocked for feeding into the area in numbers varying from 10 to 15 each. An occasional wood duck and hooded merganser were recorded during late summer. On July 28, 50 ducks of these four species were observed. That they had been there for several days was indicated by a blanket of duck feathers along the edge of the occupied cove.

STUDY AREA IV was a seepage, sedge marsh which has been maintained by beaver for many years. Its record of waterfowl use for the three-year study period follows.

Nesting. One brood each of very young black ducks, baldpates, ring-necks and hooded mergansers indicate nesting in the area. Due to low return for time spent, little effort was concentrated on searching for nests.

Broods. Table 7 summarizes the brood observations for this area over the three-year period.

In order of abundance, broods were of hooded merganser, black, baldpate, ring-necked and wood duck. The total

TABLE 7.—NUMBER OF DUCK BROODS USING STUDY AREA IV (SEEPAGE MARSH MAINTAINED BY BEAVER)

	1947		1948		1949		Total	
Species	No. broods	No. young	No. broods	No. young	No. broods	No. young	No. broods	No. young
Black duck	1	3	1	4	2	15	4	22
Baldpate			2	10	2	8	4	18
Blue-winged teal			1	8	1	4	2	12
Wood duck			2	8	1	4	3	12
Ring-necked duck					3	20	3	20
Hooded merganser	1	7	2	16	2	17	5	40
Total	2	10	8	46	11	68	21	124

production for the marsh was 124 ducklings.

Repeated observations of individual broods showed that they were remaining in the marsh from one to four weeks. One brood of baldpates first recorded on June 28 as downy young, was later seen on July 1, July 13, and July 29. A brood of black ducks was followed through from May 24 to June 9. One brood of ring-necks was checked from June 27 to July 12, and another of the same species from June 27 to July 5.

Adult activities. The number of adult ducks (omitting hens accompanied by their broods) using this area for the three-year period is summarized in Table 8.

TABLE 8.—NUMBER OF ADULT DUCKS USING STUDY AREA IV
(SEEPAGE MARSH MAINTAINED BY BEAVER)

Species	1947	1948	1949	Total
Mallard	2	5	2	9
Black duck	23	48	90	161
Baldpate	7	12	19	38
Green-winged teal	1			1
Blue-winged teal	15	6	5	26
Wood duck	15	40	65	120
Ring-necked duck			17	17
Hooded merganser	7	2	2	11
Total	70	113	200	383

Black ducks and wood ducks were the most frequently observed ducks in the marsh for each of the three years. They accounted for more than two-thirds of the total number of 383 seen.

By late spring, territories had been established by blacks, baldpates, blue-winged teal, ring-necks, and hooded mergansers.

Throughout the summer months black ducks, baldpates, and wood ducks were observed feeding in the marsh in numbers varying from three or four of one species at a time to as high as 40. In August, blue-winged teal and ring-necks in small numbers appeared in the marsh to feed. With the exception of a few blacks and mallards seen in October, the area was largely abandoned by ducks after the first of September.

On several occasions in June and July of 1948 and 1949, flightless black and wood ducks were flushed at very close range. A total of eight black ducks and ten wood ducks were observed in the flightless stage of the post-nuptial moult in this sedge marsh.

A summary of the waterfowl observations made in these four study areas showed that they were providing (1) sites for the establishment of territories by paired ducks; (2) cover and food sufficient for rearing broods; (3) an adequate source of food for adult ducks in small numbers especially during the late summer and early fall. In addition, one area furnished suitable nest sites for tree-nesting species at least, and two supplied the necessary food, escape cover, and isolation needed by black and wood ducks during the flightless period of their post-nuptial moult.

ENVIRONMENTAL ANALYSIS OF STUDY AREAS

To determine why these areas were being used by waterfowl, a detailed environmental analysis of the physical characteristics of the areas was carried on in the summer of 1949. The procedure and methods have already been discussed.

STUDY AREA I was a sedge marsh of approximately 10 acres located in the NW1/4 sec. 21, T. 45 N., R. 13 W. It

is just southeast of F Pool in Unit 1 of the Refuge.

During 1944 and 1945 (and perhaps earlier) beaver were inhabiting this marsh. Where the two drainage ditches converged and the water passed on through a natural channel, they maintained a dam 45 feet long and 3 feet high. The actual pool formed was not over 30 feet in diameter, but the dam greatly retarded the water passing out of the area and quite effectively increased the water level over the marsh. A rather small lodge was on the bank at the edge of the pool. Numerous canals had been dug by the beaver to facilitate the utilization of the aspen growing on the ridge along the south side of the marsh. Beaver cuttings were abundant. By the spring of 1947 the beaver had abandoned the area.

By 1949 the lodge was almost entirely flattened, and the dam was no longer effective. The pool held a small amount of water in the spring, but was completely dried out in the summer and was growing up to burreed (*Sparganium* spp.). Evidence of much old beaver cutting on tag alder (*Alnus incana*), juneberry (*Amelanchier* spp.), white birch (*Betula papyrifera*), and poplar (*Populus* spp.) was visible along the surrounding ridge, but no sign of active beaver was found. Significantly, not one live aspen remained on the ridge. This suggested that it was lack of food which forced the beaver to abandon this area.

This ten-acre marsh is bounded on the north by a sandy ridge which extends eastward as a peninsula from the dike road and on the east by one of the old drainage ditches, now blocked at both ends, so that it no longer carries water away. Along the south side is a long ridge the appearance of which suggests that it might be a very ancient beaver dam. On the west is a ridge which parallels the F Pool dike road. All ridges are narrow. That on the south is barely above the marsh. Those to the north and west are considerably higher.

Jack pine and red pine (*Pinus resinosa*) grow on the ridges. Spruce (*Picea glauca*), tamarack (*Larix laricina*), white birch, a few cedar (*Thuja occidentalis*), and red maple (*Acer rubrum*) are present on the south ridge, showing the influence of the lower elevation. Juneberry, viburnum (*Viburnum* spp.), and tag alder are common on all the knolls, and blueberry (*Vaccinium* spp.), bracken (*Pteris aquilina*), and sweet fern (*Myrica asplenifolia*) provide the ground cover. In the peripheral zone between the base of the ridges and the marsh proper, thick cover is provided by clumps of leatherleaf (*Chamaedaphne calyculata*), bluejoint grass (*Calamagrostis canadensis*), manna grasses (*Glyceria canadensis* and *G. borealis*), sedge (*Carex lasiocarpa*), bulrush (*Scirpus atrocinctus*), cattail (*Typha latifolia*), and burreed (*Sparganium eurycarpum*).

A rather fine sedge (*Carex lasiocarpa*) is the dominant emergent growing in the marsh, where its stems form not tussocks but beds of the type frequently known as "sedge meadows." Other sedges (*Carex chordorrhiza*, and *C. rostrata* and *Eriophorum* sp.), bluejoint grass, and rush (*Juncus canadensis*) occur in insignificant amounts.

A series of measurements of marsh cover yielded information on amount, composition and degree of interspersion of the emergent vegetation in the marsh (Figs. 1 and 2).

The method of determining the amount

and composition was as follows. Emergent growth and open water were classified into cover types. This was based not necessarily on species, but on degrees of density, on gross physical differences, on possible differences in use by waterfowl. For example, each of three degrees of density of sedge constituted a separate cover type. It was irrelevant whether the sedge was all of one species or not—provided it was of the same density. A solid stand of burreed was classed as another type, since it might be used for a purpose peculiar to itself by waterfowl. Dead brush was another cover type, while live bushes, such as leatherleaf, was yet another. Combinations, such as sedge and brush, sedge and cattails, and leatherleaf and dead trees were likewise regarded as distinct cover types.

Transect lines equidistant and parallel across the area were used as sampling bases. Each was measured, and the amount occupied along it by each cover type. From these measurements both the total number of feet occupied by each type and the per cent of the transect line which this represented were computed.

When these measurements were combined for all transects, the total amount occupied by each type and the per cent of the total transect lines which this represented were obtained. Since this combined transect line represented a cross-section of the entire marsh, the per cent of it which each cover type occupied approximated the per cent of the entire marsh which each cover type comprised.

Figure 1 shows that there are two general zones in the marsh. The first is open water with a few isolated clumps of dead brush. This accounts for about one-third of the study area. The second is sedge marsh well broken up by water into small units, and constituting the remaining two-thirds of the area. Within this sedge marsh zone, water represents approximately one-quarter of the acreage, or a ratio of water to cover of 1:3. All three degrees of density are found in the sedge, but the amount classified as dense (*i.e.*, unusable by waterfowl) is small, whereas the amount of sparse and medium is seven times as great, or slightly over half of the entire sedge marsh zone.

The method of determining the degree of interspersion was based on the idea that interspersion is a mixing of environmental types, and that its amount is determined by the number of times the cover types occur. In order to express this numerically, the total number of occurrences in a specified unit such as along a given line, was divided by the number of cover types present in the unit. The result was the numerator in the "Index of Interspersion." For example, if within a certain area, each cover type occurred but once, interspersion would be at a minimum, and the numerator would be one. If within this area, the cover types occurred more frequently, the numerator would be higher—thus indicating a greater degree of interspersion.

Another factor, which is expressed as the denominator in the "Index of Interspersion," is the size of the units of cover. Although two areas might have the same degree of interspersion, and consequently the same numerator, if the average size of the cover units is six inches in one and sixty yards in the other, it is apparent that the kind of interspersion would be radically differ-

ent in the two areas, which the respective denominators of 6 inches and 60 yards would show.

It is obvious that the size of a unit of cover type determines to a considerable extent its potential use. For example, blocks of vegetation averaging six inches long would have little utility as cover for waterfowl, whereas those averaging six feet would have extensive use. Therefore, the inclusion of the average size of the cover type units as

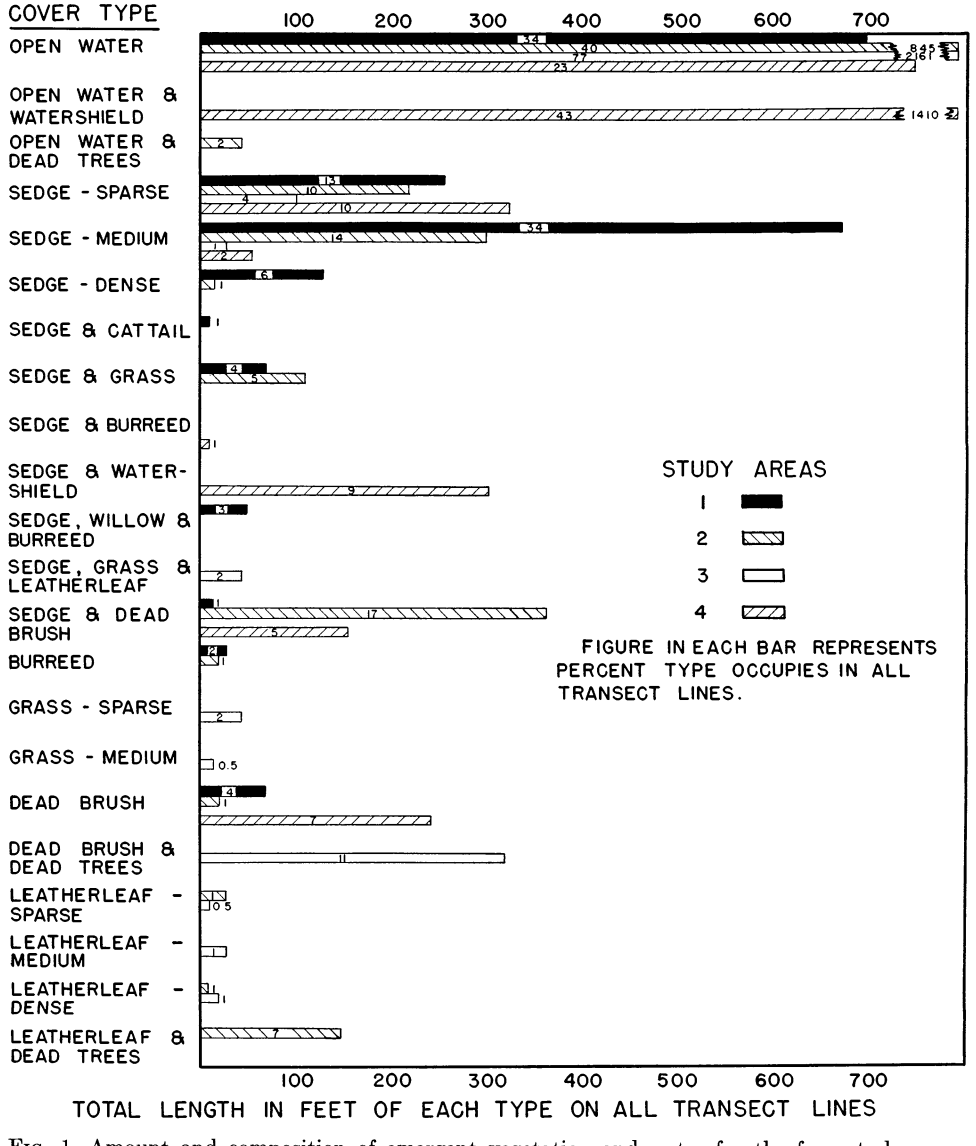

FIG. 1. Amount and composition of emergent vegetation and water for the four study areas.

part of the "Index of Interspersion" renders possible a much more accurate and complete expression of the interspersion. By the use of such an index, it is also possible to compare the interspersion of various areas both as to degree and kind. The denominator—the average size of the cover type units

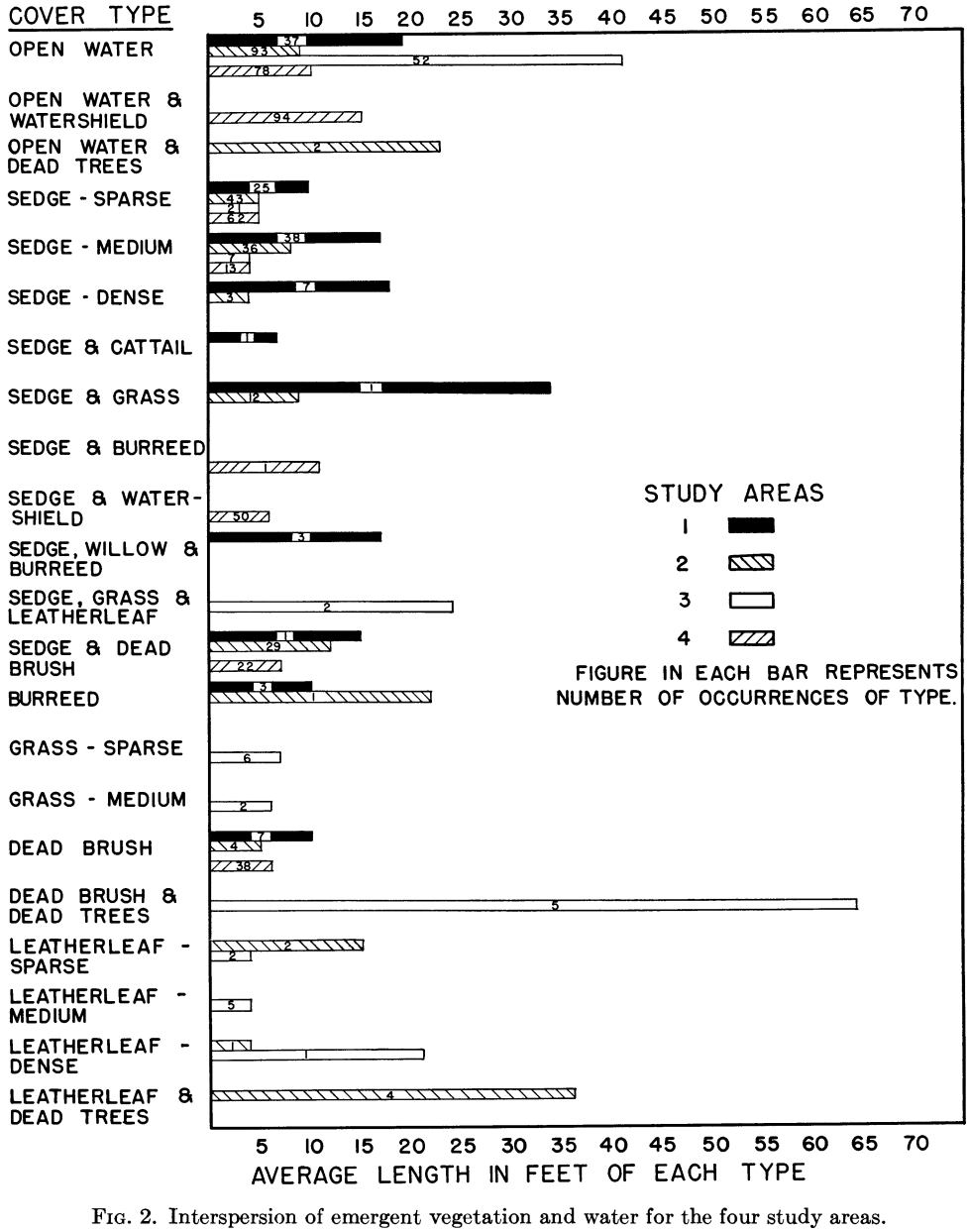

FIG. 2. Interspersion of emergent vegetation and water for the four study areas.

—is obtained by averaging the length of all cover types in the area.

Figure 2 shows that ten environmental cover types were recognized in Study Area I and a total number of 123 type occurrences were tallied. The average size for each type occurrence (based on all occurrences for all types) is 16 feet. The "Index of Interspersion," accordingly, is 12/16′.

These figures take on increased significance when they are considered in relation to the ground and aerial photographs of the area (Figs. 3 and 4). It becomes obvious that 12 as the degree of interspersion and 16′ as the average size for each type occurrence describe a marsh that is well broken up into units of cover and water of usable size for wildlife.

The submerged and floating aquatic vegetation is limited to four species: duckweed (*Lemna minor*), waterweed (*Anacharis canadensis*), bladderwort (*Utricularia* sp.), and fine-leaved pondweed (*Potamogeton pusillus*). These are sparse with puny and spindly growth. Fine-leaved pondweed produced no seed. Of the four species, bladderwort was the most widely distributed, being found in amounts varying from trace to moderate in two-thirds of the 24 sampling stations. Fine-leaved pondweed and waterweed, next in abundance, were recorded at one-third of the stations, in amounts from moderate to common. Duckweed occurred as a trace at five of the checking points. Litter of dead vegetation comprised much of the marsh bottom.

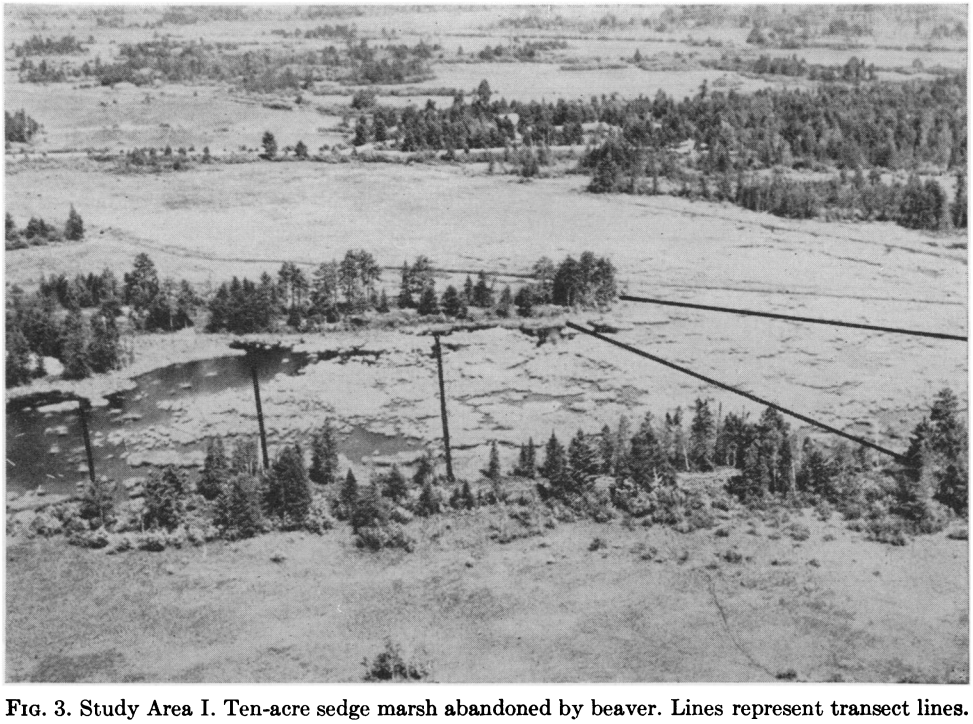

FIG. 3. Study Area I. Ten-acre sedge marsh abandoned by beaver. Lines represent transect lines.

Measurements of the depth of water taken at the 24 stations throughout the marsh showed that the maximum depth was 8 inches and the minimum 3. The greatest depths of 7 or 8 inches were in open water areas at the west end of the marsh and along the ridge on the north boundary. The depth of water in the extensive sedge growth throughout the remainder of much of the marsh varied from 4 to 6½ inches.

The results of the insect sweeps made on the emergent vegetation and on the marsh bottom are summarized in Table 9.

Both sweeps were made at each of the 24 sampling stations. Of the aquatics and bottom dwellers small snails (Planorbidae and Physidae), bivalves (Sphaeriidae), dragonfly nymphs (Libellulidae, Corduliidae, and Aeshnidae), mayfly nymphs (Caenidae), backswimmers (Notonectidae), water boatmen (Corixidae), midge larvae (Tendipedidae), water striders (Gerridae), and predacious diving beetle larvae (Dytiscidae) were found in the largest numbers and, in general, had the greatest distribution. In the sweeps on emergent vegetation narrow-winged damselflies (Coenagriidae), chinch bugs (Lygaeidae), plant bugs (Miridae), leafhoppers (Cicadellidae), moths (Lepidoptera), grass flies (Chloropidae), swale flies (Tetanoceridae), and spiders (Araneae) showed up in the highest numbers and at the greatest number of stations. The total number of individuals taken was 140 in the sweeps on the emergents and 391 in the sweeps in the water and on the marsh bottom. This showed there were

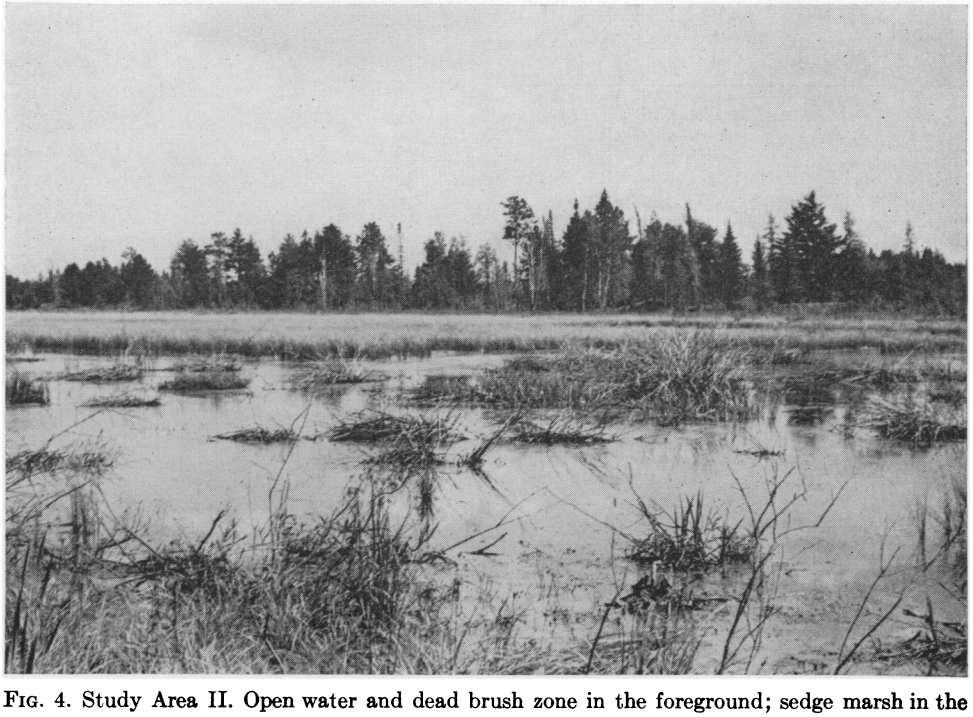

FIG. 4. Study Area II. Open water and dead brush zone in the foreground; sedge marsh in the background.

TABLE 9.—SMALL ANIMAL FORMS PRESENT IN THE FOUR STUDY AREAS*

	Area 1	Area 2	Area 3	Area 4	Total
MOLLUSCA					821
GASTROPODA					547
Pulmonata	97	291	87	72	547
PELECYPODA					274
Teleodesmacea	75	27	86	86	274
ARTHROPODA					939
INSECTA					868
Collembola	2	0	0	1	3
Orthoptera	0	5	5	1	11
Odonata	99	48	25	51	223
Ephemerida	12	2	3	1	18
Corrodentia	0	1	0	0	1
Hemiptera	90	32	38	104	264
Homoptera	30	22	10	10	72
Trichoptera	1	1	0	3	5
Lepidoptera	2	1	6	1	10
Diptera	62	50	34	44	190
Coleoptera	10	27	7	11	55
Hymenoptera	2	4	5	5	16
ARACHNOIDEA					71
Araneae	8	19	24	20	71
CHORDATA					39
PISCES					32
Haplomi	1	0	0	0	1
Ostariophysi	0	0	11	20	31
AMPHIBIA					7

* There follows herewith an enumeration of the families represented in the orders as listed above. For the sake of brevity only the total number for all of the four study areas is given. **MOLLUSCA**: GASTROPODA-Pulmonata, Planorbidae 416; Physidae 131; PELECYPODA-Teleodesmacea, Sphaeriidae 274; **ARTHROPODA**: INSECTA-Collembola, Poduridae 3; Orthoptera, Acrididae 6; Tettigonidae 1; Gryllicrididae 4; Odonata, Coenagriidae 53; Libellulidae 89; Aeshnidae 15; Corduliidae 60; Lestidae 5; Gomphidae 1; Ephemerida, Caenidae 15; Baetidae 3; Corrodentia, Psocidae 1; Hemiptera, Notonectidae 12; Corixidae 185; Belostomatidae 7; Nepidae 3; Gerridae 8; Lygaeidae 34; Coreidae 1; Miridae 13; Scutelleridae 1; Homoptera, Fulgoridae 1; Cercopidae 7; Cicadellidae 61; Aphidae 3; Trichoptera, Hydroptilidae 1; Leptoceridae 3; Phryganeidae 1; Lepidoptera, Tineidae 4; Noctuidae 3; Drepanidae 1; Pyromorphidae 2; Diptera, Tipulidae 12; Culicidae 4; Simuliidae 3; Tendipedidae 56; Heleidae 1; Stratiomyidae 4; Tabanidae 2; Otitidae 2; Drosophilidae 2; Chloropidae 64; Tetanoceridae 21; Pipineulidae 1; Dolichopidae 2; Anthomyidae 12; Dixidae 3; Ortalidae 1; Coleoptera, Haliplidae 3; Dytiscidae 11; Hydrophilidae 1; Staphylinidae 1; Coccinellidae 21; Lagriidae 3; Chrysomelidae 12; Lampyridae 1; Gyrinidae 2; Hymenoptera, Tenthredinidae 4; Ichneumonidae 7; Braconidae 4; Formicidae 1; ARACHNOIDEA-Araneae, Argiopidae 55; Drassidae 4; Epeiridae 7; Clubionidae 5; **CHORDATA**: PISCES-Haplomi, Umbridae 1; Ostariophysi, Cyprinidae 27; Ameiuridae 4; AMPHIBIA.

approximately 175 per cent more water and bottom dwellers than terrestrial forms. No pattern of distribution was discernible for any of these insects with reference to any environmental factor, such as depth of water, amount and density of sedge, extent of water, etc.

STUDY AREA II was a river marsh of approximately 6 acres located in the SW1/4 of sec. 21, T. 45 N., R. 13 W. It is just east of the northeast corner of C-1 Pool in Unit 1 of the Refuge.

By spring of 1948 when this marsh first came under intensive observation, an active beaver dam and lodge were present. Well-worn beaver trails leading out of the marsh, up over the dike and down into the adjacent C-1 Pool, suggest that the beaver are forced to leave the marsh and swim considerable distances to obtain food and supplies for dam repairs.

Because of the considerable amount of water in Gray's Creek as well as the rather strong current, the dam is constantly in need of repairs.

There are no distinctive topographical features to mark the northern boundary of this study area, just flooded trees, more marsh and stream. A line parallel to the dike at the south running from the dike on the west to the ridge on the east and crossing the point where the two arms of the creek join and form one stream channel would mark the northern limits of the area. On the east is a wooded ridge. An old road raised above the level of the marsh and a bridge over the creek bound the area on the south. Along the entire western side is C-1 Pool dike.

A moderately heavy patch of dead spruce and jack pine enclosed by the

two branches of the stream stands at the northern edge of the area. Jack pine, spruce, and juneberry grow on the knoll to the east. Along the base of this knoll is a zone of flooded leatherleaf and of dead spruce and jack pine killed when the beaver raised the water level. A few tag alders grow along the road to the south. Along the dike on the west side a fringe of bog birch(*Betula pumila*), spirea (*Spireae salicifolia*), willow (*Salix* spp.), sedges, manna grass, and bluejoint grass grow in moderate abundance.

Two species of sedge are the dominant form of vegetation in this river marsh. The first is *Carex lacustris*, coarse and rough (fittingly known as Ripgut), which grows in tussocks. The second, considerably finer than the former, is *Carex stricta* var. *strictior*. Its stems form beds of the "sedge meadow" type. A third sedge, *Carex lasiocarpa*, occurs only in one small area in the southeast corner of the marsh. Other emergents, namely, bluejoint grass, leatherleaf, and spirea are present in insignificant amounts.

There are three general zones within the marsh. The first and most important is the sedge-brush marsh well broken up by water into a multitude of small units. This environmental type comprises about three-quarters of the entire study area. The second zone is one of open water as represented by the channel of Gray's Creek running through the marsh. It occupies roughly about 15 per cent of the entire area. The third zone is a band of leatherleaf, dead brush and dead trees in various combinations that is found along the east side of the marsh. It constitutes about 10 per cent of the total area.

Within the sedge-brush marsh the ratio of water to emergent cover is slightly less than 1:1. All three degrees of density are found in the sedge vegetation. Dense sedge, however, appears as just a trace; the amount of sparse and medium sedge accounts for almost one-quarter of the entire study area.

Figure 2 reveals that 12 environmental types were recognized in this marsh and a total number of 230 type occurrences recorded. The average size for each type occurrence (based on all occurrences for all types) is 9 feet. The "Index of Interspersion" is, therefore, 19/9′ and is indicative of a marsh that has a multitude of units of cover and water of small size scattered over three-quarters of the study area. Large blocks of any one cover type are lacking with the one exception of the leatherleaf-dead tree zone (Figs. 5 and 6).

Submerged and floating aquatic plants are very poorly represented in this area. There is but one species, bladderwort, found in any appreciable amount. It is distributed throughout the entire marsh in amounts varying from moderate to common. The other two aquatics are water smartweed (*Polygonum natans*) and floating-leaf burreed (*Sparganium fluctuans*), occurring as trace to moderate. Their distribution is restricted to one small section in the southwest corner of the marsh. Litter of dead vegetation is characteristic of the entire marsh bottom.

Measurements of the depth of water were taken at each of the 20 stations spaced along the transect lines. These measurements showed that the deepest water was 34 inches and the shallowest was 9. (This excludes the creek; no measurements were taken of its depth.) The extremes in depth for the interior

of the marsh, *i.e.*, 50 feet or so away from the ridges, dikes, roads and old stream shoulders were 12 inches as the minimum and 34 as the maximum. This gave an average depth of 18 inches for the bulk of the marsh area.

The results of the insect sweeps made on the emergent vegetation and on the marsh bottom are summarized in Table 9. Both types of sweep were made at each of the 22 sampling stations. The species of aquatic and bottom dwellers which were found in the largest numbers and which, in addition, had the greatest frequency of occurrence were as follows: snails, bivalves, dragonfly nymphs, water boatmen and midge larvae. Similarly, the commonest species taken by the sweeps on emergent vegetation were short-horned grasshoppers (Acrididae), narrow-winged damselflies, chinch bugs, leafhoppers, crane flies (Tipulidae), grass flies, flies (Anthomyidae), lady beetles (Coccinellidae), leaf beetles (Chrysomelidae), and spiders. The total number of individuals taken was 157 in the sweeps on the emergents and 397 in the sweeps in the water and on the marsh bottom. This shows there were almost 150 per cent more water and bottom dwellers than terrestrial forms—at least during the season of the year (July) when this sampling was done. The distribution of these insects appeared to be random.

STUDY AREA III was a beaver pond of approximately 20 acres. It is located in the NE1/4 of sec. 11, T. 44 N., R.

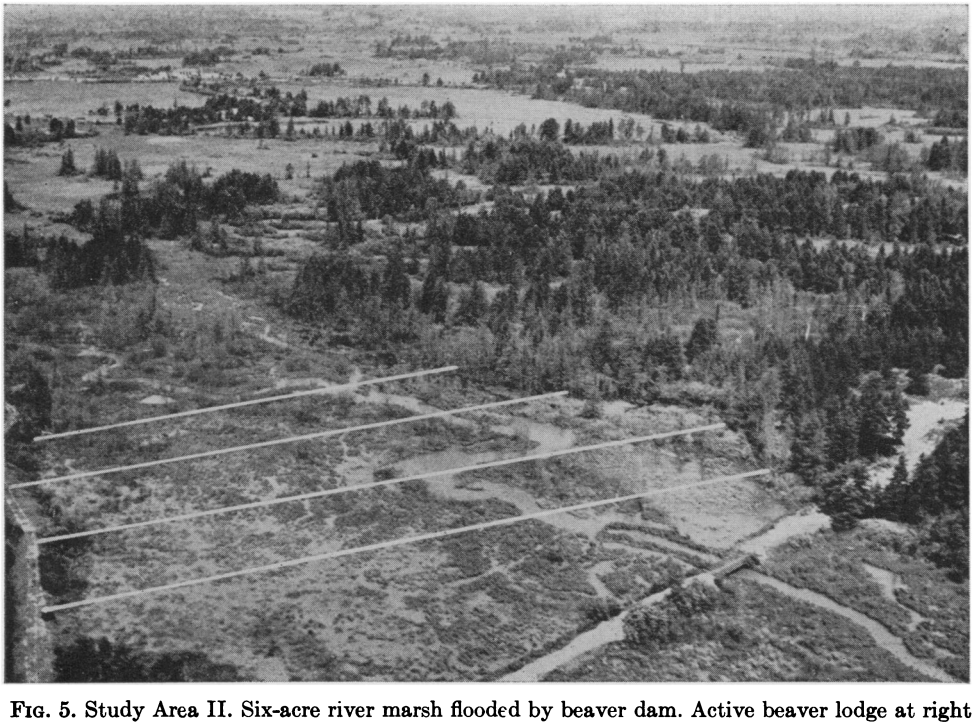

FIG. 5. Study Area II. Six-acre river marsh flooded by beaver dam. Active beaver lodge at right angle bend in the river and U-shaped beaver dam visible in foreground. Lines represent transect lines.

14 W., and lies about one half mile south of the west side of M Pool in Unit 2 of the Refuge.

In 1947 when this study commenced there were no beaver inhabiting the pond, but the remains of an old broken-down lodge indicated previous beaver occupancy. During that year in an extensive flooding to the south, a very large lodge and an elaborate system of dams were constructed and maintained by beaver.

By 1948 these had been deserted and the old lodge in the study area pond was repaired and reoccupied. Whether this was done by the same beaver that had abandoned the new flooding to the south could not be determined. During this same year, beaver sign was very noticeable on the ridges along the south side of the pond. Felled and partly cut-up "popple" of all sizes were lying about almost everywhere. One knoll bordering the southeast corner was completely denuded of its trees (all poplars). Well-packed trails led from the beaver pond up to the nearby ridges where the food trees grew.

By the spring of 1949 the lodge again had been abandoned, but not completely deserted. The animals transferred their activity to the ridges and marshes bordering the pond on the north, where they dug transportation canals and cut brush and trees heavily. Although no longer living in the pond, they continued to maintain the small mud embankment which effectively dammed the narrow outlet leading out of the pool in the southwest corner.

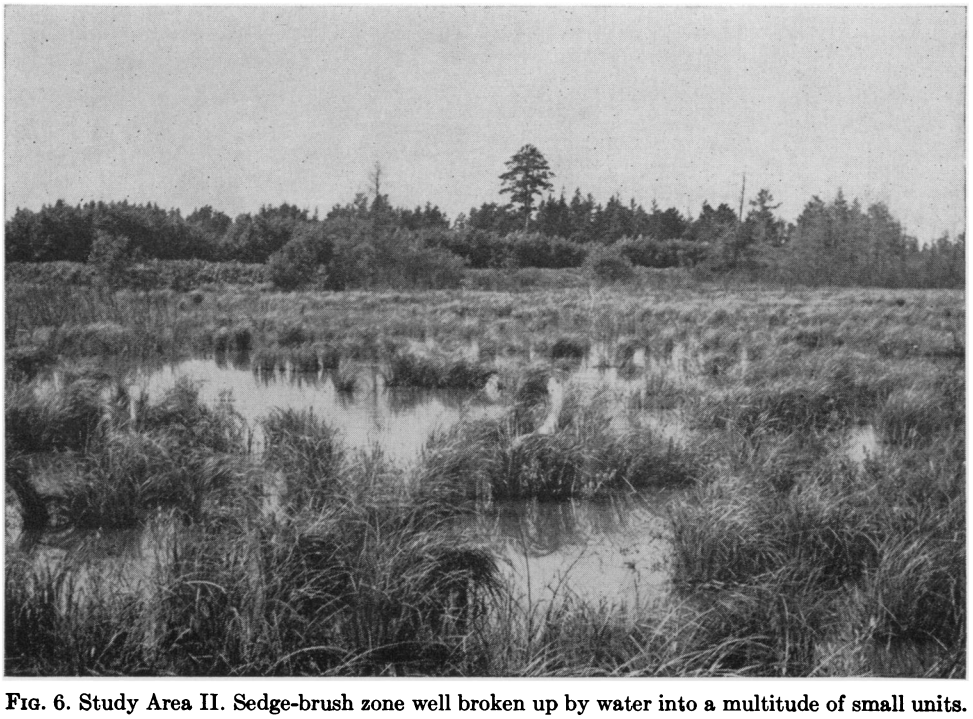

FIG. 6. Study Area II. Sedge-brush zone well broken up by water into a multitude of small units. Sedge is *Carex lacustris* and ratio of water to emergent vegetation is slightly less than 1:1.

This beaver pond is bounded on the north by a rolling ridge. To the northeast is a low marshy draw through which seepage and natural run-off water enter the pond. These are its chief sources of water. Still farther to the east is a very low sedge-covered ridge which separates the open water from the marsh. It is quite possible that this may be the remains of an ancient beaver dam, but no proof of this was discovered. A sand dike forms the eastern boundary, while along the south side a series of winding knolls successfully impounds the water. A low narrow ridge bounds the pond on the west.

Jack and red pines are well distributed on all the ridges. In addition, spruce is found on the ridge at the western edge of the pool, and some aspen and white birch on the north side ridge. Juneberry and tag alder are present almost everywhere in moderate amounts. Bracken, blueberry, and leatherleaf are the common ground cover. Leatherleaf forms dense beds at the base of some of the ridges. Much of the shoreline zone bordering the open water is characterized by abundant sedges, (*Carex lacustris*, *C. lasiocarpa*, *C. stricta* var. *strictior*), and grasses (manna and bluejoint), with frequent patches of dead trees and brush.

The dominant vegetation in this beaver pond consists of a fine sedge (*Carex lasiocarpa*), manna grass and leatherleaf. Small amounts of cattail, bluejoint grass, and rough sedge (*Carex lacustris*) occur in a few spots. The fine sedge and the manna grass are limited

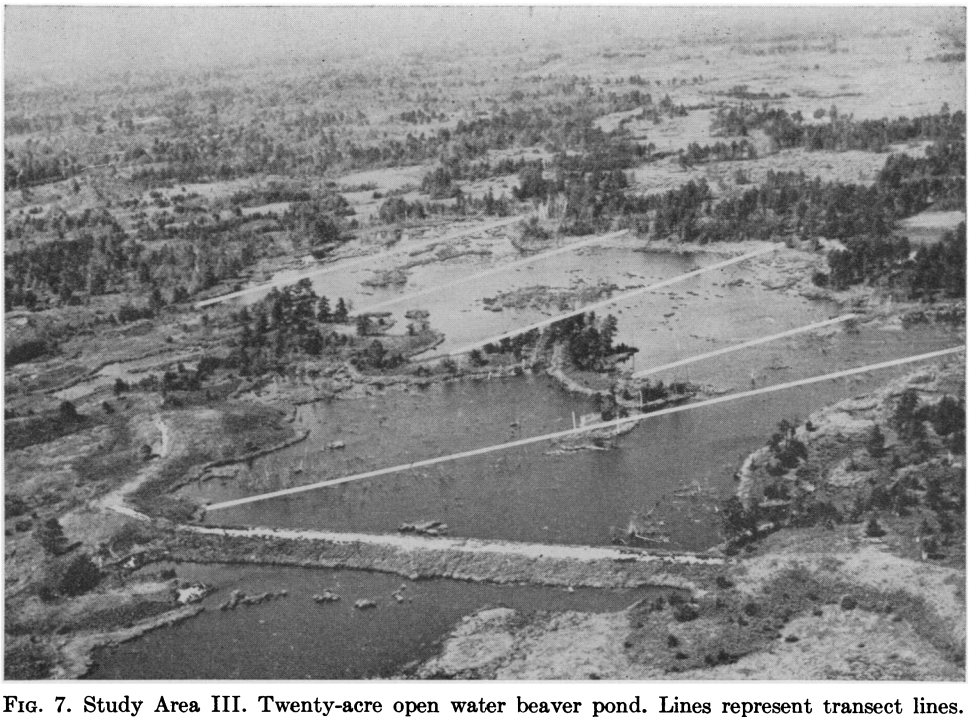

FIG. 7. Study Area III. Twenty-acre open water beaver pond. Lines represent transect lines.

to the northwest corner of the pond, constituting a sedge-grass marsh equal to approximately 8 per cent of the entire pond area. A second zone is one of dead brush and trees down in the southeast section, comprising about 10 per cent of the pond. The remainder of the beaver pond is open water totaling about three-quarters of the entire area.

In the open water zone there are several small leatherleaf islands with dead spruce or jack pine still arising from them. In the sedge-grass marsh the degree of interspersion is 28. The average length of a sedge or grass unit is 5 feet, while that of a water unit is 11. The grass and most of the sedge are in the sparse classification. There is no dense sedge and only a very small amount of the medium sedge. The ratio of water to emergent cover in this sedge-grass marsh zone is 2:1.

Ten environmental types were set up for the entire beaver pond and a total number of 103 type occurrences recorded. The average length of each type occurrence (based on all occurrences) is 27 feet. The "Index of Interspersion" is, therefore, 10/27′, indicating an area of medium interspersion with units of cover and water of considerable size. The one exception to this is the sedge-marsh zone where the degree of interspersion is high and the average size of each type unit small (Figs. 7, 8, and 9).

With the exception of bladderwort, which was recorded at 14 of the 20 sampling stations, none of the few submerged or floating aquatic plant species

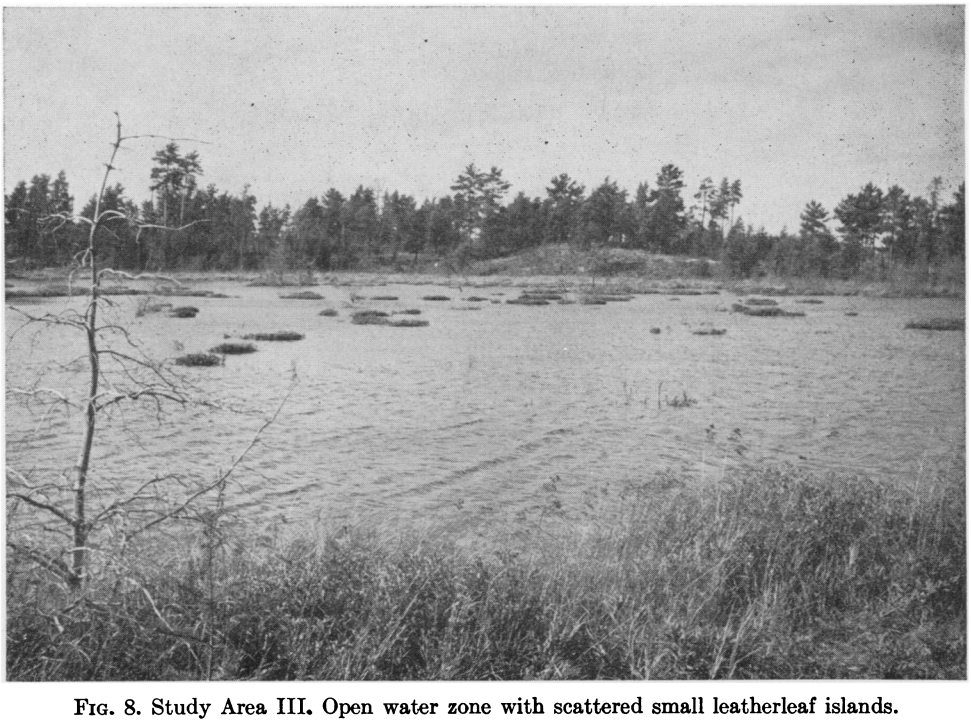

FIG. 8. Study Area III. Open water zone with scattered small leatherleaf islands.

found in this beaver pond were recorded more than three times—an indication of their very restricted distribution. Aquatic plants checked once were duckweed (*Lemna minor*) and water smartweed both as a trace, coontail (*Ceratophyllum demersum*) moderate, duckweed (*Spirodela polyrhiza*) common. Those recorded twice were musk grass (*Chara*) as trace to moderate and water milfoil (*Myriophyllum* sp.) as common. Fine-leaved pondweed was tallied three times in amounts varying from moderate to common. Much of the pond bottom was devoid of aquatic vegetation. It was characterized instead by a barren litter of dead vegetation.

Depth soundings taken at each of the 20 stations spaced along the transect lines showed that the minimum depth was 7 inches and the maximum 37. Around the edges of the pond the water averaged 12 to 15 inches deep, except along part of the south side where it was 7 to 9 inches. At the extreme eastern end of the pond where the water was held by the sand dike, the greatest depths occurred. Here it ranged from 27 to 37 inches. For the remainder of the pond the water varied from 15 to 20 inches. The one exception was in the cove where the mud dam closed the outlet from the pond. Here the water was 27 inches deep.

Table 9 summarizes the results of the insect sweeps made on the emergent vegetation and on the pond bottom. Bottom sample sweeps were made at

FIG. 9. Study Area III. Sedge-grass marsh zone of sparse to medium density. Sedge is *Carex lasiocarpa* and ratio of water to emergent cover is 2:1.

each of the 20 checking stations. Sweeps of insects on emergent vegetation were, of necessity, confined to the 13 stations where emergent growth was present. The forms of aquatic and bottom dwellers found in the largest numbers and usually having the greatest frequency of occurrence as well, were: snails, bivalves, dragonfly nymphs, water boatmen, midge larvae, and minnows (Cyprinidae). Likewise the commonest species taken by the sweeps on emergent vegetation were: cave crickets (Gryllicrididae), narrow-winged damselflies, chinch bugs, leafhoppers, clothes moths (Tineidae), flies (Diptera), midges, grass flies, lady beetles, ichneumon wasps (Ichneumonidae) and orb-weaving spiders (Argiopidae). The total number of individuals taken was 110 in the sweeps on the emergents and 245 in those in the water and on the pond bottom. This indicates that for July, when this sampling was done, there were slightly over 100 per cent more water and bottom dwellers than terrestrial forms. The distribution of these insects appeared to be random.

STUDY AREA IV was a seepage marsh of approximately 20 acres located in the NE1/4 of sec. 30, T. 45 N., R. 13 W. It is just below the dike at the southcentral side of E Pool in Unit 1 of the Refuge.

Although it was not determined when the beaver first moved back into this marsh during the latest reoccupation, they were actively present by the spring of 1948. During the spring and summer of 1949 they were regularly seen or heard.

Two dams are maintained by the beaver. Both are low, built chiefly of mud, and have utilized heavy sedge growth for their buttressing. The longer runs along the east side. It is 2 to 3 inches high and about 250 feet long. There is abundant sign of ancient cutting of poplar saplings that once grew at the dam site. The second dam crosses the depression between the two knolls to the south and thus effectively prevents the water from draining out of the marsh into the large impoundment below. This dam is 9 inches high and about 150 feet long. Here also is ample evidence of alder and poplar once growing on the dam site, but long since cut by beaver. One poplar stump measured 7 inches in diameter. A dam had been in this location for a sufficient time for a zone of sedge growth to become well established on its lower side.

Beaver sign dating from the present reoccupation of the area is not lacking. A great deal of white birch has been cut. One such tree measured 41 inches in circumference at the butt. In another instance an entire clump of six good-sized birch saplings has been felled. In addition, some tag alder, juneberry and one cherry have been cut. All the poplar that grew on the ridges surrounding the marsh was cut long ago. Today, a thorough search reveals not a single poplar growing on any of these ridges about the marsh. The well-worn beaver trails crossing the low dam at the east side of the area into the marsh and large impoundment beyond, indicate that the beaver are travelling some distance to obtain their food and construction materials.

This seepage marsh is bounded on the north by E Pool dike and by a high ridge. On the east a wooded ridge extends southward as a peninsula from E dike and from its tip the low mud

beaver dam continues across the marsh depression to form the boundary. Two high knolls connected by the second beaver dam enclose the area on the south, while a long narrow ridge lies to the west.

Jack and red pines are the dominant trees and grow on all the ridges. In addition, tamarack, white birch, juneberry, and tag alder are found on the knolls on the south and west sides. Blueberry and bracken are the common ground cover. In the peripheral zone bordering the marsh proper, tag alder, willow, and leatherleaf are common in many places, especially at the base of the ridges. Sedges such as *Carex lasiocarpa* and *C. lacustris*, manna grass, bluejoint grass, three-way sedge (*Dulichium arundinaceum*), cattail, soft rush (*Juncus effusus*) are most characteristic of this zone.

The dominant emergent in the marsh consists almost entirely of *Carex lasiocarpa*. It does not form tussocks, but rather its stems form beds of the "sedge meadow" type. Scattered dead willow brush is present in parts of the marsh. Cattail and burreed occur infrequently.

This area consists of two major zones. The first is sedge marsh which accounts for approximately two-thirds of the total acreage. The second is open water comprising the remaining one-third. The open water zone is at the east end of the area. A sparse fringe of dead brush borders it on the west side, *i.e.*, between it and the sedge marsh. In the

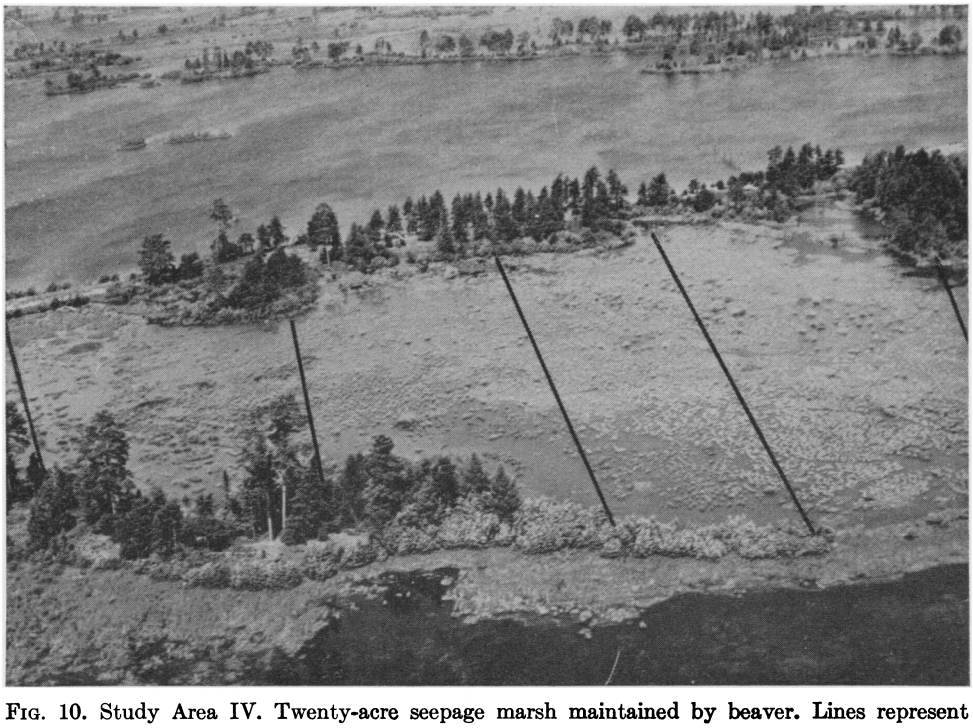

FIG. 10. Study Area IV. Twenty-acre seepage marsh maintained by beaver. Lines represent transect lines.

marsh almost all the sedge falls into the sparse class. There is no dense, and the amount of medium is small. The ratio of water to sedge is almost 2:1.

Eight environmental types were recognized for the area, and there were 358 type occurrences. The average size for each type occurrence (based on all occurrences for all types) is 9 feet. The "Index of Interspersion" is, therefore, 45/9′, indicating a marsh that has an extremely high number of units of cover and water of small size well intermixed. Large solid blocks of any one cover type are lacking, with the one exception of the open water zone (Figs. 10 and 11).

Nine species of submerged or floating aquatic plants were checked at one or more of the 25 sampling stations in this area. Water shield (*Brasenia schreberi*) in amounts varying from common to abundant had the most widespread distribution, occurring at all but four of the checking points. The two next important species were bladderwort, checked at 20 stations in amounts ranging from moderate to common, and waterweed, tallied 17 times as moderate to abundant. Fine-leaved pondweed and yellow water lily (*Nuphar* sp.) were each checked five times in amounts varying from trace to common. The remaining species each recorded at one station were: musk grass (moderate), and floating-leaf pondweed (*Potamogeton natans*) (moderate). Bottom litter of dead vegetation is present in about half the area.

FIG. 11. Study Area IV. Sedge marsh zone of sparse density. Sedge is *Carex lasiocarpa*. *Brasenia schreberi* blankets much of the open water and the ratio of water to sedge is almost 2:1.

Measurements of the depth of water taken at the 25 stations throughout the marsh showed a maximum of 28 inches and a minimum of 10. Water was deepest in the open zone in front of the low mud dam across the depression at the south side of the marsh; the largest area of deep water was at the east side. Here the depths ran from 20 to 23 inches. At the base of the ridge and dike at the north the depth was 10 to 12 inches, while along the ridges to the south it was 13 to 18 inches. For the bulk of the marsh the water depth varied from 14 to 19 inches with an average of 18 inches in most spots.

The results of the insect sweeps made on the emergent vegetation and on the marsh bottom are summarized in Table 9. Bottom sample sweeps were made at each of the 25 station points. Surface sweeps were made at the 15 checking stations where emergent vegetation was present. The species of aquatic and bottom dwellers found in the largest numbers and which, in general, had the greatest frequency of occurrence were: snails, bivalves, narrow-winged damselfly nymphs, dragonfly nymphs, water boatmen, midge larvae, and minnows. Likewise the commonest species taken by the sweeps on emergent vegetation were: narrow-winged damselflies, chinch bugs, plant bugs, leafhoppers, swale flies, grass flies, leaf beetles, and orb-weaving spiders. The total number of individuals taken was 110 in the sweeps on the emergents and 342 in those in the water and on the marsh bottom. At the time when this sampling was done (July) there were 200 per cent more water and bottom dwellers available than terrestrial forms. The distribution of these insects appeared to be random.

ENVIRONMENTAL FACTORS RESPONSIBLE FOR WATERFOWL USE OF STUDY AREAS

When all these physical and ecological characteristics are carefully reviewed and analyzed, six environmental factors are found to be, in general, common to all four areas. These factors are the usual result of beaver flooding in sedge marsh country such as Seney, and it is these same factors which largely explain the strong attraction of the beaver marsh for waterfowl and its intensive use by them.

One of the most important of these factors is the amount of interspersion present in the marshes. The reason for this lies in the habits of the waterfowl themselves. The game species using these areas depend for their safety upon instant access to clumps of emergent vegetation growing in water behind which they can quickly disappear from sight. This cover must be of such density that the ducks can penetrate it easily and without any danger, especially to ducklings, of getting tangled and caught in the dead or matted stems. In other words, it must fall into either the sparse or medium classification as already defined and used in this study. It must also be close enough to water units used by ducks for feeding to provide them with a sense of security.

Since the waterfowl require both units of cover for escape and units of water for a source of food, it follows that the higher the number of these units that an area can provide, the better the interspersion, the greater the number of ducks that can be accommodated and the larger the amount of the area that can be utilized.

A more specific idea of what constitutes good interspersion may be gained from a compilation of some of the measurements made in the study areas. The number of cover and water types varied from 8 to 12 with an average of 10. The number of type occurrences ranged from 103 to 358, and the average length of each type occurrence for each area ran from a minimum of 9 to a maximum of 26 feet. The ratio of water to cover as found in the marsh zones (this excludes large areas of open water) is one of the most significant measurements and most truly indicative of the amount of interspersion present. This ratio did not vary much for the four areas. The highest ratio of water to cover was 2:1 and was present in the sedge marsh portion of the open water beaver pond and in the seepage marsh maintained by beaver. The river marsh flooded by beaver had a ratio of slightly less than 1:1, while the sedge marsh abandoned by beaver had the lowest ratio—1:3. This last ratio is not at all surprising, since with the gradual lowering of the water table due to the disintegration of the beaver dam, the sedge is gradually extending into the water area. The "Index of Interspersion" based on the number of cover type occurrences and on the average size of the cover type units ranged from 45/9′ to 10/27′.

Another common key factor is the composition and juxtaposition of the environmental types. In all four of the areas, zones of sedge marsh, of open water and of dead brush were present. Each fulfilled some requirement in waterfowl needs, for the ducks made use of all of them. The sedge marsh provided security in the form of escape cover, especially for the dabbling ducks; the open water furnished feeding grounds and suitable sites for loafing and preening; the dead brush offered a rich source of insect food especially attractive to ducklings. Repeated observations showed the preference of the ring-necks for open water zones in which to carry on many of their activities. All three of these environmental types seemed to play a fundamental part in the ecology of the waterfowl, and it appeared essential that they be included in any area considered as good waterfowl habitat.

In three of the study areas the sedge marsh zone constituted from two-thirds to three-quarters of the entire area, with the open water and dead brush zones accounting for the remainder. In Study Area III (the open-water beaver pond), however, the proportions were reversed with the sedge marsh occupying 8 per cent, the brush and trees 10 per cent, and the open water 82 per cent of the area. In all four study areas, these three environmental types were contiguous, and the ducks were able to move quickly and easily from one to another. This was important since it enabled dabbling ducks, for instance, to make greater use of the open water zones than would have been possible if the safety of the sedge marsh zone had not been close by and readily attainable.

The third common factor of importance is the depth of water. The dabbling ducks, because of their method of feeding, are restricted to relatively shallow water. Black ducks will make shallow dives when necessary, but even they obtain most of their food by tipping and dabbling. For this reason, water depths of from 6 to 18 inches represent the optimum range for their

feeding. For the ring-necked duck somewhat greater depths of water are desired.

The average depth of water for three of the study areas was 18 inches. It was $5\frac{1}{2}$ inches for the fourth—the sedge marsh abandoned by beaver. The deepest water was in the open-water zones in each of the areas. There the depth averaged from 2 to 3 feet for all the study areas except the sedge marsh abandoned by beaver, where it was 8 inches. It was in these open water zones with their water depths of 2 to 3 feet that ring-necked broods or adults were seen most frequently diving for food.

A fourth factor of vital importance is the amount and kind of animal and vegetable foods present. Both types are required by waterfowl. Ducklings of all species rely almost entirely upon animal foods during the first two or three weeks of their existence. As they grow older, although they utilize an increasingly large amount of vegetable foods, they still consume large quantities of animal food, the amount depending upon the food habits of the individual species.

None of the study areas had a rich and abundant submerged aquatic flora. Very few species were present and, with but one or two exceptions, their growth was sparse and puny. Bladderwort was the one aquatic common to all four areas, being fairly widespread in each area and occurring in amounts varying from moderate to common. It was also the only submerged aquatic in two of the areas. Fine-leaved pondweed and waterweed grew in significant amounts in two of the marshes. The pondweed plants were small and produced no seeds, but manifested a fairly healthy growth. Characteristic of all four of the marshes and ponds was the abundant supply of bottom litter.

In Study Area IV (the seepage marsh maintained by beaver) one species of floating aquatic occurred. This was water shield. Its growth was vigorous, and it covered approximately half of the water surface of the marsh. During July abundant bloom gave promise of a prolific crop of seeds.

In three of the study areas *Carex lasiocarpa* was the dominant emergent plant. In the fourth area, the river marsh flooded by beaver, *Carex lacustris* and *C. stricta* var. *strictior* were the common emergent. Manna grass was also common in the open water beaver pond.

In contrast to the sparsity of good aquatic food plants, the small forms of animal life of the four areas were well diversified and prolific. The following groups were represented by the greatest number of individuals and were the most commonly distributed over all four areas: snails, bi-valves, dragonfly and damselfly nymphs, water boatmen, midge larvae, leafhoppers, grass flies, swale flies, chinch bugs, lady beetles, spiders, and minnows (Table 9).

For all four study areas the aquatic and bottom dwelling animal species outnumbered the more terrestrial forms found on the emergent sedge and brush by a ratio which showed a rather marked uniformity, ranging only from 3:1 to 2:1.

The results of an analysis of the gizzards of 26 ducklings of various ages collected by the writer on the refuge are tabulated in Table 10. These birds, although not shot in any of the study areas, were obtained from habitats of a similar nature. Many of the food items

TABLE 10.—ANALYSIS OF 26 DUCKLING GIZZARDS COLLECTED ON THE SENEY REFUGE[1] (1947, 1948, 1949)

Food item	Composition by Volume (%) Ring-necked duck (11, age 3–8 wks)	Baldpate (3, age 6 wks)	Blue-winged teal (8, age 1–8 wks)	Green-winged teal (1, age 7 wks)	Hooded merganser 2, age 6–7 wks)
Porifera					
Spongillinae	3	..	..	..	..
Bryozoa	tr	..	9	..	..
Mollusca					
Gastropoda	14	..	1	..	..
Pelecypoda	..	..	1	..	..
Annelida					
Hirudinea	..	..	..	tr	..
Arthropoda					
Cladocera	..	..	6	..	..
Cambarus virilis	tr	..	..	..	49
Odonata	32	..	5	..	11
Corixidae	tr	..	1	tr	..
Belostomatidae	..	..	..	..	5
Nepidae	..	..	tr	..	..
Gerridae	..	..	tr	..	..
Trichoptera	28	..	6	..	..
Heterocera	..	..	1	..	..
Chironomidae	..	..	..	75	..
Coleoptera	..	..	tr	..	..
Haliplidae	..	tr	tr	..	..
Dytiscidae	..	..	..	tr	3
Hydrophilidae	..	..	..	..	tr
Chrysomelidae	..	..	tr	..	..
Curculionidae	..	..	..	tr	..
Grinidae	..	3	..	..	..
Formicidae	..	..	tr	..	..
Hydrachnidae	..	..	tr	..	..
Chordata					
Rana sp.	..	..	..	..	32
Sparganiaceae					
Sparganium spp.	tr	..	15	..	..
Najadaceae					
Potamogeton pusillus	18	..	47	tr	..
Potamogeton gramineus	..	..	tr	..	..
Potamogeton pectinatus	..	..	tr	..	..
Hydrocharitaceae					
Anacharis canadensis	4	97	1	..	..
Gramineae					
Glyceria canadensis	..	..	..	25	..
Cyperaceae					
Eleocharis palustris	tr	..	tr	..	..
Rhyncospora fusca	1	..	..	..	..
Cladium mariscoides	tr	..	..	..	..
Carex (lasiocarpa & stricta)	tr	..	4	tr	..
Polygonaceae					
Polygonum amphibium	..	..	1	..	..
Rosaceae					
Potentilla sp.	..	..	tr	..	..
Rubus sp.	tr	..	..	..	..
Prunus virginiana	..	..	1	..	..
Ericaceae					
Gaylussacia baccata	..	..	1	..	..

[1] Stomach analyses made by F. M. Uhler and data released through courtesy of the Fish and Wildlife Service.

found most frequently are the same as those commonly present in the four study marshes.

Studies by Martin and Uhler (1939), Cottam (1939), McAtee (1918, 1939), and Mabbott (1920), likewise, showed many of the plants and small animal forms most characteristic of the study areas to be utilized by adult ducks for food in varying degrees.

A fifth factor of considerable importance is the degree of freedom from human disturbance that is possessed by the marsh or pond area. Ducks, especially during the rearing period and during the flightless stage in the postnuptial moult, will not tolerate much disturbance by people. If such persists, they will desert the area. (Beard, 1947).

Under ordinary circumstances, each of the four study areas possesses the necessary seclusion either through being located sufficiently far from the main traveled dikes, or by the existence of a screening strip of woods between it and the dike road. If any of these areas, however, should fall within a zone opened to the public for recreational use, such as fishing, their use by waterfowl will sharply decrease, as was the case in 1947 when Study Area IV was included within the area open to fishing. During that year only two broods and 70 adult ducks were seen. In the two years that followed, however, when this marsh was closed to fishing, a marked increase in both broods and adults was noticed (Tables 7 and 8).

A sixth and final major factor is the availability of suitable nesting cover within a reasonable distance from the brood-rearing marsh. There is no shortage of this type cover for any of the four study areas. For the black and mallard there are plenty of low-growing jack pine and red pine, blueberry bushes and dead brush piles; for the baldpate and blue-winged teal an almost limitless amount of dry sedge marshes; for the wood duck and hooded merganser numbers of suitable dead trees.

In summary, six environmental factors have been found common to the four areas under study. The critical analysis of the areas showed them to be key characteristics and the ones which explain in a large measure the attraction of these habitats to waterfowl. These factors are: proper interspersion of cover and water; composition of environment to include units of marsh, open water, and dead brush; suitable depth of water; adequate supply of vegetable and animal food; freedom from human disturbance; and suitable nearby nesting cover. Marshes and ponds possessing these six factors have gone a long ways toward fulfilling waterfowl requirements for optimum habitat.

Proof of this is reflected in the duckling production figures for the study area as shown in Table 11.

The average number of young produced each year per acre ranged from 1.7 to 4.6. Even the lowest average yield of ducklings (1.7) is more than 1.5 ducks per acre—and that, considering both the nature of the environment and the nesting habits of the species of ducks using these areas, is productivity of a high order.

There is a clear correlation between duckling output and "Index of Interspersion." Those areas with the most favorable "Index of Interspersion" lead almost without exception in the number of ducklings produced each year. Although this index is not a measure of

TABLE 11.—DUCKLING PRODUCTION FOR THE FOUR STUDY AREAS

Area	No. acres	Total no. ducklings in 1947	Total no. ducklings in 1948	Total no. ducklings in 1949	Total no. ducklings for 3 yrs.	Av. no. ducklings per year	Av. no. ducklings per year per acre	"Index of Interspersion"
Study Area I.....	10	71	24	13	108	36	3.6	12/16′
Study Area II.....	6	..	28	28	56*	28	4.6	19/9′
Study Area III.....	20	52	25	25	102	34	1.7	10/27′
Study Area IV.....	20	10	46	68	124	41	2.1	45/9′

* Production for two years only (1948 and 1949).

all the six key factors, it is for the important ones relating to amount, composition and juxtaposition of cover and water.

Study Area IV has the highest "Interspersion Index" (45/9′); likewise it has led in duckling production in 1948 and 1949 by a substantial number. In contrast its 1947 output was very low. This is explained by the fact that during that year it was included within the open-to-fishing zone, and because of the constant disturbance from fishermen, was virtually abandoned as a duckling-rearing marsh.

Study Area II has the second most favorable "Interspersion Index." For the two years this area was studied, the number of ducklings produced likewise ranked second.

Study Areas I and III show little significant difference in their "Index of Interspersion." Likewise the total number of ducklings produced by each of these two areas is very similar. Duckling output for the sedge marsh abandoned by beaver (Study Area I) has steadily declined during the three-year study period. This is probably largely accounted for by the decreasing water levels and corresponding encroachment of solid sedge growth occurring as the result of the abandonment of the area by beaver.

USE OF STUDY AREAS BY OTHER WILDLIFE

Other forms of wildlife besides waterfowl were not slow to respond to the very favorable types of marsh and aquatic habitat created by the beaver. They were observed in varying numbers in all the areas under study. A list of such animals would include deer, otter, mink, muskrat, and marsh birds, such as the great blue heron, pied-billed grebe, and Canada goose.

Their effect upon the ducks using the areas was not easy to ascertain. In most instances it is probable that they existed together in these marsh environments without conflict or harmful influence. For example, deer were frequently observed standing knee deep in the marsh pulling up and eating great quantities of submerged aquatics, such as bushy pondweed, fine-leaved pondweed, and waterweed. The first two plant species listed are among the preferred food plants of ducks, but there was no competition in view of the size of the area, the amount of aquatic plant growth, and the number of deer.

If muskrats in these beaver-created marshes exercised any influence at all upon the waterfowl, it was generally a beneficial one. In Study Area IV there were three muskrat houses, and musk-

rats were frequently seen swimming about. Their use of cattail and some sedge for food and construction material would be valuable in helping to thin these emergents and in creating the openings in the marsh vegetation, so well-liked by ducks, if the emergents ever began to grow too densely. This condition, however, did not exist in any of the four areas under study. Muskrat houses were favored by ducks for preening and loafing, and also supplied potential nesting sites.

A few mink were seen in the four beaver marshes or ponds. Three were trapped in November, 1949, in Study Area IV. Their prey includes both adult and young ducks. It is reasonable to assume that their presence is detrimental to waterfowl production.

Observations of otter in the study areas were made on three occasions. In September one was watched swimming and rolling in Study Area III. Two others were seen in Study Area II. Too little is known about the habits of the otter to judge whether its presence has any effect upon the waterfowl found in the same area.

Canada geese were frequently observed in all these areas, but no evidence of any conflict between them and the ducks was ever detected. In Study Area IV one Canada goose nested and successfully hatched six goslings. All the areas were used at various times by the geese for rearing their broods and by adult geese for feeding and loafing.

Marsh birds, such as the pied-billed grebe and the great blue heron, were common in the beaver pond environments. That conflict sometimes existed between the pied-billed grebe and the ducks was suggested by two observations made in Study Area IV. On May 27 two black ducks flew into the marsh and began feeding. Almost immediately a pied-billed grebe began to harass them. It rushed along the surface of the water in short spurts toward the ducks, forcing them to fly ahead a few feet. This was repeated several times. This behavior was repeated on one black duck in the same part of the marsh on June 9. Whether the grebe was defending a nest site from too close approach by the ducks is not known. The ducks certainly showed no aggressiveness, but yielded completely to the belligerence of the grebe.

The great blue heron is an integral part of these marsh and aquatic habitats. Nothing was observed to indicate that it had any influence either harmful or beneficial upon the waterfowl in the area. It is strongly suspected that very young ducklings might on occasion be killed by these herons.

MANAGEMENT RECOMMENDATIONS FOR BEAVER-WATERFOWL HABITAT

One of the major objectives in waterfowl management is to maintain and to increase suitable environment.

There are several management measures applicable. All of them either directly or indirectly relate to the beaver. Since the ponds and marshes created by the beaver under natural conditions, such as are found at the Seney Refuge, fulfill waterfowl requirements so well, it is but logical to use the beaver as one means of achieving this objective. Management efforts, therefore, should be directed toward maintaining the beaver population at the highest possible level consistent with creation and maintenance of optimum waterfowl habitat.

This means that beaver numbers must not be allowed to outstrip their available food supply. Enough beavers must be removed periodically to keep the population in balance with the growing capacity of their food trees.

The desired objective in managing beaver in areas where the interests of the waterfowl have first priority is to promote and safeguard the continuous occupation and maintenance of ponds. Such achievement depends on a trapping program which will remove enough beaver so that food needs of those remaining in the colony will not exceed the annual replacement growth of the available food trees.

Several danger signs appear when the beaver are getting out of balance with their food supply. The disappearance of poplar within several hundred yards of the lodge, heavy feeding on white birch, construction of lodges in obviously unfavorable sites, and abandonment of ponds, are examples of such warnings.

The number of beaver which can be safely removed without jeopardizing the breeding stock according to Bradt (1947) is approximately one-third of the total population. He explains: "Since a theoretical loss of 50 per cent per year would be the maximum possible without reducing the total population, and a loss of 25 per cent per year should allow a steady increase, perhaps a 33-1/3 per cent loss, or approximately one-third of the total, should be satisfactory to maintain the population, or even to permit a slow increase."

Swank (1949) figures that the annual increase in beaver is one-third of the population and that this increase may be harvested annually and still allow "a margin of safety to offset any possible unforseen circumstances that may drastically reduce the population."

The second major recommendation calls for the maintenance and repair of suitable abandoned beaver ponds wherever feasible. The job can be done simply, effectively and cheaply by the use of simple materials that are adequate to insure as great a permanence to the structure as is needed. The repair or replacement of the dam is, in most cases, a minor one, since beaver dams built in this type environment are usually not very long or high.

This second recommendation was carried out in one place on the Seney Refuge in September, 1948 under the direction of Refuge Manager C. S. Johnson. The area was a seepage marsh characterized by much sedge, leatherleaf and bordering zone of dead spruce. In 1945, it could be easily traversed by duck boat. A small dam, that plugged the road culvert and thus impounded water, and a lodge were actively maintained by beaver. By 1947 the beaver had deserted the area. The lodge and dam had disintegrated, the marsh was completely drained and sedges were beginning to invade the mud bottom. At the cost of approximately $50 for labor and materials a simple structure of board piling and wood sill, earth and rock fill was constructed across the small outlet drain (Fig. 12). This was all that was needed to stop the run-off and restore the necessary amount of water to enable the marsh again to function effectively as duck-rearing habitat (Fig. 13).

The record of waterfowl use of this small marsh during the one season (1949) since its restoration is: 46 blacks, 6 ring-necks, 6 wood ducks, 6 baldpates, 5 mallards, 4 blue-winged teal, 2 green-

winged teal, 2 hooded mergansers and one shoveller—a total of 78 ducks. Its duckling production is equally impressive. Five broods were recorded: two of wood duck and one each of black, ring-necked and hooded merganser. The number of ducklings was 13.

The immediate response to a restored beaver marsh area indicates the value and inherent possibilities in this second management recommendation. If the simple method of construction as outlined above is followed, the cost will be small. In terms of benefit to wildlife the potential value is great.

The construction of man-made "beaver ponds" is suggested as a third management measure. This recommendation is based upon the idea of imitating the beaver ponds—of creating by artificial means the same environmental conditions as those produced by the beaver in his own impoundments. A simple structure of wood plank piling, wood sill boards, and earth fill would be practical and effective when the right combination of low area, surrounding ridges and source of water occurred. In the Seney marsh area numerous places were observed where the construction of a low simple wooden dam across a low area between two ridges, for example, would be sufficient to impound successfully the seepage or run-off water and convert a profitless marsh area into a pond capable of producing ducks.

This recommendation was carried out in one favorable spot in the Seney Ref-

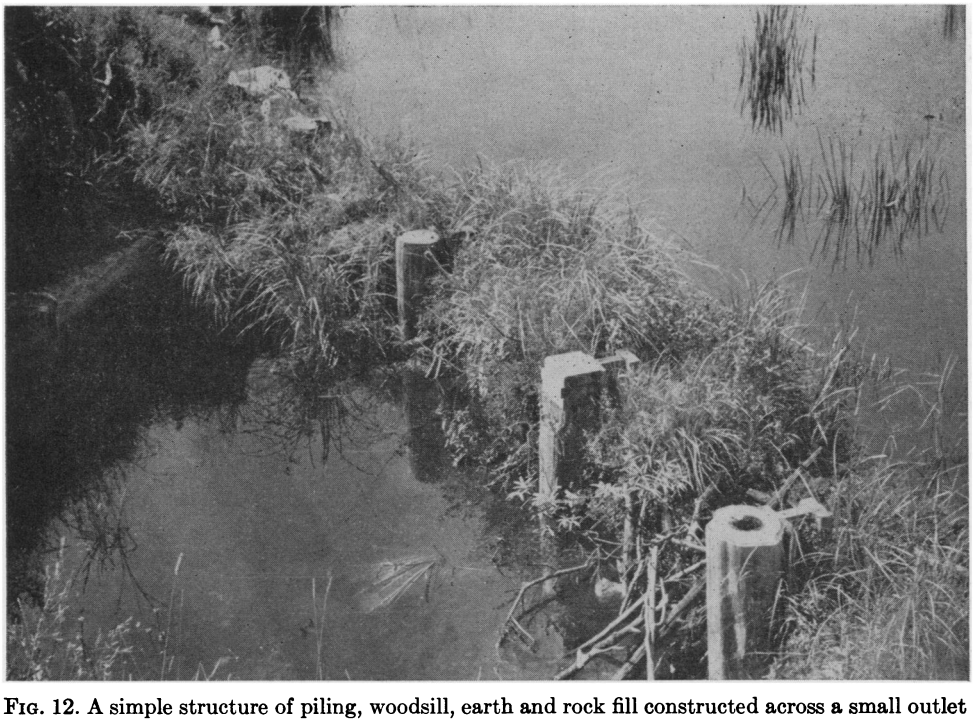

FIG. 12. A simple structure of piling, woodsill, earth and rock fill constructed across a small outlet drain and later reinforced by materials brought in by beaver was sufficient to stop run-off and rehabilitate the marsh.

uge in September, 1948. The spot chosen was a small bay at the western end of B Pool which had long been separated from the main body of the pool by a very ancient beaver dam. This dam was so old that good-sized birch trees and alder bushes had become well established on it, and its original function as a dam had long since disappeared. In the course of time a break-through in the dam deepened into a channel about 12 inches wide connecting the two bodies of water. Usually by the end of July the water in the small bay had all run out or evaporated. Wood spill boards and sill were built across the channel. Wooden piling and aprons anchored the structure to the ancient dam. Earth and rock fill buttressed the piling. Now, as a result of simple inexpensive construction, the amount of water in the bay can be regulated and a "beaver pond" has been built potentially capable of producing ducks.

It is recommended as a fourth management measure that, wherever feasible, water be diverted to suitable dry marsh areas and the beaver be relied upon to carry on from there. This suggestion proposes to follow the pattern established by streams when siltation forced overflowing of banks, spreading over the surrounding area, and cutting a channel elsewhere. As a result, the marsh is flooded and opened up and much brush killed. Areas suitable for such treatment should have sufficient fall in elevation to allow the water to wander through the marshes seeking its own level and proper spacing along

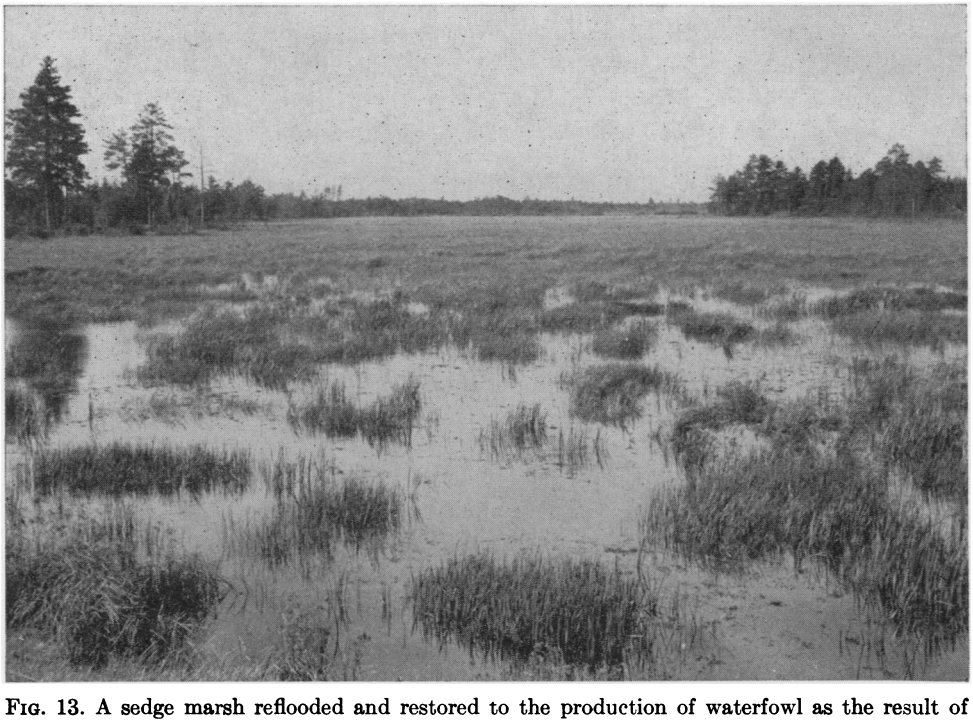

FIG. 13. A sedge marsh reflooded and restored to the production of waterfowl as the result of the construction of a simple wooden spill dam.

natural contours of enough ridges and knolls to permit the construction of occasional small retaining dikes designed to create storage pools to ensure a permanent supply of water. With the presence of this water, and provided the ridges furnished an adequate supply of food trees, it is very probable that the beaver would move in and commence building ponds. The results of such a program contributed to by both man and beaver would be a chain of marshes, small ponds, and connecting flowages to provide the type of habitat essential for dabbling ducks of the lake states. In addition, it is simple, relatively inexpensive (when compared to the cost of building major impoundments), and, in harmony with the needs and nature both of the marshes and of the waterfowl.

CONCLUSION

Waterfowl habitat requirements in marsh country, such as exists at the Seney Refuge, are well met in the marshes and ponds constructed by the beaver. This animal, quick to respond to the presence of water, moves into suitable areas and in the course of producing an environment suitable for his own needs, at the same time unwittingly creates ideal waterfowl habitat.

Wise planning on the part of waterfowl managers will take advantage of this trait and utilize it to the fullest extent. Wherever feasible, management should lend a hand and divert water into dry areas otherwise suitable, so that beavers can move in and commence a low-cost program of waterfowl marsh building. Management, also, should carefully study the composition of these beaver marshes and ponds and imitate them as closely as possible in its own plans for waterfowl habitat improvement. It should be recognized that although big bodies of water impounded by long dikes serve a useful purpose, these alone are not sufficient to satisfy duck habitat requirements. They do not fulfill the needs of dabbling ducks for much of their feeding or for brood-rearing and moulting cover.

The beaver aids the manager in still another way. When break-throughs in ditch banks occur, it is not at all unusual to find that the beaver within a short time has built a dam across the break and done it so effectively that further repairs are unnecessary. In one of the main diversion ditches in the Seney Refuge there are no less than three major break-throughs, all of which are effectively repaired by beaver dams (Fig. 14). The largest of these dams is 30 feet long and $2\frac{1}{2}$ feet high.

The relation of beaver to waterfowl in environments similar to those existing in the Seney marshes is close and important. Successful waterfowl management will profit both by the actual work done by the beaver and by the example set. The cost is low. The value received in terms of duckling production is great. Acre for acre, it is the "beaver" marshes—either beaver-made or man-made—that attain truly high productivity.

SUMMARY

Field work to study the habitat preferences of waterfowl, and, in particular, the role of the beaver as the creator of these habitats was carried on by the writer during the spring and summer months of 1947–1949 at the Seney National Wildlife Refuge in Michigan.

Four areas typical of refuge marsh

habitat and embodying different stages in beaver activity were selected for detailed study.

The objectives of the study were three-fold: (1) to keep these study areas under intensive surveillance in order to determine the extent and purposes of their use by waterfowl; (2) to analyze the physical characteristics of the areas in order to determine the important factors responsible for their attraction to waterfowl; (3) to determine practical management measures designed to maintain and to establish a maximum number of such beaver ponds and marshes.

The results of the field observations of waterfowl activities in these marshes and ponds during the three years showed that they were receiving heavy use and were fulfilling several functions of vital importance to the birds. They were serving as a place where courtship was carried on and where territories were established by mated pairs; they were providing food and cover suitable for rearing broods; they were furnishing food and cover for migrants in the spring as well as for an additional influx of ducks in the late summer; and finally, they were providing the isolation, food, and escape cover required by dabbling ducks during the flightless period of their post-nuptial moult.

The detailed analysis of the physical and ecological characteristics of the four study areas when carefully reviewed and analyzed, showed that certain factors were, in general, common to all four areas. These factors appear to be the usual result of beaver flooding in sedge marsh country such as Seney, and it is these same factors which largely explain

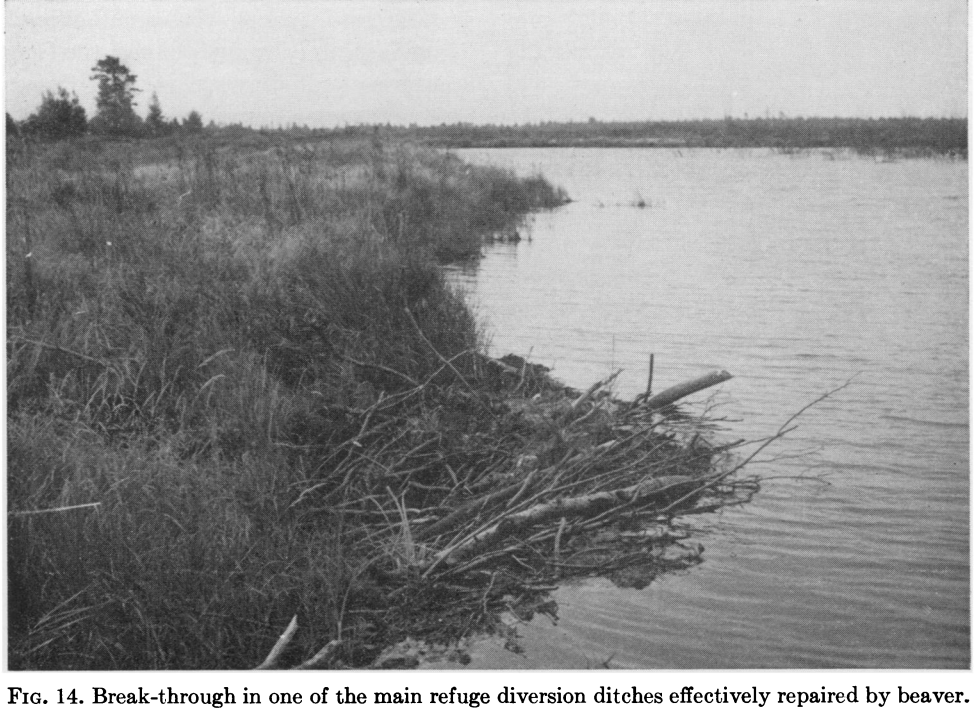

FIG. 14. Break-through in one of the main refuge diversion ditches effectively repaired by beaver.

the strong attraction of the beaver marsh for waterfowl and its intensive use by them.

The first of these factors was the amount of interspersion of cover and water present. In order to express interspersion numerically, the total number of occurrences in a specified unit was divided by the number of cover types present in the same unit. The resulting figure was the numerator in the "Index of Interspersion." This figure ranged from 45 to 10. The number of cover and water types varied from 8 to 12 with an average of 10. Since the size of a unit of environmental type conditions to a considerable extent its potential use, the average size of the cover type units was included in the measurement of the interspersion and expressed as the denominator in the "Index of Interspersion." This figure was obtained by averaging all occurrences of all cover types in the same area used to measure the degree of interspersion as expressed in the numerator of the index. The average length of each type occurrence for each area ran from a minimum of 9 to a maximum of 26 feet.

A second key factor was the composition and juxtaposition of the environmental types. In all four of the areas, zones of sedge marsh, of open water and of dead brush were present. In three of the study marshes, the sedge marsh zone constituted from two-thirds to three-quarters of the entire area, with the open water and dead brush zones accounting for the remainder. In the fourth study area, these proportions were reversed. These three environmental types were contiguous which enabled the ducks to move easily and quickly from one type to another.

The third factor of importance was the depth of water. The average depth of water for three of the study marshes was 18 inches; for the fourth it was $5\frac{1}{2}$ inches. The deepest water was found in the open water zones in each of the areas. There it averaged from 2 to 3 feet for all the study areas but one where it was 8 inches.

A fourth factor of vital importance is the amount and kind of animal and vegetable foods present in the marshes. Both types are required by waterfowl. None of the study areas had a rich and abundant submerged aquatic flora. Very few species were present and with but one or two exceptions, their growth was sparse and puny. Bladderwort was the one aquatic common to all four areas, as was an abundant supply of bottom litter.

In contrast to the sparsity of good aquatic food plants, the small animal life as indicated by sampling of the four areas was well diversified and prolific. The following groups were represented by greatest number of individuals and were the most commonly distributed: snails, bi-valves, dragonfly and damselfly nymphs, water boatmen, midge larvae, leafhoppers, grass flies, chinch bugs, lady beetles, and spiders. The aquatic and bottom-dwelling animal species outnumbered the more terrestrial forms found on the emergent sedge and brush by a ratio which showed a rather marked uniformity, ranging only from 3:1 to 2:1.

Reference to the results of an analysis of the gizzards of 26 ducklings collected on the refuge and to other food habit studies showed that many of the more important animal and plant species present in the study areas were among

the foods commonly consumed by ducks.

The possession of sufficient isolation to guard against disturbance from people was the fifth factor common to all four study areas.

A sixth and final factor of major significance was the availability of suitable nesting cover within a reasonable distance from the brood-rearing marsh. There was no shortage of this type cover for any of the four study areas.

Marshes and ponds possessing these six factors go far toward fulfilling requirements for ideal waterfowl habitat, reflected in the duckling production on the study areas. The average number of young produced each year per acre ranged from 1.7 to 4.6. Considering the nature of the environment and the nesting habits of the species of ducks using these areas, this is productivity of a high order.

There is a clear correlation between duckling output and "Index of Interspersion." Those areas with the most favorable "Index of Interspersion" lead almost without exception in the number of ducklings annually produced. Although not applicable to all the six key factors, this index is a measure for the important ones relating to amount, composition and juxtaposition of cover and water.

Other forms of wildlife respond to the very favorable types of marsh and aquatic habitats created by the beaver. A list of such animals would include deer, otter, mink, muskrat, and marsh birds, such as the great blue heron, pied-billed grebe, and Canada goose. Field observation suggested that in most instances, it is probable that they existed together in these marsh environments without conflict or harmful influence. The mink was the one important exception to this.

Several management measures were suggested as a means of maintaining and increasing to the greatest extent possible the amount of environment suitable for ducks. The first is directed toward maintaining the beaver population at the highest possible level consistent with its function of creating optimum waterfowl habitat. It suggests that careful and efficient trapping be done to keep the beaver in balance with the available supply of its food trees, so that it would not be forced to desert its ponds and dams, which, when thus abandoned, soon disintegrate.

The second major recommendation calls for the maintenance and repair at reasonable expense of suitable abandoned beaver ponds wherever feasible. The immediate response to such a restored beaver marsh indicates the value of this suggested measure.

Pond construction is suggested as a third management measure. This recommendation is based upon the idea of imitating the beaver ponds—of creating by artificial means the same environmental conditions as those produced by the beaver in its own impoundments. It calls for the use of low simple wooden dams in locations where the right combination of low area, surrounding ridges and source of water occur.

The fourth management measure recommends that wherever feasible, water be diverted to suitable dry marsh areas and the beaver be relied upon to carry on from there.

Successful waterfowl management will take advantage of the beavers' ability as a creator of ideal waterfowl habitat and will utilize it to the fullest extent.

It will recognize that although big bodies of water impounded by long dikes serve a necessary and useful purpose, they alone are not sufficient to satisfy duck habitat requirements. It will realize that the beaver has set the pattern of optimum waterfowl environment. Management will be wise to copy it.

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