1925

Roosevelt Wild Life Bulletin

Charles C. Adams
SUNY College of Environmental Science and Forestry

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Roosevelt Wild Life Bulletin

OF THE
Roosevelt Wild Life Forest Experiment Station

OF
THE NEW YORK STATE COLLEGE OF FORESTRY
AT SYRACUSE UNIVERSITY

THE MUSKRAT IN NEW YORK
CONTENTS OF ROOSEVELT WILD LIFE BULLETIN

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   (Reprinted: original date of publication, 1877.)
4. Current Station Notes.......................... The Director and Editor.
Roosevelt Wild Life Bulletin

VOLUME 3, NUMBER 2

OF THE

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AT Syracuse University
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2. Roosevelt Wild Life Annals.

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These publications are edited in cooperation with the College Committee on Publications.

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* Including only those who have made field investigations and whose reports are now in preparation.

** Resigned as Station Ichthyologist October 1, 1921.
RESEARCH ON WILD LIFE

"The discovery of new species and races based upon the study of preserved specimens of game animals, has already progressed very far; but the more attractive field which includes the habits of the game remains yet to a great extent unexplored. This field is peculiarly open for investigation to big-game hunters, and to all other men who go far afield and obtain first-hand knowledge of the conditions under which the game animals live. The closet naturalist, with his technical knowledge of the structure of animals, can be trusted to perform the work of classification to a mathematical degree of precision; but we cannot obtain from him a trustworthy account of the behavior of animals in their natural environment, or learn from him the value to the animals of the various structures or characteristics which he has shown them to possess. Much knowledge regarding the habits of game is acquired by the successful sportsman. Yet it is often infinitesimal in quantity compared to what may be acquired if the outdoors observer will direct his investigations along the broad lines covering the life history of the species with which he comes in contact. To carry out such investigations successfully it would be necessary to spend many hours and days, perhaps even weeks and months, observing certain individuals or family groups of game. This is quite beyond the limits of time allotted the average sportsman. Nevertheless much can be learned by the collected evidence from many fragmentary observations providing only these are accurate. A great mass of accurate fragmentary observations will often spell far more progress in investigations of this kind than the observations of a few trained individuals over an extended period of time."

Theodore Roosevelt and Edmund Heller.

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THE RELATION OF FORESTS AND FORESTRY TO HUMAN WELFARE

"Forests are more than trees. They are rather land areas on which are associated various forms of plant and animal life. The forester must deal with all. Wild life is as essentially and legitimately an object of his care as are water, wood, and forage. Forest administration should be planned with a view to realizing all possible benefits from the land areas handled. It should take account of their indirect value for recreation and health as well as their value for the production of salable material; and of their value for the production of meat, hides, and furs of all kinds as well as for the production of wood and the protection of water supplies.

"Unquestionably the working out of a program of wild life protection which will give due weight to all the interests affected is a delicate task. It is impossible to harmonize the differences between the economic, the esthetic, the sporting, and the commercial viewpoint. Nevertheless, the practical difficulties are not so great as they appear on the surface."

Henry S. Graves,
Former Chief Forester, U. S. Forest Service.
INTRODUCTION

To the majority of citizens outside of the fur industry itself the importance of fur-bearing animals in the commercial history of our country, past or present, is probably little known. In the early struggle of the Colonies fur (beaver) was the medium of barter and exchange, and later it was the search for more fur that led to the
gradual penetration, exploration and settlement of the great wilderness both of our own country and Canada. From those early days to this the fur trade has lived and at times even flourished. That it continues to be a going concern today may appear to many quite remarkable, for it would seem that most fur-bearing animals must long ago have become extinct as a result of continuous persecution.

The use of the skins of animals for bodily comfort or for adornment dates far back into the past and is likely to continue in the future so long as there is anything of this kind to be had. How great the demand for fur has been in very recent years may be judged from figures given by Dearborn (‘20, p. 6): “It is estimated that the money spent in America yearly for garments alone amounts to well over $100,000,000. The gross trade of fur merchants in New York alone during 1919, including exports, imports, and domestic trade in raw and manufactured furs, amounted to upwards of $375,000,000.”

In the course of two and a half centuries or more of trapping some of our most highly prized fur-bearers have become exterminated over large parts of their former range, and in a number of sections of the country they have been saved from inevitable extinction only by timely enactment of measures for their protection. Other agencies besides trapping have, of course, been instrumental in bringing matters to this pass, the most important of which has been the destruction of forests and various other habitats wherein these animals find their natural homes, and with which the fate of most of them is inseparably wrapped up. Such highly valued fur animals as the fisher and the marten, for example, are destined to survive or perish with the forests regardless of whatever protection they may otherwise enjoy from the pursuit of the trapper.

With continuing decline of the choice species attention has turned more and more toward animals more plentiful in numbers though formerly generally considered of minor rank as fur. Upon closer acquaintance, however, a number of these have disclosed qualities of fur which have gradually established them firmly in popular favor. Added to this we find these species admirably equipped by nature for the struggle for existence in that they are prolific, hardy, and highly adjustable to their changing environment — requirements of the first order for successful wild creatures in the world today. At the head of this group stands the muskrat, one of our smaller mammals but nevertheless one that is of more importance as a fur-bearing animal than any other single species on the North American continent.
at the present time, and with good prospects of becoming even more important in the future.

In the early days of the fur trade the muskrat did not occupy a very prominent position. Its present standing has been attained in comparatively recent years, as the beauty and quality of its fur, both in its natural condition as well as when artificially altered, have steadily mounted in popular esteem. The growth of the demand for muskrat fur as reflected in the trade of the last hundred and fifty years or more, is interesting. Lantz ('10, pp. 24–26) has found that from 1763 to 1800 the total number of muskrat skins imported and sold in the London market was 2,831,453, or an average of somewhat under 75,000 yearly. During the fifty-year period from 1801 to 1850 there was a total of 20,571,428, or an average of 411,000 annually; and in the thirty-nine-year period from 1851 to 1890 the total importations amounted to 99,893,591, with a yearly average of over 2,500,000 skins. For following years he gives the London sales as over 4,000,000 skins annually. Then in 1900 the total amounted to 5,285,000, and in 1905 the total output of muskrat fur as shown by the London sales rose to over 7,000,000 skins. With a rise in price which now occurred there came a falling off in skins so that the total London sales for 1908 were only 3,806,000, and for 1909, 3,771,000. In 1919, according to John F. Mallon, Actuary, Fur Dressers' and Fur Dyers' Assoc., Inc., (in a statement dated Jan 14, 1920), the total number of dressed muskrat skins for the entire country was 8,643,422.

Before proceeding to the main topic of the muskrat of New York state, it will be worth while to glance at the general situation and relative standing, numerically and commercially, of all of the principal fur-bearing mammals of our state, as presented by the Secretary of the N. Y. State Conservation Commission, W. S. Carpenter ('21, p. 22). The figures given, we are told, are for 1918 and are based upon the reports turned in by hunters on the stubs of the licenses issued in 1919, in that year required by the State of New York for the first time. These reports, it is further stated, are incomplete because hunters had no knowledge beforehand that such reports would be required, and much inaccuracy in the totals is therefore to be expected. Many town clerks neglected to turn in reports of any kind, and it is pointed out that the data do not include fur taken by farmers, who hunt and trap on their own land without a license, nor by minors under sixteen years of age who likewise may trap fur-bearing animals without this requirement. The results,
which accordingly may be considered conservative, are as follows, the values based upon the current market prices at the time:

<table>
<thead>
<tr>
<th>Animal</th>
<th>Number taken</th>
<th>Individual value</th>
<th>Total value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muskrat</td>
<td>399,938</td>
<td>1.50</td>
<td>$599,907.00</td>
</tr>
<tr>
<td>Skunk</td>
<td>187,703</td>
<td>4.00</td>
<td>750,812.00</td>
</tr>
<tr>
<td>Raccoon</td>
<td>25,349</td>
<td>5.00</td>
<td>126,745.00</td>
</tr>
<tr>
<td>Red Fox</td>
<td>15,156</td>
<td>15.00</td>
<td>227,340.00</td>
</tr>
<tr>
<td>Mink</td>
<td>8,917</td>
<td>6.00</td>
<td>53,502.00</td>
</tr>
<tr>
<td>Gray Fox</td>
<td>2,476</td>
<td>2.00</td>
<td>4,952.00</td>
</tr>
<tr>
<td>Marten</td>
<td>823</td>
<td>4.00[?]</td>
<td>3,292.00</td>
</tr>
<tr>
<td>Otter</td>
<td>591</td>
<td>25.00</td>
<td>9,900.00</td>
</tr>
<tr>
<td>Bear</td>
<td>189</td>
<td>25.00</td>
<td>4,725.00</td>
</tr>
<tr>
<td>Bobcat</td>
<td>159</td>
<td>10.00</td>
<td>1,590.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$1,782,765.00</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It will be seen by inspection of this table that the number of muskrat skins taken in this state is more than twice the number of its nearest competitor, the skunk; and that it exceeds by more than 150,000 the combined sum of the skunk and all other furs here listed. The higher price of the individual skin places the skunk in the lead in total value, but exclusive of the skunk the total value of the muskrat skins is seen to be greater than the combined values of all the other kinds of fur represented in the list. From these figures it is evident that at the present time, all things considered, the muskrat is the most valuable species of fur-bearing animal in New York State.

The large number of muskrats produced by this state is quite extraordinary when we consider the heavy toll that has been taken of the species annually over a long period of time. It is the very fact of the ability of this animal to maintain itself with such vigor in the face of the discouraging, constantly changing, artificial conditions imposed upon it in thickly settled parts of the country, together with its increasing popularity as fur, that makes it an animal of great economic possibilities. Its tenacity as a species is the more impressive because, outside of ordinary regulations of trapping seasons and more sportsmanlike methods of taking the muskrat, little or nothing has been done to encourage its perpetuation or increase. Even when the price of its fur was only ten or fifteen cents a skin, its great numbers and the ease with which it was shot or trapped were such that many persons found its pursuit quite remunerative. This was especially true in such localities as the great
Fig. 48. Portion of Big Bay Creek, Brewerton region; showing unfavorable muskrat conditions created by pasturing. Example of first type of habitat. A muskrat den in the hummock in marshy patch in foreground had been destroyed by the trampling of cattle. June 13.

Fig. 49. Another portion of Big Bay Creek where the stream is bordered by fields and hay lots. Bordering shrubbery, weeds and grasses help create more favorable conditions for muskrats. Example of first type of habitat. June 13.
marshes of western New York. Then the extraordinary prices of fur during and immediately following the World War served as a great stimulus to excessive trapping in all parts of the country. Serious depletion of the muskrat supply was the result in a number of states, and many localities are likely to feel the effects of this for some time to come. In certain parts of New York State where such close trapping has been practiced, the muskrat became so scarce that the later decline in price made trapping for a time unprofitable, and largely by reason of this perhaps were the few muskrats that remained in such places saved from impending extinction. In other localities, however, trappers pursued a wiser course, taking care to leave a safe margin of breeding stock. To such trappers much credit is due, for doubtless their policy of conservation not only safeguarded adequate breeding stock in their own territory but contributed to the restocking of depleted areas adjoining. Thus the reckless and improvident trapper profited to a degree by the foresight and restraint of his more businesslike brother. Nature has done much to provide New York State with muskrat habitats; but those who find the muskrat skin a source of revenue should do their part toward maintaining and increasing the productive capacity of these habitats. What is needed is a more general appreciation of the fact that fundamental biological principles cannot be disregarded if this condition is to be realized. And this applies to the habitat as well as to the animal itself.

At the suggestion of Dr. Charles C. Adams, Director of the Roosevelt Wild Life Forest Experiment Station, the present investigation was undertaken as a preliminary survey of the situation of the muskrat in New York State. Such a survey is essential to any more detailed and intensive study of various problems connected with this important fur-bearer. A knowledge of the life history, habits, and the actual conditions under which the animal lives in nature is of course the first requisite in matters pertaining to the proper management and development of such a resource; and in regard to none of these phases can it be said that the present available information is adequate even for a single species of our economically or commercially valuable wild animals. A strong sentiment is now developing in many quarters throughout the land in favor of increasing the supply of game and fur animals of all kinds and by all means. To this end much is written and spoken in encouragement of raising both these kinds of animals in captivity and much has been accomplished along this line, thanks
to years of patient and costly experimentation. Continued progress in this direction, however, rests primarily upon a growing knowledge of the lives of animals in a state of nature. Until we shall gradually and painstakingly have accumulated sufficient information of this sort we shall not be in position to make the most of the possibilities, whatever the species we may wish to cultivate in this way. Meanwhile the fact is not to be lost sight of that the most important and successful propagation center and nursery of the muskrat as well as of most other economically valuable wild mammals continues to be in the freedom of their own natural haunts. Here, primarily because of the disturbing habits of man himself, the struggle for existence for many of these animals is fast becoming desperate. With a sufficient body of facts in our possession we may be able both in the field and in the enclosure to do much that may now appear neither practicable nor possible.

For many courtesies extended in the course of the present investigation, for helpful suggestions, and for the unlimited use of his own personal library my sincere thanks are due to the Director, Doctor Adams. To Mr. W. A. Dence of the Roosevelt Wild Life Station I am indebted for his prompt and unfailing attention to all matters pertaining to field needs. During the course of the field work I have been under obligation to a number of persons who have been generous in their hospitality and who have taken freely of their time in order to conduct me to less easily accessible areas in their several districts which were of importance to my purpose, or who have been of assistance in other ways. More especially among these I wish to mention the following: Mr. and Mrs. Duane Joslin, Cazenovia; Mr. and Mrs. S. C. Vanderbilt, Clyde; Mr. and Mrs. Henry Landers, and Messrs. J. L. Rogers and Fred Wing, Brewerton; Mr. William Hoagland; Mr. Harrison DeGroff, Meridian; Mr. Joseph E. Buff, Syracuse; Mr. and Mrs. W. G. Cole, Byron; Mr. J. H. McCloud and Mr. Rector, Savannah. Other persons to whom credit is due are mentioned in the text.

LOCALITIES EXAMINED FOR MUSKRATS

In making a choice of territory for the present survey the region of western New York, including the great marshes and swamps there found, was decided upon as the logical starting point, since here lay the center of the muskrat population of this state. According to Mr. Joseph E. Buff, then Secretary of the Raw Fur Dealers' Association of New York, 20 to 25 per cent of the muskrat skins marketed in the
state come from Onondaga and Oswego Counties alone, of this section. In muskrat production no other single areas of like size in the state compare with the Montezuma and Cicero marshes. Within the territory chosen appeared to be found also a sufficient variety of field conditions, outside of pure marsh land, to furnish a fairly trustworthy general idea of conditions in which muskrats live in the state as a whole.

The localities examined include the following. In the region of Brewerton: Big Bay Swamp and portions of the two streams draining into it. In the Woodard region: Cicero Marsh and Mud Creek. In the Kirkville district: a portion of Black Creek, Green Lake, and about three miles of the old Erie canal in this vicinity. At Little York: the lake at this village and a portion of the stream. At Truxton: Tioughnioga River in this vicinity. In the Cazenovia district: Chittenango Creek, with visits to the reservoirs lying between Cazenovia and Pecksport. In the Meridian region: Otter Lake, Parker’s Pond, Cross Lake, Muskrat Creek, Mud Pond, and Duck Lake. In the Montezuma Marsh region: The Seneca River from a point about four miles south of the Rochester and Syracuse Electric line bridge, northward around Howland Island, and including the state barge canal which crosses the loop of the river south of the island mentioned. In the region of Savannah: the portion of the Montezuma Marsh immediately west of the village, from the West Shore and the New York Central Railroad tracks on the north to the county line on the south; also Black Creek, Butler Creek and Mud Pond, Crusoe Creek and Crusoe Lake. In the region of Clyde: the marshy ponds adjacent to the old Erie canal about two miles southeast of Clyde, and the Erie canal to a point about two and a half miles west of this town. In the region of Byron: Black Creek northeast of the town, and the marshy mill pond on this creek at the edge of the town. A quick visit was also made to the Tonawanda Swamp lands (Oak Swamp, on U. S. topographic map) northeast of South Barre. Among the localities investigated, the most favorable ones for study from the viewpoint of numbers of muskrats and accessibility at this time of year, were Black Creek, Butler Creek, and Crusoe Lake in the vicinity of Savannah; Muskrat Creek in the region of Meridian, and Mud Creek in the Cicero Marsh north of Woodard. Maps 3 and 4 are introduced to show the situation of the most important localities investigated in the Montezuma Marsh region.
PRINCIPAL MUSKRAT HABITATS

The muskrat habitats found in the territory covered may conveniently be classified under three main heads: (1) ponds, lakes, streams, canals, reservoirs or other waters without marshy borders or with a minimum of such conditions; (2) swamps; (3) marshes proper.

In the first group (illustrated in figs. 48 to 54 inclusive) are included watercourses with more abrupt shores, often with muddy margins, woods bordered, or more or less encroached upon by cultivated fields, hay lots, or patches of wild meadow. Marshy patches may occur here and there but these are usually small or lie within pastures and are so betrampled and disturbed by cattle as to be largely shunned by muskrats. This type of habitat is the least favorable among those examined, yet a considerable number of muskrats are found here because the total area is great. In the localities representing this kind of environment the muskrats confine their dens mainly to bank burrows, and consequently superficial evidence of the animals' presence is less conspicuous than in the other types of habitat. The ground surface activities are limited principally to foraging excursions into immediately bordering territory where their overland trails may be found, sometimes exposed, sometimes concealed by rank growths of vegetation. Extensive diggings for underground roots or stems do not occur. The animals here have no great abundance of any one favorite food, but apparently subsist on a considerable variety of succulent grasses, sedges, stems of plants, buds, seeds, etc. In this habitat clams are of more or less common occurrence and form a part of the muskrats' available food supply. Besides the larger watercourses referred to there are many minor spring-fed tributaries which, though small, are of sufficiently permanent character to harbor a pair or a family of muskrats during a part of the year at least. Permanency of the pool is more important than the size from the muskrats' viewpoint. In the aggregate such little centers contribute much to the maintenance of the species.

In the second type of habitat (figs. 55 to 58 inclusive) are included the swamps, in the proper sense of the word, with their intermittent pools of still water, and sluggish streams bordered by dense growths of swamp thicket which in turn is usually followed by broad-leaved swamp forest of red maple, elm, swamp oak, etc. In early summer, at any rate, the surface here is covered with water to a depth of several inches and more, and even in the drier latter
part of the summer the ground water level is quite near the surface. Here and there smaller open patches occur which contain dense stands of cat-tails, and a general scattering of cat-tails may also be found elsewhere, but the principal vegetation is of swamp character. Around the margins of open pools or bordering the streams are frequently found dense growths of swamp loosestrife or of button-bush, in other places alders, willows, sweet gale, red-osier dogwood, clusters of ferns, grasses, sedges, woody nightshade, arrow arum, arrow-head and other shrubs and plants characteristic of such situations. The surface of the open water is more or less completely covered with a dense green mat of duckweed and \textit{Wolffia}, mixed doubtless with various forms of algae. Underneath the dense canopy of swamp vegetation one finds a great network of mud-and-water trails where not only muskrats but numbers of Virginia rails, soras, Florida gallinules, and occasional broods of wood ducks and black ducks may skulk, feed, or move about in comparative safety from the prying eyes of enemies overhead. Countless footprints in the ooze testify to the volume of traffic over these hidden thoroughfares, and now and then they reveal the identity of some passer-by whose presence might not otherwise have been suspected.

Considerable difficulty is experienced in entering some parts of these swamps in summer. The dense thickets prevent the use of a boat, and water and ooze are often too deep for wading.

In this type of habitat the muskrats naturally enjoy a high degree of security during the critical reproductive season. They have abundance and variety of food. Their dens here are made, as opportunity offers, in hollow stumps or fallen tree-trunks, under the exposed roots of standing trees, or in "houses" built on or about the roots and trunks of willows or swamp shrubs, on hummocks or other available situations. These abodes are not always built above the high water level of the spring of the year, so that the occupants are then sometimes forced to vacate them temporarily. In late summer the muskrats in the drier portions of the swamps apparently withdraw gradually toward the wetter parts.

The third category or marsh habitat proper (figs. 59, 60, 61, and others) includes the great cat-tail areas such as the Cicero and Montezuma Marshes, and streams, ponds, or lakes which are bordered by considerable strips of marsh, the vegetation of these also being chiefly cat-tail flag. (Of course conditions intermediate between this third type of habitat and the second or the first are of frequent occurrence, but for our purpose these do not call for separate recognition.) The third type of environment contains a much
Fig. 50. Black Creek, northeast of Byron. Muskrat burrow entrance beside log; feeding place on submerged log. Pastured area with conditions generally unfavorable, especially in winter. Aug. 9.

Fig. 51. Small pond on creek below the Cazenovia Electric Canning Company's plant at Cazenovia. Marshy patches in such places, while often small, can be made to produce fair returns in muskrat fur. June 18.
Fig. 52. Another portion of the creek at Cazenovia, showing some of the most favorable muskrat conditions found in the first type of habitat. Muskrats are common here. June 18.

Fig. 53. Tioughnioga Creek near Truxtun. Beneath the rank growth of vegetation along this bank muskrat signs were plentiful. First type of habitat. June 19.
greater total area than either of the other two and as muskrat habitat it is the most important one at the present time. Some portions of the large marsh areas, having been rather completely drained, are no longer suitable for muskrats. In other parts permanent streams are present and the level of the water is subject to considerable rise and fall, depending upon the season. In spring and early summer some of these marsh areas are submerged, while in the latter, drier part of the summer the ground water level may be several inches below the surface. Then, with fall rains, the water table again rises and many parts of the marshes become inundated anew.

In this environment the muskrat finds living conditions approaching the ideal. The requirements of protective cover and security from disturbance are here met as fully as in the swamp habitat; and as to food, the situation is even more satisfactory, for in these cat-tail marshes in normal conditions there is a practically unlimited supply of food of the choicest kind at their very doorstep the year round. Muskrat activity here reaches its highest expression. The animals almost invariably build houses but where the marshes are crossed by railways a certain number of them may make their dens in burrows dug in the embankments. The houses are built principally of the materials abundantly at hand, namely, cat-tail stalks and mucky matter mixed with a variable amount of tiny rootlets, moss, duckweed, algae and other pond and marsh vegetation. When the floor of the marsh is exposed during low water in the latter part of the summer it becomes the scene of boundless activity on the part of the muskrats, and in places where they are plentiful one may find a perfect network of runways, canals, and tunnels. Besides countless cuttings of flag stalks the surface in the more open places is dotted with innumerable little holes dug in quest of tender underground root-stalks of the cat-tail. While, as previously remarked, in normal conditions the muskrats in this habitat enjoy a high degree of security, there is one danger to which they are exposed here more than in any other habitat and that is fire. Fires occasionally sweep the marshes in late fall or early spring of drier seasons, and at such times undoubtedly many muskrats perish, but how large this mortality actually may be is not known.

In western New York, then, we have as above described three principal habitats in which muskrats are found. One of these, the first, is by nature less suitable to muskrats than either of the other two, and through the agency of man himself or of his domestic stock has been rendered still more unsuitable. The man who is the
owner of such a habitat, if he traps, derives a slight income from it in the form of furs, a definite, easily measurable one; and a less easily computed one in the form of grazing for his stock, watering facilities, etc. While the aggregate of habitat of this sort is very large it contains fewer rats per unit area than either of the others. The second and third types are naturally admirably adapted to muskrats and, excepting those areas that have been rendered uninhabitable through drainage, are but rarely invaded and unfavorably altered by man or his beasts. From the swamp forest habitat the owner may derive an income in the form of timber or fuel, or both, and muskrat fur. From the marsh habitat the income is likewise chiefly muskrat fur, but more or less cat-tail flag is cut and marketed for use in the manufacture of furniture (chairs), for calking purposes, etc. While a certain amount of other furs such as raccoon and mink is obtained, muskrat remains the principal product of this sort. Of the crops named the tree crop takes years to mature while the fur and flag crops may be harvested annually. Other things being equal, of the latter two the fur crop yields the greater revenue. The man who has a large area of marsh and a good stock of muskrats in it does not spend much time cutting flag. In other words, area for area muskrats will yield bigger returns than flag if the marsh conditions are right for both and provided there is proper management. It is a different matter, of course, where, through drainage, the marsh has become too dry for the muskrat yet continues still to grow a good stand of flag. A fact that it is important not to overlook is that the swamps and marshes as understood in this article, except for the only crops that have any claim to consideration here—muskrat fur and marketable flag,—are great areas of general unproductiveness. Furthermore, the only one of these crops that under existing conditions lends itself easily to cultivation for greater and sustained annual returns in these areas is the muskrat. It must be kept in mind, too, that we are here dealing with lands that because of topography, prohibitive costs or other reasons, cannot be, or at least are not likely to be, drained and converted into tillable agricultural land for years to come; they are destined long to remain in their present condition.

From my own observations this past summer, with two or three notable exceptions, I do not believe that those who own or control muskrat habitats of one type or another and do a certain amount of trapping each year, properly value the possibilities their situations offer, not only for increasing their annual harvest of fur, but also for putting it on a more permanent footing. This does not apply merely
to the better suited habitats of swamp and marsh but to all localities where the muskrat is found; for wherever the muskrat occurs in this state there is little doubt that the habitats even in their present condition are capable of supporting, as a permanent capital stock, much larger numbers of the animals than are now found in them. In view of the popularity and the corresponding prices that the fur commands in the markets it would seem that the muskrat is a crop which should receive its full share of attention in any scheme of diversified farming. The returns on the capital will quite surely bear favorable comparison with those of many other investments.

GENERAL CHARACTERISTICS OF MUSKRATS: GENUS ONDATRA (FIBER)

In his Systematic Synopsis of the Muskrats ('11, p. 14) Hollister describes the genus Fiber (Ondatra) thus: "Form robust; legs short, feet large, both modified for swimming; feet and toes fringed by short, stiff hairs, and toes of hind feet partly webbed; tail long, compressed laterally, covered by small scales, and thinly haired. External ears small, scarcely extending beyond fur. Fur dense and waterproof; pelage supplemented by longer glossy overlying hairs. Strongly developed perineal glands secreting a powerful musk; mammae six; plantar tubercles five." All who are familiar with the two forms recognize the outward resemblance of the muskrat and the beaver in body form and color; except for its laterally instead of dorso-ventrally flattened tail the muskrat may easily be mistaken for a young beaver. Less generally known popularly is the close structural relationship between the muskrat and the very much smaller field or meadow mouse of the genus Microtus. But a careful comparison of the skull and teeth of the muskrat with those of the meadow mouse will reveal some striking similarities even to the un-zoological layman.

Range and Species.—The muskrat is a distinctively North American mammal, being found in the Old World (Bohemia, Bavaria, and other places) only as introduced from our continent. It occurs throughout the greater part of North America from the Bering Strait and the northern limit of trees, southward to the Mexican boundary; and across the continent from east to west. On our Southern Atlantic and Gulf coasts, according to Hollister ('11), it is absent except in southern Louisiana, and on the Pacific slope it has not been found south of central Oregon.

Within its range three distinct species have been recognized, all of the same genus: Fiber zibethicus, the most widely distributed
species; *F. rivalicus*, limited to southern Louisiana; and *F. obscurus*, the Newfoundland species. The species *zibethicus* is represented by upwards of a dozen geographic *races* or *subspecies* which grade into one another at the boundaries of their ranges.

**THE MUSKRAT AND ITS DISTRIBUTION IN NEW YORK STATE**

The muskrat of this section of the country is known scientifically as *Ondatra* (*Fiber*) *zibethica zibethica*. Hollister (11, p. 16) gives the type locality of this form as "Eastern Canada," and its distribution as "Southeastern Canada, northeastern and east central United States; from New Brunswick and Quebec west to Minnesota, and south to Northern Georgia and Arkansas, except along the Atlantic seaboard south of Delaware Bay."

Within the State of New York, except where locally it has disappeared through trapping or the disturbance of its habitat, it may be found wherever the requirements of life are available. The abundance of streams, ponds and lakes, marshes and swamps furnish a vast total area of habitat in which the species, doubtless with various ups and downs, has continued to carry on since the time when the first white man came. Quoting from "an old work on America," Poland ('92, p. 263) writes: "This Country (New York) breeds many Musk Cats, especially in Marshy grounds. These Beasts are beautiful to the eye, have black speckled Skins, their Mouths full of sharp teeth, and their long tails trail after them." Their successful existence amidst the highly artificial surroundings of a modern metropolis is sufficiently attested by Madison Grant ('02-'03, p. 328), who remarks that, "It thrives so well in civilization as to be a nuisance in the New York Zoological Park. In Prospect Park Lake, Brooklyn, a trapper is especially employed to keep these animals in check, and the catch in 1903 amounted to over 2,000, and in 1904 to 1230."

**Description.**—This is given by Hollister as follows:

"General characters.—Size large; tail long; color dark; skull large, with zygomatics not broadly spreading anteriorly; molars of medium size.

"Color.—*Fresh pelage*: Upper parts mummy brown, darkest on head; back glossy; sides chestnut to hazel. The darker color on back is due to the blackish overlying hairs, the color of the fur being much like that of the sides. Underparts like sides but paler, approaching tawny, shading to whitish on throat and belly; a small
spot on chin and hair of wrist and heel blackish; lips straw yellow; underfur light slate gray; nasal pad and tail black; feet dark brown; nails pale straw to brown. *Worn pelage*: Paler and duller throughout; upper parts and sides uniform grayish brown, or with a faded reddish mixture; back and head with little or no black. *Black phase*: Upperparts uniformly black, cheeks and long hair at base of tail chestnut; underparts dark. *Young*: back uniform dusky; sides and belly paler; cheeks rusty.

"Skull and teeth."—Skull large; zygomatic notch not broadly spreading anteriorly; interorbital ridge not especially developed, except in extreme old age; parietals large; audital bullæ rounded; molars of medium size."

Sexual differences in coloration or in skull characters do not occur. Size, weight, and longevity.—The average measurements of seven adult specimens from Lake George and Peterboro, New York, as given by Hollister, in millimeters are: Total length 563; tail vertebrae 254; hind foot 81. No figures are at hand on the weight of New York specimens but in a small series from Carberry weighed by Seton ('10, Vol. 1, p. 538) the largest male weighed 2 lbs. 4 oz., and the smallest male 1 lb. 5¾ oz. The weight of a large female was 2 lbs., 3 oz.; The average of six males was 1 lb., 10 oz. Lantz (Amer. Fox and Fur Farmer, Oct., 1923) is quoted as having found the average weight of muskrat carcasses sold in the markets as meat to be about 1.5 lbs.

How long does a muskrat live? This question is difficult to answer. As in the case of so many other wild animals there is little definite information available on this point. Dvorak ('19, p. 180) says that "it requires several years for them to attain full size," but probably few muskrats grow in size after fifteen or eighteen months of age, although they may take on more or less fat. I am not aware of any instance where muskrats have been kept in captivity long enough to furnish any data of value in this connection, but it is probably within reason to say that a muskrat may live as long as ten years or more.

Pelage and Moult.—The pelage of the muskrat consists of a dense coat of underfur, and projecting beyond this are long so-called overhairs. The overhairs, according to Hollister, appear gradually as the season advances, and together with age and season account for the variation often observed in skins from the same locality. According to the same authority, with the exception of the species *rivalicius* of the Louisiana coast region which "apparently molts twice a year,"
all muskrats so far as known have but one moult and this takes place during the summer.

*Subspecific distinctions and local variations.*—Again to quote Hollister (p. 17): "This form, the common muskrat of the Northern and Middle States, is a dark-colored animal; much darker than *F. z. macrodon* in ordinary color phase, and only slightly lighter than *obscurus* from Newfoundland. Specimens from the coast region of Massachusetts and Rhode Island average especially black in full winter pelage. Specimens from Conanicut Island, Rhode Island, have long tails, but occasional specimens from some mainland localities match them in this character, and the very slight insular variety perhaps developing here is hardly worthy of recognition by name. Prince Edward's Island specimens show no approach toward *obscurus* and are apparently typical of *zibethicus*. Specimens from Middle and Southern States average less black than New England specimens, approaching some of the less pronounced examples of normally colored *macrodon*, and have more red than most specimens from the Northeast. I have as yet, however, failed to find a single specimen from any inland southern or western locality, east of the Great Plains, that can not be matched by some strictly comparable specimen or specimens in the large series of true *zibethicus* from northeastern United States. Specimens from the lower Hudson Valley and Long Island show a decided approach toward *macrodon*, and these two forms probably blend throughout New Jersey and Delaware. Specimens from upper Delaware Bay have been referred to *macrodon*, though the discrimination at this point is difficult, and the animals could be placed with either form without much violence.

"The black phase appears to be of rare occurrence in typical *zibethicus*. I have seen it only from Lake George, New York, and Conanicut Island, Rhode Island. Several albinos and partial albinos have been examined."

**Local Variation and Distribution in New York.**—As to local variations in New York, among local trappers and handlers of raw furs the view is sometimes met with that the muskrats of one section or locality of the state are distinguished from those of another—it may be neighboring or adjoining—section or locality by rather positive differences in size and in character of pelt. In this connection I refer the reader to map 5, accompanying this paper. The heavy black lines dividing the state into four sections have been reproduced from a map on which Mr. Joseph E. Buff, of Syracuse, former
Fig. 54. A portion of the Seneca River on the northeast side of Howland Island. Long stretch on left bank rendered unfavorable to muskrats by pasturing, in marked contrast to right bank. July 18.

Fig. 55. Example of second or swamp type of habitat. Little Bay Creek, in Big Bay Swamp, Brewerton region, showing excellent muskrat conditions; signs here were abundant. June 12.
Fig. 56. An example of the swamp forest type of habitat. Big Bay Creek, in Big Bay Swamp. The scarcity of choicest muskrat food, such as cat-tails, is compensated for by the opportunities for ranging widely. June 12.

Fig. 57. A portion of Mud Pond, Meridian region; swamp type of habitat, with very good conditions for muskrats. July 10.
Secretary of the Raw Fur Dealers’ Association, has kindly drawn for me the boundaries in question. These division lines are based upon Mr. Buff’s many years’ experience in handling large quantities of raw muskrat skins from all parts of New York State. It is his conviction that the muskrats in the different sections of the state are regularly characterized by the size differences indicated. According to this classification it will be noted that the smallest and thinnest-pelted muskrats are found in the northern portion of the state, including the Adirondack region; medium-sized muskrats in the southwestern portion; and medium to small muskrats in the southeastern portion. The largest muskrats occur in the great central section, but within this area there is one locality of small muskrats in the Cazenovia region. It must be remembered that these size differences are based upon the skins only as they came, stretched and dried, from the trappers. Whether these results would be borne out by measurements of equally large series taken in the flesh is of course a question. Referring to the area of alleged small muskrats in the Cazenovia region, it is but fair to state that Mr. Duane Joslin, the principal raw fur buyer of that district, who has also had much experience in handling furs from other parts of the state, holds a different view. According to Mr. Joslin the muskrats of his region are no smaller than those of other sections of the state, the apparent difference in size being, in his opinion, accounted for by a combination of the following facts: 1, most of the trapping in the Cazenovia area is done by young, inexperienced trappers, who do not stretch their muskrat skins properly in the drying process; 2, trapping here is too close, that is, too thorough, so that a large percentage of rats do not live to attain full size; 3, many of the largest skins of this territory are marketed elsewhere and therefore do not enter into consideration in the classification above mentioned. Another experienced raw fur dealer, Mr. Fred Newcomb, of Homer, expressed a similar opinion. Many trappers in this region, according to Mr. Newcomb, are mere boys who do not take pains to stretch their skins sufficiently. He admitted, however, that there were some rather small muskrats in little creeks west of Homer, and that in the Montezuma marshes the rats “were said” to run a little larger than in the Homer region. Mr. Frank Pender, a trapper of many years’ experience in the area about Little York, believed that the muskrats of Otisco Lake are a little larger than those at Little York. Likewise Mr. Henry Landers, of Brewerton, declared it as his experience that on spring-fed creeks of that region the muskrats are not quite so large as those of the cat-tail marshes and the swamps.
In coloration also some local variation may be recognized by trappers. Thus Mr. Joslin gave his opinion that the muskrats of the Cazenovia region are on the average somewhat darker than those of the larger marshes. This is due, he believes, to the fact that most of the muskrats in the former area live in streams where they are not so exposed to the action of sunlight as are those of the marshes. Yet it would seem that an animal that is chiefly nocturnal would hardly in any case be exposed sufficiently to sunlight to be noticeably affected thereby.

So far as the above mentioned variations are concerned there may be no question as to the observed facts. It is clear, however, that if anything definite is to be established there must be certainty as to the locality which a given specimen represents; care must be taken that strictly comparable specimens as to age, season, degree of development, etc., are used in comparison, and all measurements should be taken from animals in the flesh.

Regarding causes of the size differences mentioned it is held by some trappers that they are probably associated with the character of the food material in the different localities. In the Cazenovia region, for example, where there are no important marshes or swamps, there is lacking that abundance of cat-tails as well as other characteristic marsh vegetation upon which the muskrats are either known or believed to feed. Cat-tail flag is the one obvious and outstanding item of muskrat food in the great marshes and in many other localities of the section furnishing large skins, and it is largely absent in many if not most of the localities from which the small skins come. It is natural therefore that considerable significance should be attached to this fact.

The so-called black muskrat skins apparently occur in proportionately small numbers within the territory covered by this survey. Trappers with whom I talked stated that on an average perhaps not more than 2 per cent of their catch were black skins. Mr. Buff estimated the number to be much smaller, “about two in five hundred.” A number of such skins shown me by Mr. Buff were a rich blackish brown.

Partially or completely white, fawn-colored, or mottled specimens are of very rare occurrence.
BREEDING HABITS OF THE MUSKRAT

Period of Gestation.—The exact period of gestation has not, so far as I am aware, ever been determined for the muskrat and few references to this subject occur in the literature. Persons who raise muskrats in captivity have here a subject which merits their attention. Lantz ('10, p. 15), on the basis of analogy with the common house rat, suggested that the period of gestation in the muskrat is probably not more than 21 days, a period which he considers probable also for the field mouse, an animal which the muskrat is believed to resemble more or less in breeding habits, as it does in structure. Seton, on the other hand ('10, p. 550), gives the period as “probably 30 days,” and the same figure is repeated by Dvorak ('19, p. 180). In neither case is any basis for the statement given. Butler ('85, p. 1049) states that the period of gestation is “about six weeks.”

Number and Condition of the Young at Birth.—The most reliable data as to the number of young produced at a time are furnished by records of embryos or fetuses contained in the uterine horns. It is pretty generally known, however, that the number of intra-uterine young in some species of mammals may exceed any number of young of the same species ever found in an individual nest, and this doubtless because a number of the young sometimes die soon after birth. This is more especially true probably where litters are large. Seton ('10, p. 550) gives the number of young of the muskrat as 4 to 9, while Lantz ('17, p. 7) gives records secured by the Biological Survey, of 3, 6, 8, and 13 embryos or fetuses found in different females. MacFarlane ('05, p. 738) states that the number of young at a birth varies “between 8 and 20,” but any number above 14 or possibly 15 as the maximum must be looked upon as of rather doubtful occurrence. It is believed by many that the smaller number of young is produced by younger females usually, but that in certain years when unfavorable conditions are thought to exist older females also produce small litters. Early spring litters are believed to be small, as a rule.

In the Imperial Valley of California Dixon ('22, p. 141) found that the average number of embryos in twenty-three pregnant females was six, “with three and nine as extremes.”

In western New York different trappers gave the number of young to the litter as 5 to 7 and 5 to 9. S. C. Vanderbilt said that he had once taken a female which contained 11 fetuses, the greatest number in his experience.
At birth the young are naked, blind, and helpless. The age at which their eyes open is not definitely known. Mr. Vanderbilt believed it to be about the ninth day. He was not sure of this but said that he had seen young muskrats "with a good deal of fuzz on them" whose eyes were still closed. In this connection it may be mentioned that Mitchell ('12, pp. 46-47) states that "Rats [common house rat], which are born naked and blind are covered with hair on the eighth day and are able to see on the thirteenth day."

**Period of Suckling and Parental Care.**—According to Seton ('10, p. 550) the young muskrats are suckled until three or four weeks old. In Connecticut, he remarks, they first venture out about the middle of May, when about one-third grown. In northern Lake County, Minnesota, June 22, 1912, close beside a muskrat house, I took a suckling female muskrat, and on each of the succeeding nights, in the same place, I took a young muskrat until in all five young were taken, when no more came into my trap. These young muskrats unquestionably belonged to the female that was taken the first night. For how long a time previously the young had been making excursions into the open is of course impossible to say, but I believe that this was not the first occasion. They were baited with young shoots of poplar and, in addition to the evidence of partially stripped twigs, the contents of their stomachs proved that they had eaten of the leaves. The average total length of these young muskrats was 11.66 inches and the total length of the adult female was 22.4 inches. The average body length of the young, exclusive of the tail, was 6.56 inches, and the body length of the female, 12 inches.

On July 5, near Meridian, New York, I saw two young muskrats leave their house when my boat touched it, and these, according to my estimate at the time, had a body length of not over five inches.

Butler ('85, p. 1049-1050) says that the young muskrats remain in the nest until about half grown, and that he has never (in Indiana) found the young caring for themselves until after the beginning of July.

If we may refer again to the house rat, by way of analogy, Mitchell ('12) states that its young "are turned out to shift for themselves when they are thirty-nine days old."

**Number of Litters Per Season.**—Regarding this question especially one finds many conflicting statements and very little by way of positive evidence. There seems to be a tendency among more recent writers to accept as established that there are usually two or
three litters a year and occasionally as many as four or five. It will be of interest to quote a number of the statements and consider the nature of the evidence upon which they are founded.

Merriam (’86, p. 283) states that in the Adirondacks of New York the muskrat "is said to raise three litters in a season."

According to MacFarlane (’05, p. 738), for the Mackenzie River region, "the female muskrat has two litters the first season and three each succeeding season. . . ." This statement we are told was based on information obtained from hunters of the Hudson Bay Company. Seton (’10, p. 550) writes that in Manitoba "there are commonly said to be three litters during the year, the first litter of the year having young themselves early in the autumn."

Lantz (’10, pp. 13–15) refers to the statement made long ago by Richardson and repeated by Audubon and Bachman, that the muskrat has three litters in the course of the season, and then goes on to say: "The writer, in March, 1900, talked with a considerable number of muskrat trappers in Dorchester County, Md., about the breeding habits of the animals. The best informed of these men state that from three to five litters (normally but three) are produced, and that the number of young in a litter varies from 3 to 12 or even more, the average being probably 6 to 8."

"In mild winters sporadic breeding occurs. Thus, in the open season of 1908–9, in January one trapper found a female that had recently suckled young, and on the same day found young near by that were only about one-third grown. Another trapper in February captured a female that contained 3 embryos, and still another, a Mr. Insley, on March 6, took a female that had 3 embryos." Further on he says: "I am indebted to R. J. Slocum, of Cambridge, Md., for a detailed account of his observations during many years while residing near the marshes and trapping in them. He confirmed the statements of the more intelligent trappers as to the number of litters and number of young: . . ." Thereupon the matter is summed up thus: "All this testimony shows that in their breeding habits muskrats are not unlike field mice. This conclusion is further strengthened by the remarkable way in which the marshes, depleted by vigorous winter trapping, are replenished before the opening of another season. The known facts may be thus summarized: Normally the animals mate in March and the first litter is born in April; a second litter is due in June or early July, and a third in August or September. In favorable seasons a fourth or even fifth litter may be produced."

In a later bulletin (’17, p. 6) Lantz states: "It is now well established that the animals breed from three to five times in a year.
. . .” However, no further evidence is here introduced in support of this assertion.

According to Nelson (’18, p. 411), “Like the latter [meadow mouse] the muskrat has several litters of young each season.”

Evermann and Clark (’20, p. 466), for Indiana, declare that “At Lake Maxinkuckee the muskrats raise at least two litters, and probably three, each season, the first litter being born about the first week in May.” Their evidence consists of the following: “About half-grown” young seen “about the middle of June, 1901,” which they considered to be of the first litter; a nest of young with eyes not yet open, found June 15, 1903; one young “about one-third or one-half grown” caught May 31, 1901; “two young not more than half grown” seen on September 5, 1906; young seen on two “other occasions” with no date given. They conclude, “From these data it is evident that at least two litters per season are raised in this vicinity.”

Dixon (’22), in regard to the muskrats of the Imperial Valley, states that the animals breed “every month in the year”; that “small woolly juvenals barely able to leave the nest and forage for themselves have been caught in mid-winter, and small young have been trapped during every month of the year”; and that most of the young are brought forth in the period between February 15 and October 30.

“Three and possibly more litters are raised in one year.”

Hollister (’11, p. 10) gives the following “actual breeding records noted on the labels of female specimens,” a number of which are also given by Lantz (’10, ’17): “Summit, Mont., June 18, 1895, 13 large fetuses (V. Bailey); Ward, Colo., June 8, 1893, 8 fetuses (J. A. Loring); Newport, R. I., April 18, 1900, 6 fetuses (Dr. E. A. Mearns).” E. R. Warren (’10, p. 107) gives breeding records from Colorado as follows: Grand County, May 12, eight good-sized embryos; Lily, Routt County, June 1, young 2 or 3 weeks old; Barr, Adams County, May 30, very small young, not much larger than adult Microtus modestus; Meadow Ranch, Costilla County, June 24, seven embryos, second litter.”

Referring to Warren’s account (p. 107) one finds in connection with the last mentioned (June 24) record, the further stated fact that the female had been suckled and therefore the fetuses contained must have represented a second litter. This record consequently is significant. In a recent personal letter to me Mr. Warren furnished the record of a half-grown muskrat seen Oct. 29, 1916, in the region of Fort Collins, Colo., and of a muskrat which he had seen “moving young about the size of a Microtus in a pond in a park in this city (Cheyenne), July 3, 1921.” Warren says, “I should not
Fig. 58. Muskrat Creek and swamp habitat, near Meridian. A considerable amount of cat-tail flag and other marsh vegetation found here combine with the other factors to make this the best kind of swamp habitat. July 6.

Fig. 59. Example of the marsh type of habitat. A portion of the Montezuma Marsh, looking south from the railroad tracks about one mile west of Savannah. Dense stand of cat-tail flag. July 16.
Fig. 60. Marsh type of habitat. A portion of Cicero Marsh about half a mile west of Stop 6, Syracuse-Brewerton electric line. Excellent conditions for muskrats. June 14.

Fig. 61. View of Black Creek about one mile west of Savannah, showing swamp conditions on left and a portion of Montezuma Marsh on right. Excellent muskrat habitat. Swamp loosestrife in left foreground. Aug. 1.
regard it at all improbable that these animals regularly had three litters in a season in this region, and in warmer climates four, when the season would begin earlier."

The claim that the muskrat has only one litter a year is not so often met with in published accounts, yet Kennicott evidently held that view, as implied in his statement (1857, p. 107) that "from five to seven young—more or less—are produced in April or May."

Butler (1885, p. 1049), in regard to the muskrats of Indiana, wrote: "I am convinced that in this vicinity one brood of muskrats is regularly brought forth each year. There are, in all probability, occasional exceptions to this rule, when perhaps two and even three broods are born." Regarding a late litter Butler remarks (p. 1050): "In September, a few years since, a litter of young muskrats was taken from a nest in the canal bank. They were not over one-third grown. This record I have always considered as referring to a second or perhaps a third brood, and is my only note that would indicate a plurality of broods." Whether this record was made early or late in September is not stated, but young of the size mentioned may well represent the "kits" of later in the season, taken in the fall trapping in New York and other sections of the country.

Likewise Shiras (1921, p. 200) states that "In many parts of its range the muskrat is supposed to raise from three to four litters a year. Along a great portion of the southern shore of Lake Superior I have never seen any evidence of more than one set of young a year. In this section occurs one of the deepest snowfalls of the country, and this unusual condition doubtless affects the muskrat."

Since in some of the quotations above presented much of the evidence adduced in support of the view that the muskrat has as many as three to four or five litters a year, is in the form of testimony of trappers in other parts of the county, it may be permissible here to set forth the views expressed on this subject by trappers and fur buyers in western New York. These persons whom I questioned during the course of the present survey, are all intelligent men of many years experience as muskrat trappers or raw fur handlers or both.

Henry Landers, of Brewerton, declared that the muskrats in that section had at any rate three litters and in exceptional seasons possibly as many as four litters a year.

Frank Pender, of Little York, was positive that there were never more than two litters a year, the first born about April first and the second rather late in the fall, sometimes as late as November 1.

George S. Tremper and George Taylor, of Savannah, each held
that there were two litters a year. Mr. Tremper stated that the second litter was born in August. He had seen very small muskrats in November, however, but believed that in this case the first litter had been born late. Mr. Taylor maintained that the second litter was born in late August or early in September, the first litter about May 1.

S. C. Vanderbilt, of Clyde, who conducts the most extensive trapping operations in the Montezuma marsh region, was likewise positive that there were not more than two litters a season, the second born in July; and that a third litter was an occurrence so rare that it probably "did not happen more than once in the lifetime of a muskrat."

R. Lapp, another man who traps on a considerable scale in parts of the Montezuma marsh adjoining Mr. Vanderbilt's, was convinced that there were three litters, as a rule. He said that he had once known of a muskrat house in which there were three sets of young, but could not now give any further details. His main reason for believing that there were usually three litters a season was, he said, that the muskrats repaired their houses three separate times during the summer months, or once in preparation for each brood.

E. A. Lamphere, of Weedsport, said that the younger females have two litters a season but that older animals produced three or four. An old female, he said, might produce as many as forty young in a single season. Mr. Lamphere frankly admitted, however, that he had no evidence to support this view but that it was a common belief among many trappers.

Joseph E. Buff of Syracuse, who has had a very extensive experience as a dealer in raw furs and who has a large acquaintance among trappers, replied that he knew it was a commonly held opinion among trappers that there were as many as three or four litters of muskrats a year, but he had not heard of any reasons for this view.

John M. Cooper, of Bainbridge, who has been a raw fur buyer for forty years and who has a wide acquaintance among trappers in all sections of New York, declared it to be his firm belief, based on the testimony of the best informed muskrat trappers with whom he had come in contact, that the muskrat usually has but a single litter of young in a season; that old females may occasionally have two litters; and that while three litters "have been known, they are very rare."

In regard to the question whether members of the first litter of the season themselves have young in the fall of the same year, there is likewise much difference of opinion. That they do, is frequently
stated in the literature, and the belief is also prevalent among some trappers though stoutly denied by others. Yet here, too, we find no actual evidence presented, and in some of the published accounts neither the nature nor the source of the information on which they are based is given.

MacFarlane’s statement (’05, p. 738), based on the authority of hunters of the Hudson’s Bay Company, that the muskrat begins to breed when about a year old, sufficiently indicates that in that part of Canada the first litter was not generally believed to produce young the same season; and Seton’s remarks for Manitoba, already quoted, that the first litter produces young in the early fall, are evidently based on the general view among trappers of that section.

Lantz (’10, p. 14) adds in regard to the early spring litters, such as are indicated for example by the records of pregnant females taken on the 6th and the 15th of March, that “The young of these early litters are said to breed in the same fall.”

Dvorak (’19, p. 180) writes: “The first litter also have young that season, although the young muskrats do not grow up [!] . They remain small and are known as kits. This accounts for the large number of small muskrats or kits caught during the fall and winter season.” In this quotation is thus revealed what is probably the main reason for the view in question.

Among the New York trappers already mentioned, opinions on this subject were also divided. According to one view, held by three different trappers in the Montezuma marshes, the first-born may have young in the fall of the same year, and if so, their young are born in September or October. The basis for this view was the assumption noted in Dvorak’s statement that the so-called “kits” taken in the fall are the offspring of the first-born litters.

Mr. Pender, who declared that he rarely found any kits among his catch, was convinced that the first litter produces no young the same season. He looked upon the kits as members of late-born second litters.

Mr. J. M. Cooper insisted that the kits in the region of New York represent young muskrats—of the first and only litter of the season—that were born as late as sometime in June or July.

Mr. Vanderbilt was emphatic in his support of the opinion that no young are produced by the first-born litter before the next season. His conviction was based on his experience that he had never taken young female muskrats in the fall or early winter trapping which showed any signs of having been suckled.
My own observations during 1923 in New York were too limited to contribute anything of a conclusive nature in answer to the questions that have here been raised. Since, however, they were made during the middle and latter parts of the breeding season they may be set forth in the present connection. Although I first entered the field on June 12, unfamiliarity with the region, the necessity for considerable preliminary scouting, and the inaccessibility at that time of many of the muskrat marshes visited, prevented me from giving much attention to the question of breeding habits during this month. The first young muskrats of the season were seen on July 5. On that date, as my boat struck against a little cat-tail island on which a house was situated, two little muskrats swam out. The body length of these muskrats (tail not included) I estimated to be not over 5 inches. They remained for a few moments floating at the side of the house, then dove. On July 17 a house was opened in which was a female with two young. The latter had an estimated body length of 4 inches. One of these clung to the teat and was dragged out as the mother escaped, the other crawled about the chamber in an effort to conceal itself. On August 1 a young muskrat was seen whose body length was estimated to be 7 inches. On the same date a house was opened in which were seen an adult muskrat with a young one whose estimated body length was about 5 inches. August 3, a dead young muskrat was found in the chamber of a house which evidently had been deserted. This individual apparently had been dead a week or more. Its body length measured 5.5 inches, tail length 4 inches. The same day a young rat that had been very recently killed and partly eaten, evidently by some preying bird or mammal, was found in a cat-tail marsh; its tail length was 5 inches; the hind foot 2.75 inches. From what remained of the body I judged it to have been larger than any of the other young rats thus far seen. August 15, two young rats were seen which I took to be of about the same size as the one last mentioned. August 21, another young muskrat was found which evidently had been killed the preceding night. Its tail had been half eaten; body length 8 inches, hind foot 2.7 inches. August 23, two young of approximately the same size as the last were seen to leave a house as I approached.

On August 26, along the old Erie canal near Clyde, I heard a commotion in the water and upon cautiously moving into a position where I could overlook the spot, saw an adult muskrat plunge and leap through the shallow water along the bank as if in desperate pursuit of something or other, and then disappear, evidently in a burrow. It is only a possibility that here was an instance of mating
activity and that the muskrat which I saw was the pursuing male. This was about noon on a clear day.

These data, so far as they go, show merely that young muskrats of different ages are found throughout July and August. How many of these represent the first litter of the season, how many a second, and how many possibly a third, is a matter of conjecture only. While many inhabited houses were opened in the expectation of finding new-born young none were happened upon.

It may be mentioned here that in northern Lake County, Minnesota, on June 22, 1922, I took a female muskrat which contained 7 fetuses, about the size of the common house mouse (Johnson, '22, p. 37). On the same day I took the first one of the five young muskrats mentioned on page 228 of the present article, and the weight of one of these young I estimated to be about one-third that of the average adult. I am inclined to consider both of these sets as first litters of the season, an earlier and a later one.

Since, for lack of knowledge on the muskrat’s breeding habits, the house rat is not infrequently introduced to furnish evidence by analogy, the following may be quoted from Chalmers Mitchell’s Childhood of Animals (pp. 46-47): “On the twenty-first day they have reached the size of a house mouse, and are turned out to shift for themselves when they are thirty-nine days old. They begin to breed when they are less than six months old and are fully grown a few months later.” The difference between the house rat and the house mouse is brought out in the next sentence: “Mice will breed when they are six weeks old and are fully grown at three to four months old.”

Is the Male Muskrat Polygamous?—Seton ('10, p. 550) considers it pretty well established that the muskrat is monogamous. The testimony for this is the indirect evidence that pairs of muskrats have been observed working together, carrying materials either for food or building purposes and presumably therefore for the common purpose of caring for the young; and assistance on the part of the male in bringing up the young, is, according to this author, a trait characteristic only of monogamous animals. On this question there seemed to be little information among the most experienced trappers whom I met in western New York. Henry Landers and J. L. Rogers, of Brewerton, were both positive that the male muskrat mates with more than one female at a time. The same view was given by George Taylor, of Savannah, another trapper of long experience. Landers and Rogers both maintained that
the house is built by the female alone, or, in the fall, by the female and the young. The male, they admitted, may sometimes build a house for his own shelter, but usually he does not. On the other hand S. C. Vanderbilt insists that the male does take part in building the house, and that a house may be built by participation of the whole family.

After mating, according to Landers and Rogers, the male muskrat seems to go into hiding or retirement. These men make it a practice, they said, in their spring trapping never to set traps near the muskrat houses, and for that reason they catch few females since the males alone travel about in search of mates. When the females have mated they become more active, wandering about a great deal more than at other times and are then taken in the traps in numbers. This is the signal for these men to take up their traps.

The mating season in Western New York was given by Landers and Rogers as the month of March, beginning a few days earlier or later in different years. Last spring (1923) they ceased trapping March 26, on which date a good many females were caught.

During the mating season there is much fighting among the males and many skins show the marks of combat. Then, also, more or less squeaking of the usually silent animals is to be heard at night.

Conclusions as to Breeding Habits.—In consideration of all that has been written above on the breeding habits of the muskrat it is clear that in regard to a number of important points our knowledge is very imperfect. The exact period of gestation is unknown. Concerning the question of the number of litters, published statements repeatedly appear that there are from three to five, yet no evidence of a conclusive nature accompanies these statements by way of substantiation. The records presented are few and cannot fairly be said to indicate more than that young muskrats of various ages are found throughout the summer season, and that occasionally individual females have been found to breed in the winter months. They show that in some sections of the country muskrats probably have two litters a season and that in other parts there is a possibility of even more. The greater number would naturally be expected to occur in the milder regions of the country where the breeding season might be longer; yet the testimony of trappers does not seem to associate fertility with climatic divisions when we find different men claiming different numbers of litters for neighboring or even the same localities. Even the descendants of
the muskrats introduced into Bohemia in 1906, which are now established also in Bavaria and Saxony as well as Austria and Moravia, have evidently remained true to their American traditions, for we find Ahrens ('21, p. 236), in reference to these muskrats, repeating the usual statement: "The animals established in Europe breed twice or three times a year and produce 6 or 8 young at a time."

In connection with the breeding habits of the muskrats due consideration must be given such matters as individual and age differences in breeding females, as well as periodic fluctuations in fecundity such as are generally recognized among various other species of rodents—to mention only the well known cases of the lemming of Europe and our own snow-shoe rabbit or varying hare. Muskrats born at different periods in a given season may probably be expected to breed at correspondingly earlier or later periods the following year. A female in the prime of life and sexual vigor may have more litters in a season than a younger or an older one. That the rapid increase of muskrats often noted in some localities may in part be explained by larger size of litters rather than by larger number of litters is a possibility; and increase by invasion from surrounding territory is also a possibility. In many localities the size of the muskrat's brood may perhaps not usually be subject to any great degree of variation from year to year, since the conditions under which muskrats live are not given to very abrupt changes and the animals are capable of considerable self-adjustment. Yet that the rate of increase in the muskrat exhibits seasonal variation is generally credited (e.g., Henderson, '23), although to what extent this increase is the result of more litters in the season or to larger size of litters is of course unknown.

Another question that requires a more satisfactory answer in this connection is whether the male muskrat mates with more than one female, as is maintained by some trappers, or whether it is monogamous as is believed by others. If it is polygamous, this fact must have an important bearing on the rate of increase of the animals, because it would mean that more females of breeding age would be likely to produce young in a given season than if the males were strictly monogamous. This would be true wherever and whenever the stock of females exceeds by a considerable margin that of the males; and that it does, in some localities at least, is a probability supported by the claim of men like Landers and Rogers, that by their trapping methods they catch a relatively small percentage of females.
In conclusion it may be remarked that, granting the possibility that the muskrat may have from three to five litters a season, as so frequently stated, the fact seems nevertheless to remain that in no instance has any conclusive evidence as yet been introduced along with these statements which would indicate that one and the same female muskrat had produced as many as five, four, or even three litters of young in one season. And neither in regard to the question whether or not the earliest-born litter may produce young the same season have any data of positive or unquestionable character been submitted.

Those who may be raising muskrats under conditions of control here clearly have a number of important questions which merit their notice.

**FOOD AND FEEDING HABITS**

As is well known the food of the muskrat consists mainly of vegetable matter, a considerable variety of plants growing in or about the water entering regularly into its bill of fare. But while predominantly vegetarian the animal partakes also as opportunity affords of a certain amount of animal food.

**Animal Food.**—In the class of animal food freshwater clams take first place. In many localities where clams are plentiful great quantities of these bivalves are eaten by muskrats. In northern Minnesota I have found single heaps in which I have counted more than a hundred pairs of empty shells, and I have seen many piles that probably contained several hundred. Such midden heaps may be found at various places on the shore near the water, in shallow water, or on flat stones or rock platforms in pond or stream, which are used as landing and feeding places by the muskrat. F. E. Wood ('10, p. 558) lists the following species of clams "which had been opened by muskrats on a sand-bar of the Sangamon River, near White Heath. The pile of empty shells included 7 shells of *Symphynota*, 41 of *Quadrula undulata*, 4 of *Q. pustulosa* and 1 of *Q. coccinea*, 7 of *Lampsilis lutcolus* and 1 of *L. ventricosus*, 3 of *Tritogonia tuberculata*, 3 of *Alasmodonta complanata*, and 1 of *Anodonta grandis.*" Baker ('16, p. 237) reports the following species represented in "a muskrat pile on Frenchman Island," Oneida Lake, N. Y.: *Anodonta cataracta*, 3; *A. implicata*, 5; *A. marginata*, 3; *Lampsilis lutcola*, 1; *L. radiata*, 21; *L. borealis*, 11; *Elliptio complanatus*, 8.
Just how the muskrat opens the clam shell has long been an interesting topic for discussion and speculation. Of various explanations that have found their way into print, some are fanciful while others doubtless contain a good deal of truth if not the whole of it. Since a number of these accounts are found in publications not generally available it seems desirable to quote a few of them here. Some of the older accounts especially contain explanations that generally are not referred to in more recent writings.

Kennicott ('56, p. 106) evidently considered the opening of the mussel shell no mysterious feat, for he simply remarks that the muskrat carries the clams in its teeth to some convenient place and, grasping them in its fore-paws, "opens the shells with the incisors as skillfully as it could be done with an oyster-knife. . . . I have observed that those species with thin shells are most sought for, and have often found large specimens of Unio plicatus unopened among the piles of empty shells, the muskrat apparently considering them not worth the trouble of gnawing apart the valves at the back, in which manner the heavy shells are sometimes opened."

Brayton ('82, p. 153) also declares that the shells are opened by the muskrat's incisor teeth "as neatly as a squirrel opens a nut."

Butler ('85, p. 1052), from his own personal observations believes there are three ways by which the opening of the clams may be accomplished: 1, Many species of clams, when handled, withdraw the foot very slowly and the muskrat could easily insert its long claws or teeth between the valves and tear them apart; 2, many shells show that they have been cut by the muskrat's teeth; 3, heavier shells are opened after the clam is dead.

Lee ('86, p. 8) tells of having "had the satisfaction of seeing the operation performed," and continues: "I saw a muskrat swimming down the stream . . . , and after a few minutes I saw him dive down and over a mussel lying on the bottom and insert his claws into the shell from the under side, completely encircling the shell. The muskrat then swam to the shore, proceeded to pull the valves apart and devour the contents. . . . The ease with which the muskrat did it leads me to think that when the claws were inserted they must have struck some vital part and thus deprived the mollusk of the power to close the shell; otherwise the shell would probably have been broken, but close examination failed to show a fracture or any marks whatever."

The foregoing quotation may have been a cause for the disgust of Abbott in his delightful book ('86, p. 202) where he writes:
"Probably the most remarkable of the stories is to the effect that a muskrat was seen to carefully approach a mussel which at the time had its foot extended. When sufficiently near, the muskrat put forth one paw very quickly and transfixed the mussel's foot with one or more toe-nails; then taking the captured mollusk in its fore-paws, swam to the shore—of course, using its hind-limbs only—and then, in a necessarily erect position, walked up a steep bank, and, once on level ground proceeded to eat the mussel. Now, even if this muskrat had accomplished three impossibilities, it never could have gotten through with the fourth, that of releasing the mussel from its shell without injury to the latter; yet this marvelous account was given to a scientific society as an explanation of the curious phenomenon that the shells of mussels eaten by muskrats were never broken."

I am indebted to Mr. Herbert Lang, of the American Museum of Natural History, for calling my attention to the following paragraph in the Cambridge Natural History (1895, Vol. 3, pp. 57-58): "Rats devour the ponderous Uniones of North America. When Unio moves, the foot projects half an inch or more beyond the valves. If, when in this condition, the valves are tightly pinched, the foot is caught, and if the pinching is continued the animal becomes paralyzed and unable to make use of the adductor muscles, and consequently flies open even if the pressure is relaxed. The muskrat (Fiber zibethicus) seizes the Unio in his jaws, and by the time he reaches his hole, the Unio is ready to gape." As authority for this account reference is made to a paper in the Journal of the Trenton Natural History Society, and there we find a very interesting article by Apgar ('87, pp. 58-59) reporting some actual experiments with the clam to test the foot-pinching possibilities. He writes: "Nearly every method proposed [of opening the Unio shell] has been based upon the strength of the adductor muscles and the supposed impossibility of overcoming their power without killing, or at least poisoning the animal. In experimenting with some Unios last summer, I found that it was an easy matter to get the shell open as far as the ligament would open it, and that in this condition it required much less than a muskrat's strength to force it entirely open.

"When the Unio is traveling along, its foot projects a half inch or more from the lower side of the shell. If, while the foot is in this, its usual condition, the two valves be pinched, the foot will be caught between the closing shells; if the pinching be
continued for a half or three-quarters of a minute, the animal, probably from the pain (?) produced, becomes paralyzed and unable to make use of the adductor muscles. Now, if the shell be released, it will fly open about one-half inch, and can easily be torn entirely open. The strength needed to keep the foot from being drawn into the shell is not great, being far less than that of the jaws of the muskrat.

"So all that is necessary for Fiber to do when he wants his dinner is to swim along until he sees a Unio at the bottom, dive, and quickly seize the animal; then swim leisurely to his hole or the bank. By the time he has reached a good place for eating his meal the Unio will be ready to open far enough for the insertion of paw or nose, and the luscious bivalve can be devoured from the whole shell. In my own experiments I was usually, though not always successful. The failures I think were always due to the fact that not quite enough of the foot was caught by the closing shell; this was caused by disturbing the animal before taking hold of it. If the muskrat be not more supple than I, he must occasionally miss his meal."

The experimenter apparently did not determine the possibility of the Unio recovering from its paralysis, in order to know what the chances might be of the tables being turned and the paw or the nose of the muskrat pinched between the valves in their turn. But while no question may be raised as to the facts of the experiment, so far as performed, it may well be doubted that any considerable number of clams are actually thus opened by the muskrat, because it would imply that the animal must seize the clam quickly and grasp it in the proper manner in order to accomplish the stated result; delay or fumbling in this part of the performance would permit the clam's foot to be safely withdrawn. It might be more easily conceived that a few clams are accidentally opened in this manner.

Rhoads ('03, p. 105) states that muskrats "have a habit of gathering mussels from the mud and piling them upon logs and rocks to die. The shell thus opens and the contents are devoured by some animal, presumably the rats, though I have never seen them do it. No doubt, minks, coons, foxes, etc., participate in the feast."

That the unbroken shells have opened as result of the death of the clam has been suggested also by Lantz ('10, p. 17), and Baker ('16, p. 237) thinks that this explanation "may be nearer the truth than is generally supposed."
Eye-witness testimony to the use of the teeth is offered by Coker and co-authors (’21, p. 123) as follows: “During the winter of 1904 a muskrat was observed feeding on mussels along the broad ice crack that extended from the end of Long Point northeastward across the lake. The muskrat was about 50 feet from the shore. It repeatedly dived from the edge of the ice crack and reappeared with a mussel in its mouth. Upon reaching the surface with its catch it sat down on its haunches on the edge of the crack and, holding the mussel in its fore feet, pried the valves apart with its teeth and scooped or licked out the contents of the shell. ‘Some of the larger mussels were too strong for it to open, and a part of these were left lying on the ice.” Incidentally, it is noted by the same authors that the muskrat does not seem to care for the gills of gravid mussels, these parts being occasionally found untouched at the feeding places.

It is sometimes said (e. g., Butler ’85, p. 1051) that clams seem to be eaten by the muskrat mainly as winter or early spring diet. However, I have found numerous instances of freshly opened, empty shells in the midden heaps of muskrats in northern Minnesota, all through July and August. Doubtless the situation as to other kinds of food determines to some extent at least when clams “are in season” with the muskrat and when not.

In connection with the clam-eating habit of the muskrat and the much discussed question of how the shell is opened, it seems not a little strange that the mink has escaped attention in this particular. Yet the mink is widely credited with eating clams (Merriam ’86, p. 64; Coutes, ’77, p. 177; Rhoads, ’03, p. 105; Seton, ’10, Vol. 2, p. 887, and others) and therefore the problem of clam opening must have been solved by him also. Whether his jaws are more powerful than those of the muskrat may offer opportunities for argument, but all will agree that clams both within and beyond their respective powers are doubtless encountered by each in numbers. The forepaws of the mink, lacking the characteristic hand functions of those of the rodent, would seem to place their owner somewhat at a disadvantage in such a performance as clam opening; and the incisor teeth of the muskrat will unquestionably be considered superior to the canines of the mink as the essential tools with which the operation must be accomplished. However, while much speculation has been indulged in about the muskrat in this respect no one seems to have raised the question as to how the mink manages to open the clam. Probably their methods are essentially the same, for their teeth are, I believe, the chief instruments.
Fig. 62. Example of muskrat cuttings of cat-tail flag. Only a small portion of the core of each stalk, at the point of cutting, is utilized. July 20.

Fig. 63. Muskrat cuttings. Dense stand of cat-tails newly cut by the muskrat. Patch about 25 feet across. Here likewise only a small portion of the core of each stalk had been eaten. July 25.
Fig. 64. Two new shoots on underground stem of cat-tail stalk; a much-sought food of the muskrat. Montezuma Marsh. July 25.

Fig. 65. Hole newly dug by a muskrat in quest of underground cat-tail stem and roots. Left-over remains on edge of hole. Montezuma Marsh. Aug. 16.
Other kinds of animal food which the muskrat is credited with eating are insects, crayfish, snails, fish, and young birds if caught in the water; and apparently amphibian and reptilian flesh is not despised on occasion. Fishes likely to be caught and eaten by the muskrat are “carp and other sluggish fish that bury themselves in mud” (Lantz, ’10, p. 16). Dr. E. A. Mearns (says Hollister, ’11, p. 9) “observed a muskrat fishing in the Verde River, Arizona, and notes ‘it occasionally coming out upon a log to eat the fish it caught!’” Merriam (’86, 285-287) quotes a number of other reports on the fish-eating propensities of the muskrat.

Warren (’10, pp. 106-107) gives this interesting account: “One [muskrat] was seen in a lake near Crested Butte chasing under water a ‘water dog,’ Amblystoma tigrinum, which it finally captured by making a sudden dash forward and seizing it with its teeth. The rat then came to the surface with its prey in its mouth, and not until then was it seen to be a muskrat, for while the chase was in progress the observers supposed it to be a mink.”

Evermann and Clark (’20, p. 464) found in Indiana that turtles are sometimes eaten: “They also feed on turtles of various species which they find dead or which they themselves may kill. On several occasions we have found partly devoured turtles under circumstances which left no doubt as to what had been feeding on them. Dec. 11, 1904, several dead painted turtles [Chrysemys marginata] and a few musk turtles were found near Norris Inlet lying on their backs on the snow or ice, with the flesh wholly or partly devoured, and muskrat tracks leading to and from them and all about.”

In streams in the marshes and swamps examined by me during the past summer the bottom was not very suitable for clams, and little if any of this food was here available. However, in habitats of the first type, already described, clams were of common occurrence and heaps of empty shells noticed here and there along the water courses were sufficient evidence that clams are a common food of the muskrat in these localities. The most frequent signs of the sort were noted along the Seneca River in the region of Montezuma.

In the marsh bordering Black Creek (Savannah region) three dead terrapins (Chrysemys marginata marginata) were found in muskrat feeding grounds among the cat-tails. Portions of the fleshy parts of one of these had either been eaten or torn away by some animal, but whether done by muskrats or not is very uncertain.
Mr. S. C. Vanderbilt informed me that after burning of the marshes, muskrats would occasionally feed upon the carcasses of individuals of their own kind that had perished; usually the tail was eaten first.

**Vegetable Food.**—Considerable attention was given to the question of the vegetable food of the muskrat, in the course of this investigation, and a record was kept of the different species of plants and shrubs which could with certainty be determined to have been eaten by the animal. The list of these which follows is unquestionably very incomplete even for the particular localities where they were found, and various other species not here mentioned are generally known to serve as part of the muskrat’s diet in other places. For aid in the identification of most of the species I am indebted to my associate in the field, Mr. Aretas A. Saunders. Dr. L. H. Pennington of the New York State College of Forestry has kindly identified the species of *Wolffia.*

*Typha angustifolia* (Narrow-leaf Cat-tail)  
*Typha latifolia* (Broad-leaf Cat-tail)  
*Decodon verticillatus* (Swamp Loosestrife)  
*Leersia oryzoides* (Rice Cut Grass)  
*Sagittaria latifolia* (Arrow-head)  
*Solanum Dulcamara* (Woody Nightshade)  
*Lemma minor* (Duckweed)  
*Acorus calamus* (Sweet Flag)  
*Polygonum pennsylvanicum*  
*Saururus cernuus* (Lizard’s Tail)  
*Sparganium eurycarpum* (Bur-reed)  
*Iris versicolor* (Blue Flag)  
*Heraclium lanatum* (Cow Parsnip)  
*Rumex obtusifolius* (Broad-leaved Dock)  
*Bidens frondosa* (Bur Marigold)  
*Geum rivale* (Purple Water Avens)  
*Nymphtha adenophora* (Yellow Pond Lily)  
*Taraxacum officinale*? (Dandelion)  
*Fraxinus americana* (White Ash). Leaves  
*Salix sp.* (Willow). Leaves  
*Cornus stolonifera* (Red-osier Dogwood). Leaves  
*Cephalanthus occidentalis* (Buttonbush). Leaves  
*Myrica gale* (Sweet Gale). Leaves  
*Carex sp.*  
*Wolffia punctata*  
*Wolffia columbiana*
Arrow arum (*Peltandra virginica*) is abundant in many parts of the marshes and swamps, yet it seems to be but rarely touched by the muskrats, whether stems, leaves, roots, or fruit. The seeds of the plant are said by local trappers and hunters to be extensively eaten by the wood duck, probably also by the black duck, and in November I saw pretty conclusive evidence that the English pheasants were then feeding upon them. But the most extensive attack on the arrow arum by the muskrat that was discovered during the entire time in the field was the case of one plant where one of the smaller stems had been cut off and either eaten or carried away for other purposes, and two stems partly severed. In one instance the sheath surrounding the fruit body, and a few of the seeds, bore unmistakable impressions of the muskrat’s teeth, but neither had been more than barely tasted.

As to the relative standing of the plants listed above as muskrat food it can only be said at this time that the two species of cat-tails take first place wherever they are found in muskrat-inhabited territory. A number of the remaining plants appear to be eaten quite regularly, while others may be eaten but rarely. In some cases all parts of a plant are seemingly acceptable, in other cases only certain parts are usually selected. In the case of the bur-reed, while the white basal portions of the stems are frequently eaten (as in case of other plants), I am not sure that the fruit bodies are attacked until the seeds are mature and drop out. Perhaps the prickly character of the seed heads is responsible. Sweet flag and blue flag, although quite plentiful in many parts, seemed to be eaten but sparingly, doubtless because of the abundance of associated cat-tail flag which was preferred. A single cow parsnip plant was found which had been gnawed off at the base and a portion of the root dug up and eaten. The rice cut-grass is listed on the strength of one instance where a young muskrat was observed carrying a mouthful of the grass, freshly cut and green, into a bank burrow. The same applies to the arrow-head. On two occasions—in June and in August—an adult muskrat was seen transporting a green stem and leaf to its house or den. In only one instance was the broad-leaved dock, which, like the cow parsnip, occurred sparingly, found freshly cut and partly eaten among other plant remains at the feeding place of a muskrat.

Other species found to be eaten occasionally were *Polygonum pennsylvanicum*, lizard’s tail, dandelion, bur marigold, purple water avens, and the leaves of young shoots of the white ash, red-osier dogwood, sweet gale, and buttonbush.
While the leaves of such species as white ash, willow, and doubt
less other trees, may not always be available to the muskrat they
nevertheless seem to be an acceptable variation in diet which the
animal will put forth considerable effort to get. On August 27, a
number of white ash sprouts of the season were found which had
been cut off and stripped of their leaves by the muskrat in a rather
interesting way. These shoots had grown up from the sides of
stumps of larger trees that had been cut down a year or more
before. The muskrat—one or more—had first climbed to the top of
the stump and then had stood up on its hind legs and gnawed off the
young shoots. One of the stumps was 18 inches high, a second
26 inches, a third 22 inches, and a fourth 28 inches; the diameter
of each of the first two was 7 inches, that of the third 3 inches,
and of the fourth 6 inches. A fifth stump was the smallest in the
lot. The largest of the several shoots which had been gnawed off
measured three-eighths of an inch in diameter, and some of them
had been gnawed off into shorter sections. In climbing up the
stumps the rats had evidently been aided by the sprouts themselves
and a few twining plants.

Many more instances were met with where the muskrats had
fed upon the leaves of young shoots of willow. Sprouts of the
season were most often taken, but in a number of cases the much
harder stems of older growth had been cut. Thus in one clump
of willows of which several older stems had been gnawed off,
the two largest measured one half and nine sixteenths of an inch
in diameter, respectively, at the lower edge of the cut. Some of
the stems here had likewise been cut into sections eight to ten
inches long, and all the smaller twigs on these stems had been
bitten off. Only the leaves had been eaten. Most of these cuttings
had been carried to the water's edge a few feet away, but part of
the feeding had been done on the spot.

Both the willows and the ash grew in the midst of quantities of
cat-tails and other marsh and swamp vegetation and had evidently
been eaten from choice.

The woody nightshade grows abundantly in many parts of the
cat-tail marshes and the swamps. Not until the latter part of
August did I find unmistakable evidence of its being eaten by
the muskrats. From the 20th of the month on, feeding places
became increasingly numerous where the animals had cut off and
trimmed the leaves from numerous stems of this nightshade.
Examination of the material showed that the animals had evidently
eaten mainly the young and more tender stems, but probably also
Fig. 66. A group of four holes dug through the litter of old flag in quest of underground portions of new shoots of cat-tail flag. An abundance of such diggings occurs in many areas. Montezuma Marsh. Aug. 3.

Fig. 67. A muskrat feeding bed among the cat-tails, with litter of cat-tail leaves. Montezuma Marsh. Aug. 23.
some leaves, although most of these had been left on the ground. The berries seem not to be eaten and in most cases remained untouched on the plants that had been cut down. Examination of many clusters lying on the ground amidst the débris, and some of those on the growing vines, showed, however, that the berries had at least been "sampled," for the firm, green ones especially, often bore clearly defined impressions of the incisor teeth where a single gentle bite had been made into them. Frequently several berries of a ripe cluster would be found crushed in exactly the same way, with the tooth marks unmistakable in many cases. The berries were probably rejected because they were distasteful rather than for any poisonous qualities which they are reputed to possess.

In the latter part of August, on three different occasions, a muskrat was seen feeding upon Wolffia, which in these particular localities covered the surface of the water like a dense green mat. The muskrats were at distances varying from about twenty-five to thirty feet from me, and their activities were carefully observed with the aid of a field glass. They swam slowly about and at times lay floating, gulping in and munching this green matter with evident relish. Samples of the material taken at the spot were kindly examined by Dr. Pennington who found them to contain two species, Wolffia punctata and W. columbiana. Mixed with these was more or less of the duckweed, Lemna minor, but the great bulk was of the former two species.

On one occasion I believe a muskrat was feeding upon an alga, Spirogyra, but of this I could not be quite certain.

The swamp loosestrife is another plant which seems to be of some importance as muskrat food. It is abundant in many parts of the swamps and marshes, growing in dense patches in or about pools in the midst of the cat-tails, as well as along margins of the larger ponds and the sluggish streams. As in the case of the woody nightshade no evidence was encountered in the early part of the summer that this shrubby plant was eaten by the muskrats; but in the latter half of August relatively extensive harvest grounds were repeatedly met with in territory that I had previously gone over without finding any cuttings of this kind. In these feeding places the ground was often covered with the leaves of the loosestrife, which apparently were not eaten. So far as could be learned it is mainly the young stems that are eaten at this season. In a number of cases the animals had climbed to the upper surface of
dense clusters of the plant and had trimmed off practically the entire top stratum. One such patch was about ten feet square. In winter also the loosestrife seems to be an important item of food, for during the last week of November, on a visit to Crusoe Lake, I found numerous such cuttings in the vicinity of the muskrat houses and elsewhere along the shore. Now a great many of the larger stems had been severed near the ground, and from these as well as from the stumps left standing, not only had the inner bark been gnawed and eaten but also a large portion of the deeper woody parts. Many of the stouter stems, which were about three-quarters of an inch in diameter, had been gnawed half through for a distance of several inches. The outer spongy bark which surrounds the basal portions of the older stems of the loosestrife had been rejected and lay scattered about the base.

The most important food of the muskrat, quantitatively at any rate, in the great marshes and swamps of western New York, is the cat-tail flag, both species. The total amount consumed in the areas with which I am familiar must surely be greater than that of all the other foods combined. In the early part of the summer, or so long as the flag retains its tenderness and succulence, a large part of each plant cut down, excepting the fruit body, may be consumed, and in the case of the smaller, non-fruiting, young plants practically all is eaten. In the larger and more mature plants on the other hand it is the core of the stem that is sought especially, the outer sheaths and leaves generally being rejected, although the more tender terminal portions of the leaves are often eaten. As the season advances and the cat-tails lose their succulence the acceptable part becomes limited mainly to a few inches of the central part of the stem near the base. Where the stand is dense, and relatively few small or young plants are found, great quantities of stalks are now cut down of which only this small part of each is eaten (figs. 62, 63). Often the plant is entirely severed, but just as frequently it is merely torn open from one side, the core eaten out, and the stalk left to stand or fall as the case may be. In areas where much new flag springs up in the middle and latter part of the summer these young shoots are greatly preferred. It is not alone the above-ground portions of the plant that are eaten, but the underground stems or root-stalks are equally sought (see fig. 64). In such areas as those just mentioned where new flag is springing up, the young sprouts just appearing above ground are first eaten and then their underground portions are dug up, often to a depth of five or six inches,
and frequently to two or three inches below the sub-surface water level. Where the muskrats are plentiful hundreds of such diggings may be counted to the acre (figs. 65 and 66). The dense mat or débris of dead flag of previous seasons which in many places covers the new sprouts, if too compact to be pulled or pushed away, is gnawed through in the efforts of the muskrats to reach their objective. As previously suggested, the fruit bodies or spikes of the cat-tails seem not to be eaten, although I have found them at times torn to pieces as if they had been tested for palatability.

In the winter, according to the trappers, the cat-tail roots are the staple food of the muskrats in the marshes. In the latter part of November I found many young sprouts, protected by the cover of dead flag, which were white and tender, and much activity had been displayed by the rats in digging for such plants and their roots as well as for the roots of the dry stalks. In addition to this food and the loosestrife previously mentioned, the animals were still feeding upon the stems of the woody nightshade, Carex, and blue flag and sweet flag, more or less of which was still to be found in acceptable condition, especially the basal portions of the stems.

Habits in Feeding.—The statement is sometimes made (Dvorak, '19, p. 180) that the muskrat "always washes its food before eating it." This belief I have found exists also among certain trappers. While there is no doubt that the muskrat is an animal of cleanly habits, yet anyone who has watched the animal eat or who even has taken pains to examine the situations where it generally feeds in many localities will, I am sure, be ready to dispute the statement that it regularly washes its food. Since the muskrat very often sits in shallow water when feeding it is easy to get the impression that it washes its food every time it drops one piece and picks up another; but so far as any actual washing of the food is concerned, I personally have never seen it. It is moreover a simple fact that in numerous places where the muskrat eats its food there is no water at hand with which to wash it (figs. 65, 66). Where the cat-tail roots or other kinds, for example, are dug up in soft muck or mud and might indeed seem to require a little rinsing at least, there is nothing to indicate that this food is washed but every evidence to show that it is not washed before eating. Numerous instances of this kind may be found close to water as well as farther away from it. The habit of the muskrat of
frequently carrying its food to the edge of the water to eat it, is probably a precautionary measure only, taken for its own safety.

Besides eating their food on the spot (fig. 67) or transporting it to the water's edge, the muskrats often carry it to the shelter of some overhanging bank, projecting root or ledge, into the cover of dense vegetation or other convenient retreat where they may feel secure when their attention is thus engaged. In the marshes I have also found many old, partly collapsed houses used as dining places. These were generally in situations where the water level had fallen below the surface so that the old entrance holes were exposed. In these entrances, protected by the overhanging materials of the house, the muskrats are concealed from the prying eyes of overhead enemies at least, and the amount of débris found in such places testifies to their frequent use. The chambers of such old houses, even where they have not been filled in by the collapse of the house, seem not to be used as feeding dens; the same appears to hold true generally for the occupied houses. Some trappers stoutly maintain that the muskrats never eat inside their houses; and this accords with my own experience, to this extent, that in none of the houses which I have opened have I found any evidence that the chambers themselves were being used or had been used as dining halls. On the other hand the threshold of the entrance seems to be so used, for the water at the inner end of the plunge-hole is sometimes littered with the shredded remnants of green stuff. However, a number of naturalists have reported that food matter of various kinds has at times been found in the chambers, and this has been interpreted to mean that the muskrat eats there.

A number of points in regard to the flag-cutting activities of the muskrat are of interest. The animal has often been compared to the beaver in regard to its form and habits in general, but the comparison holds true pretty well even when we follow it into some of the details. When, for example, we examine larger cat-tail stalks cut by the muskrat we find that the great majority are severed several inches above the ground, or above the water, for often they are cut where standing in shallow water. In the case of a number of such cuttings measured as fair average examples, the height at which the stalks had been cut varied from 7.25 to 8.25 inches from the ground. Any number may be found which have been cut at lower and higher levels, as will be noted presently, but those mentioned were selected because they were standing on practically level ground. It is evident that for an animal the size
of a muskrat to gnaw off a stalk at a height of seven or eight inches from the ground it must stand up on its hind legs to do so. This is exactly what takes place and the attitude assumed is essentially that of the beaver when cutting down a sapling. To mention one such instance observed this last summer, the muskrat, a large adult animal, rose up practically to its full height, rested one paw above the other on the stalk and severed it between them. One stalk which was about three-quarters of an inch in diameter was severed in probably not more than five or six seconds, according to my estimate.

When a larger cat-tail stalk has been cut down it is often cut into shorter sections. This I have found to be generally true in the early part of the summer, when practically all except the spike portion is used for food. Similar sectioning of willow and ash shoots has already been mentioned. This habit is another one that closely parallels the performances of the beaver. Whether in the case of the muskrat the cutting of the stems into shorter pieces is done primarily to facilitate handling in transportation or manipulation when feeding may be a matter for argument but there is no doubt that it serves both of these ends. In the case of the long, straight cat-tail stems the sectioning habit is neatly illustrated. In the foraging grounds of the muskrat many little piles of such cuttings may be found, several pieces often lying side by side in parallel arrangement as if awaiting transportation. The length of the individual sections is variable but the majority are probably from three or four to eight or ten inches long. Often the sections show considerable uniformity in length.

In the latter part of the summer the quantity of cat-tail cuttings increases greatly. This is evidently due partly to the seasonal increase of the muskrat population and partly to the fact, already mentioned, that only a small portion of each plant is now acceptable as food. "Clearings" rapidly appear in the midst of dense stands of flag and along edges of open water, varying from a few feet to several yards across, in which there is often hardly a solitary stalk left standing. Much random, scattered cutting also occurs, but it is striking what concentrated effort and thoroughness are frequently displayed in certain spots while neighboring luxuriant stands of flag have been but lightly touched or not at all. Little islands one or two hundred feet from the shore may be completely stripped of their flag before any extensive attack is made on the denser growth on the mainland itself, where the lodges evidently of these same animals are situated.
Food Storage.—In the literature a few instances of food storage by the muskrat are mentioned, but the species seems not to have any regular established habit of storage in the ordinary sense of the word. Seton ('10, p. 554) quotes the noted Sioux writer Dr. Charles A. Eastman as follows: “When our people (Sioux) were gathering the wild rice (Minnesota) they always watched for another plant that grows in the muddy bottom of lakes and ponds. It is a white bulb about the size of an ordinary onion. This is stored away by the muskrat in their houses by the water side, and there is often a bushel or more of the psinchinchah to be found within.” Merriam, ('86, pp. 278-279) refers to a statement by Audubon and Bachman who found turnips, carrots, unripe ears of corn, and other articles of food stored in an underground burrow of the muskrat. Merriam furthermore expresses the idea that the muskrat house itself represents a form of food storage (p. 277): “The materials of which the hut is composed, it will be observed, are such as serve as food for the animals during the long winters; hence the muskrat’s house is, in reality, a storehouse which he devours piecemeal as the winter advances! The one structure supplies both the food itself and the shelter in which it is eaten.” More on the storage question is found on page 278, where he speaks of “old stumps whose roots extend out under water, along the borders of ponds and streams. . . . Such stumps will frequently be found, as cold weather approaches, stuffed full of the wads of grass that are used in hut building, the angles and crevices between the roots being packed with the same material. Advantage is also taken of other inconspicuous places in which to deposit food, and sometimes where there is no current, floating hoards of grass and roots are established—veritable floating islands in miniature—in the vicinity of their huts.” Seton ('10, p. 554) says: “Although not usually credited with storing up food for winter, the muskrats do so at times. All through the summer, from at least the first of June, they may be seen carrying great bundles of green stuff into their dens. If intended for bedding, it seems to show very poor judgment on the part of the rats, but it ends well, for they commonly eat these piles when they have need of them. This is indeed a kind of storage . . . .”

The results of my own observations of the past season were negative so far as any evidence of storage is concerned. Muskrats were seen transporting food materials in the middle of June and
later, evidently to their lodges or burrows, but I am inclined to believe that this had nothing to do with storage in the true sense. A more plausible interpretation, it seems to me, would be that many of the muskrats one sees transporting food material at this season are females which have young in lodge or bank burrow. While they doubtless spend a little time feeding in their foraging grounds at various distances from their dens, they are quite likely to be somewhat uneasy when afield, so long as their young are small, and therefore carry more or less of their food to the den entrance or its immediate vicinity before eating it. Then, too, the muskrat is largely a nocturnal animal which even in the best of situations is not given to extensive or prolonged daylight activity. But the desire for food comes now and then through the day, when individuals venture forth to "rustle a bite," but they may prefer to eat it in the shelter of their doorway. Seton ('10, p. 546) tells of finding quantities of green grass, stalks and jewelweed in the corners of a den in Connecticut; and Frank Stephens ('06, p. 133) states that, "A burrow opened by Schott near Yuma contained screw beans." But the question that will arise in such instances is: how much of this material actually represents storage in the true sense and how much is merely left-over food that has accumulated in the course of longer or shorter periods? Excess of food that has been carried into the house whenever the animal eats there cannot properly be termed storage.

In regard to the view that the house of the muskrat represents a kind of food storage, it is doubtless the case that in winter, in situations where other food becomes scarce or is not easily accessible, more or less of the green matter included with other materials in the construction of the house is eaten, for it is likely to be kept in fresh condition for a considerable time, being at this season frozen into solid masses and serving as a kind of cold storage. However, one fact that is to be kept in mind at least so far as the muskrat houses of the marshes and swamps of western New York are concerned, is that the great bulk of the materials of which the new houses are built, and the old ones repaired, is the fallen, dead and dry or partly decayed cat-tail stalks of previous seasons; it is not green or recently cut and sun-dried material of the sort which might presumably serve as food in time of need. Further reference to this will be made later under the head of house building.

Certain other evidence which is not in harmony with the idea
Fig. 68. A muskrat's feeding raft at edge of cat-tails; composed of newly cut cat-tail stalks, radially arranged, with litter of leaves and other remnants at feeding place. Parker's Pond, Meridian region. July 6.

Fig. 69. A series of closely spaced burrow entrances of the muskrat in the bank of the Seneca River on east side of Kipp Island; exposed by breaks in the bank. July 31.
Fig. 70. Another burrow entrance, showing part of nesting material exposed. Same locality as in Fig. 69.

Fig. 71. Muskrat house in which two young muskrats were seen on July 17. One of the entrances is seen exposed at this low water stage. Monte-zuma Marsh.
that the muskrat house may serve as a food store in time of need is offered by that early but careful observer, Samuel Hearne (quoted by Godman, '31, pp. 60-61): "It sometimes happens in very cold winters that the holes in their [the muskrats'] houses freeze over, in spite of all their efforts to keep them open. When that is the case, and they have no provision left in the house, the strongest prey on the weakest, till by degrees only one is left in a whole lodge. I have seen several instances sufficient to confirm the truth of this assertion: for when their houses were broke open, the skeletons of seven or eight have been found and only one entire animal."

All this, however, does not necessarily imply that in the more or less remote past the muskrat house may not have had its origin in masses of stored food materials, nor that storage may not have been a regular habit among the ancestors of our present day muskrat.

Such "floating hoards of grass and roots" or "floating islands in miniature" as are mentioned by Merriam seem to be interpreted by Seton ('10, p. 548), and I believe correctly, as being primarily landing places for the purpose of feeding, and doubtless they serve at times also as resting places. Figure 68 is from a photograph of one such "rat-raft" which was found at the edge of the cattails in Otter Lake. It consists of long cat-tail stalks which have been cut by one or more muskrats and apparently transported to the place from the immediate vicinity. The stalks had a distinct radial arrangement, the butts toward the center. The whole was sufficiently compact to support at least one or two of the animals, and quantities of shredded stems and leaves resting upon it was evidence that it had been used as a feeding place.

**MUSKRAT HOUSES, DENS, AND BURROWS**

As in the case of the beaver, muskrats do not always build houses. Whether they do so or not depends a great deal upon local conditions. In the West, muskrat houses appear to be unknown, according to Stephens, who says ('06, p. 133): "I have seen no 'houses' and can learn of none in the west." Where houses are not found the muskrats live in bank burrows, rock crevices, hollow logs, or other suitably placed, ready-made shelters. But even where the great majority of the animals live in places of this kind an occasional house may be found. In such localities as Tioughnioga Creek, parts of the old Erie canal, the Seneca River
and the Barge Canal, Black Creek in the region of Byron, and other localities which fall within the first type of habitat, muskrat houses were the exception. In all those places the banks were of a character suitable for burrowing, and where the muskrat can find proper conditions for bank dens these have preference over the "house." In certain places bordering the Cicero Marsh where there was some elevated ground, a few muskrats had taken advantage of the situation and had dug bank burrows while close neighbors lived in houses. In one instance, where a pasture bordered the marsh, the muskrats had tunneled into a low knoll to a distance of about thirty-five feet from the water's edge. At the end of the tunnel was the nest chamber. Unhappily for these individuals the cattle had broken through into both tunnels and den and the place had evidently for that season been abandoned. The entrance to a bank burrow on Black Creek, in the vicinity of Byron, is shown in figure 50; and figures 69 and 70 are from photographs taken along the Seneca River on the northeast side of Kipp Island. While the entrance to a burrow is usually under water, with the tunnel leading obliquely upward to the chamber, the falling of the water level in the drier periods of the season may temporarily expose a great many burrow entrances. Along the Seneca River, in a considerable number of instances, as illustrated in the last two figures, the tunnel openings had become exposed as a result of sliding of the abrupt banks where these had been undermined by water action. The length of the tunnels here was estimated as originally probably about three to five feet. With the breaking off of portions of the bank the den at the inner end of shorter burrows may become exposed, as in figure 70, where part of the nesting material can be seen.

**Location and Construction of Houses.**—In swamp and marsh habitats, particularly the latter, the muskrat house is a familiar sight in this state and furnishes conspicuous advertisement of the presence of muskrats in a given locality, or at least of their recent occurrence. In the cat-tail marshes the vast majority of houses rest flat upon the marsh floor (figs. 71, 72, and others) but many are built on or around exposed roots and trunks of willows (fig. 73) or other trees, on tussocks, on hummocks of marsh-growing shrubbery, on floating islands, or any other suitable location. In some situations they are entirely surrounded by water, but this is rarely more than about two feet deep and the house rests upon a foundation of mud or decayed vegetation built up from the bot-
tom. In other places the house may at no time be surrounded by open water, although connected with it by short underground water tunnels. The ground water level is often subject to considerable fall during the course of the season or year, but so long as the muskrat can find water by burrowing and digging it is usually satisfied to remain in its house rather than move elsewhere.

The materials used in the construction of the houses are generally such pond and marsh vegetation as is near at hand. Sometimes a few small sticks are found as incidental inclusions, but a muskrat house built chiefly of sticks is uncommon and probably to be found only where the ordinary materials are scarce (Shiras, '21, p. 193). In the cat-tail marshes the bulk of the material naturally consists of cat-tail stalks. That filling the interspaces consists principally of balls or wads of bladderworts, naiads, Spirogyra, Chara, fibrous rootlets, moss, duckweed, leaves, etc., all more or less mixed with mud or mucky matter. It has been mentioned on a former page that the main bulk of the material in a house consists of dead, dry, or partly decayed vegetation. Green cat-tail stalks or other larger plants are not found among the house materials except incidentally when a few green things may be included, scattered throughout the whole. This applies to the occupied houses, which receive additions from time to time throughout the summer, as well as to new houses built during the late summer and fall. The coarser materials of the new houses which I found being built in the latter part of August consisted entirely of the old, lodged cat-tail stalks of the previous year with, at times, a small amount of stalks which had been cut down for food purposes during the present summer and therefore were dry. It was all material that was already down. In the latter part of November, however, I found on several houses that had just been built or were in the process of construction, a considerable amount of flag of the season, now dead and dry, that had been lately cut down for the purpose.

Many muskrat houses in the marshes and swamps which were found occupied in the summer of 1923 evidently were more than one year old, but the majority appeared to be of the preceding season's construction. The cat-tail stalks are quite firm and relatively slow of decay, so that where the bulk of the house is composed of this material the walls do not quickly cave in and fill up the chamber. In many old, weed-grown houses which clearly had long been unoccupied, the chambers were still in fair shape although the entrances had become closed up.
The particular location of muskrat houses on the borders of a marshy pond or stream, other things being equal, is probably determined mainly by the average high water level. For example, along Muskrat Creek, which is bordered by a strip of cat-tail marsh probably fifty to seventy-five feet wide, the houses were usually situated near the middle of this strip. In this location they were doubtless safe from inundation during the period of high water, while in the drier season the water table did not fall below the level of their sub-surface tunnels. Where there are wide areas of wet marsh the houses may be rather promiscuously scattered, but the many little open-water pools which generally occur here are frequently centers of more or less concentration of the muskrat population. In the prolonged dry periods of some seasons the ground water level in these marshes may fall a foot or more below the surface, so that even the bottom in most of the pools becomes entirely exposed. This was the case during the latter half of the past summer, and the great majority of muskrat houses in many marshes visited were left standing high and dry. But the occupants remained, and when I approached such a house they would escape either by an open channel or by an underground tunnel which led to the surface a few feet away and continued as an exposed runway, along which the muskrats then scurried.

Size of Houses.—While there is considerable variability in the size of muskrat houses the largest I measured was 8.75 feet in diameter at the ground, and 2.5 feet high. There had been no recent additions to this house and its height had probably been reduced a few inches by settling. Many houses which are occupied for a number of seasons gradually increase in size by periodic additions and therefore contain considerably more material than a house of the season; but newly built houses may appear larger because of the loosely piled condition of the materials.

The Interior of Houses.—Generally the muskrat house contains a single unpartitioned interior space, or chamber. Occasionally, however, there may be two completely separated rooms, and possibly more, though personally I have never known of such a case. Where there are more than one it is generally supposed that each is inhabited by members of different families of muskrats. The single main chamber is usually of irregular shape and contains often two, three, four, and possibly more recesses or alcoves, in open communication one with another by somewhat narrower passages. Each of these alcoves contains the resting or sleeping bed of
Fig. 72. Example of occupied muskrat house situated on the edge of an open pool among the cat-tails. Surface of water covered with dense growth of duckweed and other vegetable matter. Montezuma Marsh. July 26.

Fig. 73. Muskrat house built around the trunks of a clump of willows. Such houses offer fine basking places for the water snake. (*Tropidonotus*). Cicero Marsh, June 14.
Fig. 74. Floor plans of several muskrat houses; reproduced from field sketches.
probably a single individual. In some cases I have found that only one or two of these resting places contained dry bedding and obviously were in use, while the others were damp, without litter, and showed no signs of recent occupancy. In figure 74 is shown a series of sketches representing the interior plans of a number of muskrat houses, with occupied and unoccupied beds as indicated. In one is a circular chamber surrounding a thick central pillar of material supporting the roof. One of the two beds found here contained, among a scant layer of dry litter, two short pieces of green cat-tail leaf; the other was damp, without dry litter and had not been recently occupied. The house in this case was an old one, much settled, and had received no additions of material in a long time.

The chamber of a muskrat house is probably enlarged and the number of alcoves or resting compartments increased from time to time as the needs of the occupants may require. The interior appearance of many a house, especially an older one, is doubtless quite different from what it was originally. The floor of the chamber, which is usually a few inches above high water level, may be raised a foot or more so as to be about half way to the top of the mass.

The size of the chamber varies considerably. In some houses the room may be from 8 to 10 inches wide, 10 to 15 inches long and 7 to 9 inches high, with a single bed; in such cases there is doubtless but a single occupant or perhaps a female and her small young. Where more than one bed occurs the chamber is correspondingly larger although its height remains much the same.

In Minnesota in years past when it was a practice to spear muskrats, it was a commonly held view, at least among many boys who hunted muskrats, that the southeast side of the house had the thinnest wall, and the spear was thrust in from that side. The idea was that the muskrat built its chamber nearer this side because it was the most sheltered and got the benefit of the morning sun.

As to the number of muskrats that may be found in a house, accounts differ. Brayton ('82, p. 151) speaks of “several pairs constructing and occupying the same houses and burrows,” and Samuel Hearne is quoted by Godman ('31, p. 61) as having found seven or eight skeletons of muskrats in winter houses where the animals had perished from starvation. It may be doubted whether such sociability as Brayton implies exists among muskrats, the several individuals representing more probably members of the
same family; but outside the breeding season there is no good reason to suppose that individuals of different families may not sometimes be found in the same house.

The entrances and exits are usually two, but sometimes only one and it is possible that in certain cases there are more than two entrances though I have never happened upon such an instance. When more than one separate chamber occurs of course each has its own entrance or entrances. In the instances of this kind illustrated there was only one entrance to each chamber.

"Eating Huts."—At this point may be mentioned the structure known as the "eating hut." Seton (‘10, p. 549) presents a description by John Rae of this type of hut as found in British America where, it is told, such structures are by no means common and appear to be built only in larger ponds where all parts cannot easily be reached from the main house. Briefly, such a hut consists of a little pile of "mud and weeds" built over a hole in the ice, and "just large enough to hold one rat comfortably." When these huts become covered with snow they prevent the hole from freezing over and the muskrats thus have safe and cozy outposts near their foraging grounds. Merriam ('86, p. 281–282) has quoted a description of such huts by Henry Thacker, who saw them in the Chicago area in the winter of 1844-45. I have personally seen the same type of hut in Minnesota, and I found it a familiar object at least to some of the trappers in western New York where these huts are common. While it is to be inferred from the published descriptions that these eating-huts are built only in the winter, such is not the case in New York; neither are they limited to larger ponds. In the Montezuma Marshes west of Savannah I found several eating huts of the previous season, now merely collapsed, flattened heaps of decaying material, which evidently had covered plunge-holes leading into tunnels under the root mat. This was in the midst of the cat-tails. On August 20, I found one such hut situated on the edge of a dried-up pool (fig. 75). This hut was composed of decayed pond vegetation and showed unmistakable signs of being in use, but it was not of recent construction. Two other newly constructed huts, shown in figures 76 and 77 were found August 16 and 24 respectively. Each covers a plunge-hole and is situated in the vicinity of an occupied house. The one shown in figure 76 had been built between the 3rd and the 16th of August. On October 30 I was able to revisit this place and found that no more material had been added to the hut. The fall rains, how-
ever, had raised the water level to such an extent that the hut was partly submerged. Seven other newly built similar structures were found between August 16 and 23, and on a visit to Crusoe Lake on November 24, two recently built eating-huts were seen on small hummocks projecting above the shallow water of the marshy border. Often these little huts are so inconspicuous as to be readily overlooked. In the winter time, according to trappers, the eating huts usually are buried under the snow, and one man referred to them as "snow-bank houses." While one use made of these huts is doubtless that of shelter when feeding they probably also serve in an important capacity as retreats and means of escape for the animals when they are driven from their houses.

**Season of House-building.**—In Manitoba, according to Seton ('10, p. 547), the muskrat "begins in July to get ready for the winter either by repairing the old home or beginning a new one." On July 5, in western New York, I noted the first fresh additions to a house and from that time on throughout the summer frequently saw houses with newly added material. Prior to July 5, however, my time had been spent mostly in localities in which, when houses were sighted, I was unable to examine them closely because of inaccessibility. It seems not improbable that houses which are occupied throughout the year receive new additions from time to time during the entire summer, as sporadic manifestations of the building instinct, but the tendency to build increases apace towards the close of the breeding season.

On August 16 I found the first new house started, a solid pile of cat-tail stalks about the size of a bushel basket. Another one was found the next day, which was already as large as an ordinary lodge, but the chamber had not been excavated. The greatest building activity had been displayed between my departure from the marshes August 27 and my return visits in October and November. On October 30 I found three newly built houses in a small area which I had marked in the Montezuma Marsh, and on November 24 I counted more than twenty houses along the water's edge on the west shore of Crusoe Lake, which had not been built at the time of my visit there August 24. This increased building activity in the latter part of the season is doubtless due to a very considerable extent to the new generation of muskrats.

**Excavation of the Chambers.**—When a muskrat house is to be built in water, the first efforts of the animals are concerned with gathering together sufficient material to form a foundation reach-
ing to the surface. Since the material used consists mostly of water-soaked, more or less decayed vegetation, mud, etc., little difficulty is caused by its liability to float away; besides, the building site is usually chosen in quiet water. When the accumulations in this operation, according to Seton (10, p. 547), have reached a height of several inches above the surface, a chamber is made in the interior of the mass by excavating from below the water level. Working upwards into the mass above water the animal gnaws out a cavity which will be enlarged as required, as the pile grows and the house nears completion. Where the lodge is built on land the excavation of the chamber involves less difficulty, and this is especially true in the marshes. The ordinary dwelling houses as well as the eating huts are here often built over plunge-holes. Whether the house be built in the thick of the cat-tails, on ground where the foragings of the muskrats have left only a stubble standing, or on a spot where there is more or less lodged flag of the previous season, in any case when the house materials are brought together the bottom layers rest against or upon the flag stalks and stubble, or upon such inequalities as generally occur on the marsh floor, and more or less of unfilled space is left underneath the mass. Such conditions I have repeatedly found in examination of houses in the process of building. These spaces are now enlarged and rounded-out by the muskrats by gnawing off projecting stalks and blades. The litter thus formed accumulates on the floor which thus gradually becomes elevated. As the ceiling is lowered by the slow settling of the roof the gnawing away of the material apparently continues, as described by Seton, until the mass becomes stabilized and the space requirements of the animals are satisfied. By this time the floor may have become elevated several inches above its original level.

Transportation of Materials.—The methods employed by the beaver in transporting poles, boughs, mud, and other materials has been described quite fully by a number of writers, but I have found no published descriptions of the methods used by the muskrat in handling the various materials, often of similar character, which it is known to transport. Personally, I have many times seen muskrats carry in their mouths little bundles of grass, sedges, shorter sections of cat-tail leaves, etc., and, while I have never happened to witness the transportation of the wads of wet, mud-mixed vegetable matter used in their house building, examination of individual loads of such material indicates that these are carried in
Fig. 75. Example of "eating hut," situated on a cat-tail hummock at edge of a dry pool. This hut was just large enough for one muskrat, and was in use at the time. The floor was on a level with the top of the camera case. Montezuma Marsh, Aug. 20.

Fig. 76. Another example of "eating hut," newly built over a plunge-hole near a muskrat house which is seen in the middle background. Montezuma Marsh, Aug. 24.
Fig. 77. A newly built "eating hut" (in foreground) placed over a tunnel, in another part of the Montezuma Marsh. A large occupied muskrat house at left. Aug. 16.

Fig. 78. Muskrat dung deposits on an old tree trunk. Montezuma Marsh, Aug. 22.
the same manner. The muskrat apparently never employs its forepaws in carrying such material, in the way the beaver does. The bundles of grass, etc., are held between the jaws, often as big a mouthful as the animal can grasp, the ends bristling out at the sides. Larger stalks are usually grasped near one end, in the only way possible for successful transportation, and dragged or towed one at a time.

Although the forepaws are not used in transportation, they have the same handlike functions seen in many other rodents in the manipulation of food.

Defecating Habits.—The muskrat in common with so many other wild mammals is one of cleanly habits. Excrement seems never to be voided within the lodge which always appears remarkably clean and free from any odors resulting from dung or urinary discharges. In the vicinity of the lodge and on the foraging grounds certain particular spots are generally used for excrement and these often contain the accumulations of considerable periods. At one side of a lodge in the vicinity of Little York I saw a heap of droppings of such size that it must have represented the accumulations of several weeks. In the cat-tail marshes little elevations of one kind or another seem particularly favored spots for dung disposal; such are old logs (fig. 78), little hummocks, platforms of lodged flag, or any other exposed, elevated and accessible surface. Many such places contain old dung remains evidently dating back several months, as well as more recent and fresh deposits. Doubtless the same places may also be used by different individuals and in some cases even by different generations of individuals.

While the tendency in general is for the muskrats to deposit their excrement in certain spots as described, there is also more or less indiscriminate scattering of smaller amounts throughout their foraging grounds and other places of activity. And excrement is not only voided on land but in the water as well. This is evidently done while the animals are swimming, for in still ponds where the water is shallow one may see at any time, resting on the bottom over considerable areas, an abundance of scattered, recently dropped pellets.

MUSKRAT TUNNELS AND CANALS

Besides the rather limited amount of tunneling performed by the muskrats where they make their dens in banks, the marshes and swamps are the scenes of much more extensive and varied operations of similar character. While more or less digging apparently
takes place throughout the year in these places, the greatest activity is manifested during the summer season, especially after much of the marsh floor has become exposed by the falling of the water level in the drier part of the season. Each house is usually at the center of a more or less elaborate, converging system of tunnels, canals, and surface runways, which may extend outwardly to a distance of many yards; and similar passageways often may be seen coursing out at right angles from a stream or pond to forage grounds among the cat-tails. Figure 79 represents a typical canal and trail system about a house in the Montezuma Marsh, reproduced from a free-hand sketch made in the field. The house was situated in an open, roughly oval space, about 75 and 45 feet in long and short diameters, respectively. The ground was carpeted with a dense layer of last year's flag, except in the immediate vicinity of the house where the surface was bare. A scant growth of new flag occurred in one part. At the periphery of the open area some of the trails were lost on the surface among a luxuriant stand of green flag, while others, here exposed, there covered by the lodged flag, continued on to undetermined distances. The only places at which the sub-surface water level was reached in this system were in the plunge-holes and underground tunnels leading from them to the lodge.

Since the muskrat is chiefly nocturnal its more extensive operations are carried on between sunset and sunrise. When seen abroad in the daytime it is usually in connection with feeding or food getting; but occasionally it may carry on some of its other work during daylight hours, and one bright forenoon last summer, as I was sitting very quiet among the cat-tails, I very plainly heard a muskrat digging in an underground tunnel within a few feet of me. At nightfall, however, the population comes out in force, old and young, and the industry with which they have plied both tooth and nail is at once apparent on one's visit to the marsh in the morning.

The canals and channels of the muskrat have much in common with those of the beaver, both in their form and in the purpose which they serve. I know of no actual eye-witness account of the manner in which the muskrat works when excavating these travel ways. Do a number of individuals at times join forces in such operations, as is sometimes stated, do they usually work singly or in pairs, or is there no well defined method? These and other questions come to mind as one gazes upon the elaborate systems of channels,
Fig. 79. Canal and trail system about an occupied muskrat house in the Montezuma Marsh; reproduced from a field sketch made Aug. 20, 1923.
canals and tunnels which so frequently occur about the dwelling places of these industrious animals. The canals of the beaver have been looked upon by some noted students of that animal, such as Morgan ('68, p. 191) and Dugmore ('14, p. 64), as constituting more conclusive evidence of intelligence than that furnished by the dam or any of its other works. "To conceive and execute such a design," says Morgan, in regard to the canal, "presupposes a more extended and complicated process of reasoning than that required for the construction of a dam; . . ." "These canals," says Dugmore, "I venture to say, are a demonstration of the highest skill to be found in the work of any animal below man." Contemplating such equally finished examples of canal building as that illustrated in figure 80, one may feel entirely justified in asking: Shall not the muskrat be credited with an equal display of intelligence? That the purpose or purposes of the canals are fundamentally the same for the muskrat as for the beaver, I believe will hardly be denied by anyone who has taken the trouble to examine both. Of course the canals of the muskrat because of their small size are much less conspicuous features of the landscape than those of the beaver, and for that reason are less likely to attract attention; but when the relative size of the builders is kept in mind, the energy, industry, and intelligent behavior displayed by the one appear in every way equal to those credited to the other. The muskrat does not build dams. If this one feat had been added to its accomplishments the animal would doubtless have been the object of the same amount of attention, wonderment and admiration as has been bestowed upon the beaver.

In the construction of its canals as well as in other operations the muskrat wastes much time and effort. In its canal building this is especially evident in connection with the disposal of excavated materials. In numerous freshly dug canals which I have examined, the materials removed have been deposited, not all along the sides of the canal as the digging progressed, but at certain points only. In the case of shorter canals the materials had been thrown out at one end, as in the case of tunnels (figs. 80, 81). Where the canals were longer the intervals between the heaps were relatively long, and clearly pointed to a great deal of unnecessary labor in transportation (see fig. 79). Since the canals are of quite uniform depth in such stretches, and the banks offer no more difficulty in one place than in another for climbing out, much time and energy could have been saved by depositing the material on the
banks all along. In a number of newly dug beaver canals which I have noted, the excavated materials had been piled up on the sides and at much shorter intervals; so short in fact that it seemed as though they had been deposited at the nearest convenient point. But whether this distinction holds true generally for the methods of work of the two species can not be stated.

In figure 80 is shown about six feet of a newly dug canal which was approximately twice the length here visible. At the nearer end was a small heap of excavated materials which in the photograph is concealed by the lodged flag. It will be seen that there are no dump heaps on the banks of the canal. Where the ground water is so near the surface that the canal fills with water as rapidly as it is dug, if the earth is of fine mucky or muddy character so that it becomes mixed with and is held in suspension in the water, it can not of course be removed by the muskrat, and in such places this fact may sufficiently account for the absence of dump heaps. But the reference above is to the coarser materials forming such a large part of the floor of the marshes where the muskrat works.

In figure 81 is seen the pile of material at the mouth of a newly dug dry tunnel, the entrance to which is indicated by the leaning flag stalk at the further end of the trail. The material in this instance is of soft, but not wet, mucky consistency, permitting but a small quantity to be grasped at a time, so that a great many trips back and forth must have been made in the course of these diggings. The truth of this seems to be confirmed by the smooth-worn trail leading from the mouth of the tunnel to the dumping ground. The nearer end of the pile (to the observer) in this case is about five feet from the mouth of the tunnel, an unnecessary distance to cover, for the materials could just as well have been deposited at the sides close to the entrance.

Figure 82 shows a plunge-hole which leads into a sub-surface tunnel. The main pile of excavations is seen in the foreground and a smaller heap is on the farther side of the hole. These contain mainly fibrous roots and underground stems of cat-tails, gnawed and shredded by tooth and claw.

But whatever waste of effort or energy may be exhibited in the works of the muskrat it seems to be no greater than that observed in various undertakings of the beaver, or, for that matter, of any other animal of complex but largely instinctive behavior. In building the canal the muskrat evidently follows closely the same method which it employs in constructing the tunnel, carrying
out the excavated materials at the end where the digging was started. As the canal increases in length much time is lost in transportation for the animal seems not to have learned to shorten the labor by disposing of the material on the banks near by. The reason back of all this is possibly to be sought in the evolutionary history of the canal. The tunnel doubtless is an older institution than the canal — in fact, the canal may be looked upon simply as a modification of the tunnel — so that when digging a canal the muskrat merely follows its deep-seated habit of disposing of the excavated materials in the only way possible for it when tunneling, namely, at the (open) end where it started.

In many parts where dense layers of old flag cover the ground considerable stretches of canals are roofed over by this mat, and the same is true also with many surface runways.

In the proximity of houses there is frequently found a series of shorter, radial canals leading to a central plunge-hole which in turn connects by tunnel with the house (figs. 83, 84). In each of the examples illustrated there are five such radial canals. In the first case the majority are of a previous season's construction, in the second all are newly dug. From the ground level to the bottom at the central plunge-hole the depth is about 12 inches, while peripherally the canals or channels become gradually shallower until they end at the surface. These systems of channels would seem to serve admirably to guide the muskrats to the plunge-hole from the various directions from which they might approach it, and would likewise offer a number of avenues of escape, for while the water table is now several inches below the surface, when the fall rains come, or in the more favorable water conditions of spring and early summer, these places are transformed into shallow ponds. Three similar sets of channels occurred on other sides of the house shown in figure 84.

In a number of instances the plunge-holes and underground tunnels were filled with a thin ooze rather than water, yet they clearly showed that they were being used, and that this was a fact was further confirmed by a trapper who insisted that the muskrats do not hesitate to plunge into such holes.

**THE SPACING OF INDIVIDUALS OR FAMILIES**

The question of spacing is an important one since it has to do with the limits to the number of animals that may successfully occupy a given area at the same time, from the viewpoint here
solely of their behavior toward one another, and without regard to the question of sufficient food supply, water, etc., which are other matters. These other requirements being met, how close a proximity to neighbors will a muskrat or a family of muskrats tolerate when free in a state of nature? Little is as yet known in regard to this subject either for the muskrat or most other wild mammals. Concerning muskrats in captivity, Hornaday ('10, p. 84) has stated that when any number are kept together in an enclosure they are difficult to handle because of their tendency to fight. Although it is not safe always to judge of an animal’s behavior in the free state by what it does in confinement, there is at least a suggestion of a limit to the crowding that muskrats will stand.

Hahn ('08, p. 519), in regard to the muskrat of Indiana, remarks that, "A trapper who went to the Kankakee country in 1865 told me that at that time muskrat houses stood so thickly in some places that it was possible to open three or four of their houses from an anchored boat." This statement may or may not mean a great deal as to the number of muskrats, for in "some places" even at the present time three or four muskrat houses may be found close enough together for all to be reached from an anchored boat (as for example the groups of houses at Crusoe Lake, mentioned beyond), but the inference evidently is that the muskrat population in that part of the country was then much denser per unit area than it is now.

At the present status of the species it would doubtless be difficult to find anywhere in the country any locality, however small, in which muskrats might be sufficiently abundant to suggest an overcrowding of their numbers.

During the present investigation an attempt was made to gather some data on the spacing of muskrat houses in a portion of the Montezuma Marsh where the trapper in control had kept a certain area closed to trapping, so that the muskrats here were relatively more abundant than in any other area examined. The summer season is, however, very unfavorable for making observations of this kind, due partly to the soft, practically impassible condition in many parts of the marsh and partly to the dense stand of cat-tail flag, eight or nine feet tall, the combined effect of which is to make visibility decidedly "low." Such notes as were obtained therefore pertain only to a very limited accessible area, and furnish nothing more than a general idea of the distribution of inhabited
lodges. It is important to mention that the owner of this marsh claimed that in this particular area (and also in adjoining parts of the marsh) muskrats were too numerous for the welfare of the cat-tail flag, three or four acres of it having been destroyed by these animals the preceding winter. However that may be, the muskrat houses were found rather unevenly distributed over the entire area, there being a tendency in places, usual in every muskrat locality, of grouping of two, three, or four houses closer together while others were scattered singly and at greater distances apart. For some thirty houses located in this particular area, it was found that the shortest distance from one house to the next was about 25 feet, and the greatest about 75 feet, the distance being in some instances based on pacing and where this was not possible, on careful estimates. While it happened in this small plat that no houses were found nearer together than about 25 feet, closer spacing often occurs even where muskrats are relatively less plentiful than on the ground in question. For example, at Crusoe Lake, on November 24, I found a group of four newly built houses situated in a row near the water's edge, between which the distances in order from each one to the next were, respectively, 9, 12, and 8 feet; and in another group consisting of five new houses, in different arrangement, the distances from each to the next nearest were, in order, 14, 18, 30, and 15 feet. Such groups of closely spaced houses probably represent the work of members of the same family, that is, young muskrats which have been born in the immediate vicinity.

In the case of bank dens no spacing data are at present available, but it may be remarked that in instances like the one shown in figure 69, where five burrow entrances are situated at very short intervals, we probably also have before us burrows dug by the same family of rats, or possibly by the same pair of individuals at different times; for as before mentioned, only one of these burrows showed signs of being in use at the time they were found.

SWIMMING HABITS AND UNUSUAL BEHAVIOR

Manner of Swimming.—The muskrat swims and dives much like the beaver. Seton (10, p. 553) considers its ordinary rate of swimming to be about a mile an hour, but that when pressed its speed may be increased to possibly three miles an hour. Under water it is able to swim about a hundred yards without coming up for breath, according to his estimate.
Fig. 80. Part of a newly dug muskrat canal among the cat-tails. About six feet of the canal is shown, the greater part being covered by overlying flag. A pile of excavated materials at near end is concealed from view. Montezuma Marsh, Aug. 22.

Fig. 81. Muck excavations from a newly dug tunnel, the mouth of which can be seen at the further end, crossed by a sloping cat-tail stalk. The near end of the pile is about 6 feet from the tunnel opening. Montezuma Marsh, Aug. 23.
Fig. 82. Plunge-hole or entrance to a newly dug muskrat tunnel in the Montezuma Marsh. A considerable pile of excavated materials on near side and a smaller amount on opposite side. Aug. 3.

Fig. 83. Exposed set of five radiating channels beside an old muskrat house. The one in the foreground leads to the house entrance; three of the remaining channels are short, ending on the surface, while the fourth continues some distance.
Kennicott ('57, p. 105) long ago wrote in regard to the muskrat that "its stout tail and muscular hind-legs, being provided with broad feet and toes, furnish it efficient means of locomotion in the water. . . ." Baird (Brayton, '82, p. 151) clearly suggested the use of the feet in swimming when he described their oblique position which permits the animal to "feather the oar," and similar reference to the feet is made more recently by Stoner ('18, p. 97). Both Brayton and Stoner speak of the tail as a rudder. The only positive and specific statement, however, which I have encountered is made by Dugmore ('14, p. 213) in comparing the beaver's method of swimming with that of the muskrat: "In swimming the beaver uses its hind legs and to a very limited extent its tail, chiefly for sudden starts and turns. In this respect it differs entirely from the muskrat, which swims entirely with its tail, which acts as a scull." In the light of my own experience this statement is remarkable and I am sure that it will be challenged by many others who are familiar with the animal in its haunts. The long laterally flattened and sinewy tail would indeed seem to be admirably suited for propelling its owner by sculling movements; and such use is actually made of it in making sudden starts and turns, as mentioned for the beaver, and probably also when the animal is forced to exert itself in the water, as for example when pursued or when breasting a current. Very often when a muskrat is swimming about at the surface it makes so many little turns, this way and that, and the tail is consequently so active in its main capacity of rudder, that one easily gains the impression that it is the only propelling organ,—the more so since the feet cannot as a rule be seen. But when the animal is swimming in a direct course, and at ease, the case is different. This I have a number of times witnessed when a particular point was made to observe the method of swimming. Once, in Colorado, a few years ago, while I was standing partly concealed behind a bush at the edge of a beaver pond, two muskrats, evidently entirely unaware of my presence, swam past me at a distance of probably not over 6 or 8 feet. They swam with their feet, and not with their tails. While I could not in either case see the foot of the opposite side and thus be able to tell positively whether the two feet worked both at once or alternately, I judged from the action of the body that the strokes were made simultaneously, exactly as in the case of the beaver. There were tail movements, to be sure, but these were of a feeble and irregular kind that could only be interpreted as steering move-
ments. A number of muskrats which I have since watched while they were swimming leisurely and unalarmed, among them one that was transporting a stem and leaf of a marsh plant (Sagittaria), swam steadily and without any vigorous or continuous movements of the tail which might indicate that this organ was being used as a scull in the proper sense of the word.

Examination of the hind feet of the muskrat alone furnishes sufficient evidence that they are for use in swimming. Foot and toes are relatively long and wide-spreading, and while the toes are only partly webbed, their sides and the sides of the foot proper from the heel down are provided with dense fringes of stiffened hairs which offer effective resistance to the water and help make the foot as a whole an effective paddle.

When the muskrat lies passively floating it often holds the middle section of its tail out of the water in a low arching curve, with basal and terminal portions below the surface. When alarmed, the animal often gives what is commonly considered a warning splash, which can be heard some little distance. According to Stone and Cram ('13, p. 125) this signal, as in the case of the beaver, is made by slapping the water with its tail.

**Suspended Breathing Under Water.**—The ability of the muskrat to remain under water for several minutes has, as in the similar instance of the beaver, been a matter for considerable wonderment, and a number of writers have attempted to explain the phenomenon. According to Morgan ('68, p. 138) the muskrat in order "to lengthen the period of suspended respiration," resorts to the following method: "When swimming under the ice he comes up to its lower surface and having expelled the air from his lungs, waits for a moment, and then, after drawing in again the bubbles of air, proceeds on his way. This fact has been confirmed to me by many different observers, and I see no reason to disbelieve its truth. Whether the air by its contact with the ice recovered some property of which it had become exhausted, I leave as a question to those capable of its determination. It is claimed that the beaver resorts to the same expedient, but I have not been able to verify the fact."

Of recent date we have the following account by Evermann and Clark ('20, p. 466): "In early winter, after the ice has formed some distance out from shore, Muskrats are often seen swimming under the ice. They move along quite rapidly, and present a peculiar appearance, a bubble of air at each nostril ex-
panding and contracting as they breathe, and a number of small bubbles on the fur giving them a silvery color. Apparently the Muskrat before diving fills its lungs with air, portions of which it exhales and rebreathes again. During the time the air remains as a bubble at each nostril it is purified through its contact with the water and rendered fit for breathing again. This peculiar habit would seem to account for the ability of the Muskrat to remain under water so long."

On the contrary this explanation would seem entirely inadequate to account for the phenomenon in question. It remains to be explained just how the relatively small amount of gaseous exchange that can take place in the two little bubbles at the end of the muskrat's nose is going to have any appreciable effect upon the animal's available oxygen supply, and by what means the animal is able under water to keep up the circulation of this quantity of air to its lungs and back again to the bubble without doing violence to known facts about the respiratory mechanism of mammals. Anyone who has seen frogs, turtles, or any other of our well known aquatic vertebrates under water knows that similar bubbles of escaping air are often seen in all of them; and I have also seen them in trapped beaver where they had no noticeable effect in preventing the animal from drowning. But there really seems to be no reason why the suspended breathing of any of these animals under water should be the occasion for more fantastic explanation than the similar phenomenon in diving birds, otters and other inland forms, or in such marine mammals as sea lions and seals, not to mention dolphins and whales. In all of them, as in man himself, the ability to stay under is probably determined only by their several capacities to "hold their breath"; in other words, so long as the available oxygen supply contained in the air in their lungs at the time of submergence holds out.

Regarding the idea that muskrats may come up to the under surface of the ice to breathe, it is well known that after a pond or stream is frozen over an air space often forms between the ice and the water, as the level of the latter falls. That these spaces, sometimes so narrow as not to be easily perceptible to one looking down from above, are resorted to by muskrats, beavers or other aquatic mammals such as otters and mink, can hardly be doubted.

Migrations.—On another page it is noted that in certain seasons of drought, scarcity of food, or other observed conditions suggested as responsible, muskrats have been found wandering
about in unusual places, apparently in search of more favorable locations. At such times they may occasionally be met with at considerable distances from water. Kennicott ('57, p. 108) tells of having at times in dry seasons found muskrats "on the prairie at great distances from water"; and E. R. Warren in a personal letter to me relates that on October 29, 1916, about twenty-five miles north of Fort Collins, Colorado, along the road to Cheyenne, he met a half-grown muskrat which was traveling in the opposite direction. This spot, Mr. Warren had been informed, was several miles from water.

Besides individual movements or wanderings of this kind the muskrat now and then seems to be seized with the desire to migrate en masse, the cause or causes for which are quite unknown. A remarkable example of such a movement is described by Thomsen ('21, p. 9) in a letter to Mr. Carlos Avery, then Commissioner of Fish and Game for Minnesota: "I thought I would write you in regard to a strange occurrence among the muskrats on Oct. 9th. On that date at two o'clock in the afternoon a large body of muskrats were traveling south on the state road south of Medelia (Minnesota). There was a drove of them of more than 100 (of course it was impossible to count them), they were traveling in a compact mass between the paving and the ditch, there were none on the paving, there is a strip of dirt about 6 to 8 feet wide along the side of the paving, and they were all on this strip of dirt, they must have covered the ground from about 75 to 125 feet. There were all kinds of cars passing on the pavement, and lots of people stopped to watch them, which did not seem to disturb them in the least. Quite a number of people got out and approached them, they immediately showed fight, but none of them would leave the road or change their course. Now, where they all came from or where they were headed for I am unable to say, for they were all going south. The strange part of it seems to be that they were leaving a place where there was plenty of water, for northeast of them was Goose Lake and south for a great many miles was no water to speak of."

Mr. Thomsen remarks further upon the strangeness of this phenomenon and adds that while he had traveled over a great deal of the territory about the lakes and sloughs that same fall he had seen very few signs of muskrats anywhere, although the water in the lakes and sloughs was unusually high for that time of year.
Attacks on Man.—The muskrat is generally recognized as a vicious fighter when called upon to defend itself, and has even been credited with having successfully routed a female mink (Cram, '23). Aside from purely defensive tactics, however, a number of writers have described a more remarkable tendency of individuals at times to attack human beings, apparently entirely unprovoked. Most instances of this sort are reported for muskrats which have been encountered some distance from water, in situations strange and unusual to them, evidently in the course of some erratic excursion or migration on their part. Nelson ('18, p. 414) gives an instance for this state: “The first muskrat I ever saw was one which a farmer met in midwinter in a snowy road in northern New York. As soon as the man drew near, the animal rushed at him with bared teeth and fought savagely until killed.”

While attacks of this sort have the appearance of being unprovoked it is possible that near approach to the muskrat at such times is in itself sufficient provocation to cause the animal to defend itself by attack. Being far removed from its natural protective element it doubtless is in a state of uneasiness and high irritability. The behavior of the same animal in its own environment when approached in the same way might be entirely different. That cases of apparently unprovoked attack may not always have been so from the point of view of the muskrat is indicated by the following account, sent me by my brother Dr. A. M. Johnson, Minneapolis, Minnesota, of such an attack experienced by him in that city a few years ago. The spot at which the incident occurred is about a quarter of a mile from the Mississippi River, the nearest water. “In regard to that muskrat attack I find in my diary for Thursday, September 14, 1916, the following somewhat brief note: ‘Went down to Oak Street at 6 A. M. to get a morning paper and some fruit. It was raining. At Washington Avenue I came upon a big muskrat prowling in the grass along the sidewalk. I started toward it when it suddenly wheeled and pounced upon me. My hair stuck out immediately as if suddenly charged with a strong current of electricity, and to protect myself I thrust my open umbrella in front of the on-coming rodent and kept it away from my feet, but it managed to tear a hole or two in my umbrella. . . .” The italics are mine. There seems to be little doubt that the move made toward the animal at close quarters was what provoked the attack.
AGENCIES DESTRUCTIVE OR HARMFUL TO MUSKRATS

Natural Enemies.—Among the animals which are believed to prey more or less upon the muskrat in this state are minks, foxes, weasels, otters, Cooper's hawks, marsh hawks, and great horned owls. Little seems to be known as to the extent of the depredations of these enemies, singly or collectively.

According to Cram ('23, p. 22) the mink "seems to prefer muskrat flesh to any other food, and hunts and kills muskrats, both old and young, at every season of the year." Also in the region covered by these notes the trappers generally agreed that where the mink occurred in fair numbers it was the most important enemy of the muskrat; but in a number of localities this flesh-eater was said not to be very common. In the Cazenovia region I was told that the mink would occasionally take a trapped muskrat, but that the total of such loss was unimportant; yet from accounts given the mink seemed to be more common in this territory than in other parts visited. As a general rule I found that those who trapped muskrats on a considerable scale, that is, in the larger marshes and swamps, were of the view that the mink was very destructive to the muskrats and believed that there should be an open season on the animal at all times in order to prevent it from becoming plentiful. Its fur value was considered insufficient to compensate for its destructiveness to the muskrats. In the Montezuma Marshes, according to S. C. Vanderbilt and George Taylor, the mink is not now so common as formerly.

Little information of definite character was obtained in regard to the extent to which raptorial birds prey upon the muskrat in this region. Undoubtedly it varies with the season, year, and locality. The spring and fall migration periods, when there is a considerable movement of birds of prey and when, too, the cover in the marshes and swamps is less dense, are probably the seasons of greatest danger to the muskrat from this source. In the midst of winter the rats do not venture out upon the surface generally and consequently are not much exposed to hungry foes. In the summer time their enemies have many other sources to draw from, and cover and means of escape are then at their best. During the latter part of August I several times saw marsh hawks flying low over the marshes, and in June a nest with eggs of one was found in a muskrat marsh near Little York. Undoubtedly the young
muskrats especially suffer occasional attacks from this and the other species of raptors, although Eaton ('14, p. 72) writes that most of the marsh hawks from the Montezuma swamp whose stomachs he had examined contained nothing but smaller birds and batrachians, while those from the more cultivated areas contained mostly mice and insects. Prof. A. G. Whitney, of the New York State College of Forestry, informs me that about the first of April of last year, in Cicero Swamp, near Syracuse, he saw a marsh hawk fly up from beside the body of a muskrat which had been taken by a trapper and the pelt removed. The hawk seemed about to feed upon it when interrupted. I have the record of only one Cooper's hawk and one sharp-shinned hawk seen over the marshes visited, the latter species on November 24.

Among less generally recognized enemies of the muskrat are the pickerel and the snapping turtle. A large pickerel would probably have no difficulty in swallowing a young muskrat of the size it is when it ventures out for the first time. The power of the average snapping turtle is well known, and indeed Abbott ('90, p. 269) testifies, "I have known a quite small snapper to seize a full-grown muskrat by a hind leg and drag it into deep water, where I suppose it was held until drowned."

Mr. B. A. Scudder has kindly furnished me the following note in regard to an incident witnessed by him, which I quote herewith. "While in charge of wild life conservation on a large private estate in Connecticut during the years 1916 and 1917, excellent opportunities were afforded me to study the food habits of the common snapping turtle (Chelydra serpentina). A large lake on the property, partly natural, but which had been enlarged by the construction of a dam at its outlet, fairly swarmed with these reptiles.

"One of my first duties consisted in reducing the numbers of this voracious reptile, destructive alike to fish and bird life.

"Early in the month of August, 1916, while paddling in a canoe along the shores of this lake where the water was a foot or possibly a foot and a half in depth, I saw on the bottom of the lake a snapping turtle weighing approximately twenty pounds tearing away at the body of an adult muskrat. While I did not attempt to remove the muskrat, the clearness of the water and its shallow depth enabled me to note that the muskrat had been freshly killed, and evidently by the turtle then engaged in feeding upon its body."

During the time in the field (1923) I found only two musk-
These young muskrats lay in open patches in the cat-tail marsh where they doubtless had been engaged in feeding; one within a few feet of a stream, the other several rods from open water. They were found in the morning and were in perfectly fresh condition, having evidently been killed during the night or early morning hours. Of one of these only the posterior half of the body and the greater part of the skull remained, the latter picked clean and the brains devoured; of the other, only a part of the tail had been eaten, but the abdomen had been torn open and part of the intestine was protruding. I left this rat on a log nearby and the next morning it had disappeared.

Spring Floods.—During the high water of spring, so trappers informed me, muskrat houses or dens in some of the marshes and swamps, but especially those bordering the streams, are often flooded and the occupants are forced to seek temporary quarters elsewhere. In the big marshes, on the other hand, it was said that the water level usually does not rise sufficiently to flood the lodges. However, if there are helpless young in the houses that are flooded at such times a certain number of them are quite sure to perish. S. C. Vanderbilt informed me that he had on occasions of this kind actually seen females swim out from houses that were being inundated, with small young clinging to their teats. The mother muskrat would sometimes get a hundred feet or more from the lodge before the young would all have dropped off, one after another, whereupon she would turn about, pick them up with her teeth and transport them, one at a time, to a place of safety. As an example of flood difficulties of muskrats Butler ('85, p. 1049), for Indiana, gives the following very interesting and detailed account:

"Mr. E. R. Quick relates one instance when, during a flood, July 3d, 1873, he saw a female muskrat swimming along in the muddy water with five young, about the size of a full-grown house rat, holding on the tufts of the mother’s hair with their mouths, while she made her way slowly and cautiously along the shore; carefully she avoided all obstructions and swift water, seeking a shelter for her precious tow. Some boyish enemy, preceiving the homeless family, threw a stone which struck the mother and scattered the young. The latter apparently knew nothing of diving and but little of swimming; with difficulty they gained the shore,
and while seeking the protection of some reeds a part of them were caught.”

**Drought.**—Exceptionally dry seasons may have more or less serious consequences for the muskrats where ponds and streams dry up or are left too shallow for the winter requirements. At such times the animals may roam about seeking better locations, and in so doing necessarily become exposed to an unusual extent to enemies that prey upon them. Mr. Vanderbilt told that at such times, too, in their search for water, they often get into open wells and there perish, as many as five or six having sometimes been found in a single well.

**Unfavorable Winters.**—I learned of no particular winter difficulties that had been known to affect muskrats generally in this state. In more northern parts of the continent, however, serious conditions are reported to occur in certain winters although their exact nature is not known. Thus Henderson (’23, p. 265) mentions a high winter death rate among the muskrats of the Peace River District of Canada, giving as an instance the winter of 1915-16, when there were “thousands” in the fall, yet in the spring after prolonged hunting he was able to secure less than a hundred skins. Seton (’10, p. 555) and others mention that sometimes in certain very cold periods muskrats may become sealed up in their houses and then prey on each other.

As a usual thing the winter conditions in the marshes and swamps of New York must be of very favorable nature to the muskrats. The surface in these habitats is generally covered with a dense mat of flag and other vegetation, and does not become frozen to any depth before it receives a blanket of snow as still further protection. Under this cover the deeper waterways of the muskrats remain open and the animals are able to move about freely. With an abundant food supply at hand in the form of underground stems and root-stalks these muskrats are much better off than those inhabiting streams and ponds of higher ground. Occasionally, however, individuals may get out to the surface from their houses or tunnels and then be unable to find their way back again. Mr. Vanderbilt told of finding one such individual in a little den in a snowbank on a hillside two or three hundred yards from the marsh.

**Marsh Fires.**—Occasionally in late fall or early spring a marsh is swept by fire and it is believed that the mortality among the muskrats may then be considerable. Mr. Vanderbilt said that after
such fires he had taken many muskrats whose fur had been singed off short; one season he took about forty. While the pelts of these rats usually would be found uninjured the fur of course was worthless.

**Disease.**—Little seems to be known concerning diseases among muskrats although they doubtless occur. Now and again one finds a news item of a paragraph or two telling of an epidemic among muskrats in some remote section of the country, but such reports are so vague and lacking in details that it is difficult to separate possible facts from mere fiction. More recently there came a report from the Yukon (Fur Trade Review, Sept., 1923) of great destruction of muskrats in that and other regions of Northern Canada, supposedly due to some epidemic of unknown nature. Thousands of muskrat carcasses were said to have been found in the bogs and tundras.

According to S. C. Vanderbilt, individual muskrats in his region of the Montezuma Marsh are sometimes afflicted with a lump or swelling in the throat region. This lump, he said, may be no larger than a hazelnut or it may be nearly as large as a man's fist, interfering considerably with the movements of the animal. It is situated just in front of the forelegs, and is full of pus or matter which has a bad odor. He did not believe the lumps due to infection of wounds received by the animals in fighting among themselves. In a certain area of his marsh he had known such rats to be rather common while absent in others. Diseased individuals would be seen moping about, looking listless and dazed, and displaying a tendency to work their way towards the outer edges of the marsh. The afflicted animals usually died.

Other trappers told of taking male muskrats with festering sores about the anterior parts of the body especially, which, since these rats were taken in the spring trapping, apparently were due to combats of the breeding season. It is well known that muskrats in traps are often attacked by their own kind, and the skin so lacerated by the sharp teeth as to be rendered practically worthless.

On August 6, near Golah, under a small bush within a few feet of a little stream, I discovered a muskrat lying as if dead or asleep. Picking it up by the tail I found that it was alive but evidently dying. There were no outward signs of injury and the animal was in normal condition of flesh. When carried to the creek and placed in the water it pawed feebly with its fore feet and headed
back towards the shore. It seemed unable to move either its hind legs or its tail. The rat was an adult male.

Parasites.—The muskrat is the host for a considerable number of parasitic worms belonging to the so-called flat-worm (Platyhelminthes) and the round-worm (Nemathelminthes) groups. Most of these parasites have been described by Barker (’15, ’16) as new species. They are mainly intestinal but the author mentioned (’16a) quotes Dr. A. J. Smith as having in his possession “a specimen of liver of the muskrat which is tremendously enlarged and riddled with Cysticercus fasciolaris, the larval form of the tapeworm Taenia crassicolliis which is of frequent occurrence in the intestine of the cat. Cysts of the same kind have been reported for the muskrat by Stiles and Hassall (’94), and by Linton (’15) who found it both in the liver and in the omentum.

A suggestion as to the frequency of infestation among the muskrats is found in the following statement by Barker (15a, p. 570): “In forty-two muskrats, 881 parasites were found. No parasites were found in four muskrats, three harbored cestodes, trematodes and nematodes and three harbored a single species of trematodes.”

The following is a list of parasites of the muskrat, based on Barker (’15, ’16a):

**Round-Worms**

Trematodes:
- *Catatropis filamentis*; in duodenum.
- *Cladorchis (Stichorchis) subtriquetrum*—Amphistomum subtriquetrum (Leidy, 1888), believed by Barker to be *Wardius zibethicus*.
- *Echinostomum coalitum*; in duodenum.
- *Echinostomum echinatum*; in duodenum.
- *Echinostomum callawayensis*; in duodenum.
- *Echinostomum armigerum*; in duodenum.
- *Echinoparyphium contiguum*; in duodenum.
- *Hemistomum craterum*; in duodenum and cecum.
- *Monostomum affine* (Leidy, 1858), believed by Barker to be a species of *Notocotyle*.
- *Notocotyle quingueserial*; “most abundant parasite found; generally occurs in cecum”—Barker.
- *Nudacotyle novicia*; “from the intestine”—Barker.
- *Plagiorchis proximus*; in duodenum.
- *Wardius zibethicus*; “generally found in cecum.”
Nematodes;
Capilaria ransonia; in duodenum.
Trichurus opaca; in duodenum.
Trichostrongylus fiberius; in duodenum and cecum.

Flat-Worms
Cestodes;
Anomataenia telecopica; in duodenum.
Cysticercus fasciolaris; in liver and omentum.
Hymenolepis evaginata; in duodenum.

Regarding Echinostomum (Distomum) echinatum, Leidy ('04, p. 211) suggests that muskrats become infested with this parasite in the same manner as do ducks and other water birds which also are hosts for the mature worm. In the larval state the worm lives in freshwater snails, which according to Leidy, are eaten by the muskrat.

Evermann and Clark remark ('20, p. 467) that the muskrat “has long been suspected” of being the intermediate host of certain parasites which induce pearl formation in freshwater mussels, and to which Monostomum affine, listed above, is said by them to be closely related.

RELATIONS TO ASSOCIATED BIRDS AND REPTILES

Birds Frequenting Muskrat Habitats.—Reference has already been made to bird enemies of the muskrat, and the latter’s occasional taste for fish, amphibian and turtle flesh. Opposed to these habitual or more or less sporadic predatory relations are certain others that apparently are of more peaceful character. It is well known, for example, that a number of water birds occasionally make use of old muskrat houses as nesting sites. Among these is the black tern which not infrequently makes its nest in such piles of débris, and Rockwell ('11, pp. 123, 194) describes nests of mallard, canvasback, and ruddy duck found on muskrat houses in Colorado. Samuel Hearne (quoted by Godman, '31, p. 61) tells of the tops of muskrat houses being favorite nesting places for wild geese; and there are probably other species. Friendly as all these associations appear on the surface to be, and on the birds’ part doubtless are, there lurks a suspicion that the muskrat on its
side may not be entirely innocent of attacks upon the young of the 
various bird species that nest on the marsh floor or lead their 
broods about the watercourses in its haunts. It has been accused 
of seizing young ducks by the feet and drowning them, and 
Abbott ('90, pp. 188, 269) says that any young of the green heron 
that may fall to the ground, if found by the muskrat, are quickly 
dispatched despite any defense the parent bird may offer. Perhaps 
the young of other marsh birds meet a like fate more often than 
is generally supposed.

In the marshes of western New York, soras, Virginia rails, and 
Florida gallinules are common to abundant. Numerous nests of 
these birds, now vacated, were found among the cat-tails, and 
often within a few feet only of muskrat houses or surface trails. 
In the Savannah region of the Montezuma Marsh newly hatched 
young of the black tern were found in an open area amidst the flag 
where the muskrats were plentiful and very active in their digging 
operations. The young of the Florida gallinule and of the rails 
mentioned, of practically all sizes, were seen in many other musk-
rat-inhabited localities, and in the streams and pools occurred 
broods of wood ducks and black ducks. Nests of the least bittern, 
both with eggs and with newly hatched young, were also found. 
The great blue heron, the black-crowned night heron, and the 
bittern were common in a number of localities; the long-billed 
marsh wren was abundant. The soras and Virginia rails were 
several times observed feeding along newly dug canals of the 
muskrat, where they doubtless found more or less food matter 
exposed.

The Water Snake as a Tenant of Muskrat Dens.—The water-
snake Tropidonotus (Natrix) fasciatus sipedon (Ditmars, '08, p. 
251) is abundant in the marsh and swamp habitats. It makes 
free use of the muskrat houses for basking places, and in the cat-
tails on one occasion I saw one of these snakes slide into the plunge-
hole of a muskrat burrow beside which it was lying. The musk-
rat house is also sometimes used by the water snake as a retreat 
during its sloughing period. In the late afternoon of August 23, 
as I cautiously approached a muskrat house in a wet marsh, three of 
these snakes, which were lying on the top of it, disappeared appar-
tently into the interior of the structure, at different points. Upon 
closer examination I found three more or less circular holes, each 
of which led into an irregular but smooth-floor ed cavity in the wall 
of the house, a couple of inches below the surface. These evidently
were the dens of the snakes, and other openings led from these spaces either into the interior of the house or through the body of the structure to the other side, where I saw one of the snakes emerge at the base. Shortly thereafter, while pushing aside the outer material of a neighboring house I discovered another water snake lying coiled up in a similar den. This snake was about to shed its skin; being unable to see, it made but feeble attempts to escape.

While the water snake is abundant in many muskrat marshes it is not known to feed upon warm-blooded prey, and its relations to the muskrat are therefore probably entirely harmless.

**Turtles Nesting in Muskrat Houses.**—In marshes or swamps where suitable ground for nesting is wanting or distant, muskrat houses, both occupied and unoccupied, serve as nesting places for the snapping turtle (*Chelydra serpentina*), and also, though I believe less commonly, for the painted terrapin (*Chrysemys marginata*). Doubtless in other places other species of turtles occasionally use the lodges for the same purpose, but in the localities in question the two mentioned are the common forms. July 7, a nest of the snapping turtle containing 22 eggs was found in the wall of a tenanted muskrat house along Black Creek, in the region of Meridian; July 15, two sets of 21 eggs each were found in an unoccupied house of the last season’s construction, and on August 20, a batch of 32 eggs was uncovered in the mass of a much older one, in the Montezuma Marsh near Savannah (figs. 85, 86). In the first mentioned instance the eggs lay about four inches below the surface of the top of the house, and separated by about the same thickness of material from the occupied chamber. The two nests of July 15 were buried about four inches below the surface and eighteen inches apart. The third set lay seven inches below the surface. In all these cases the house material at the depth at which the eggs were imbedded was moist, and an egg examined in each instance showed incubation to be proceeding successfully.

On July 15 a batch of 3 eggs, presumably of *Chrysemys marginata*, was found in a flattened mass of rubbish that once had been a muskrat house, in another part of the same marsh.

The finding of the eggs of the snapper and the terrapin in muskrat houses has been previously mentioned by Rhoads (’03, p. 106).

Clark and Southall (’19, p. 5) have told of the common habit
Fig. 84. Another system of channels newly dug beside a last season's muskrat house which is seen at upper left. Three other similar channel systems were noted about this house. Montezuma Marsh, Aug. 18.

Fig. 85. Two nests of the snapping turtle exposed in an old muskrat house. Montezuma Marsh, July 15.
Fig. 86. Nearer view of one of the snapping turtle nests shown in figure 85.

Fig. 87. Part of an area in Montezuma Marsh in which it was claimed that the cat-tail root system had been seriously damaged by muskrats during the preceding winter. Recently dried up pool at left. Scattering of new flag springing up through dense cover of old flag. Aug. 1.
of the snapping turtle of hibernating in muskrat burrows in the vicinity of Muscatine, Iowa. It had been reported to them that as many as five tons of turtles had been taken from muskrat burrows in one season. In one instance twenty-six individuals had been found in one burrow, and from another burrow 1,420 pounds of turtles had been secured.

**DAMAGE CAUSED BY MUSKRATS**

While muskrats by their burrowing habits have been known to cause considerable damage to dikes, railroad embankments, dams, etc., I heard of no complaints of such damage in the localities visited, at the present time. Mr. Ray Phares, one of the section men on the Syracuse and Rome Branch of the Rome, Watertown and Ogdensburg Railway, told me that where the tracks cross the Cicero Marsh, some years ago, before the roadbed had been widened, the muskrats frequently burrowed into the embankment as far as the first rail, causing cave-ins. After the roadbed was widened, however, no more trouble was experienced. The animals continued to burrow more or less but were apparently unable to penetrate far enough to do any harm. This was due principally, Mr. Phares thought, to the fact that cinders now began to be used as filling material and this tended to discourage the digging operations of the animals because of the constant caving in of their tunnels.

One or two farmers told of occasional raids on carrot patches which had been close to muskrat marshes, and of instances where ears of corn in the shock had been cut off and carried away. Such cases had, however, been infrequent, and one man said that keeping the grass moved between his field and the marsh was usually sufficient to prevent visits from the muskrats.

That the muskrat if fairly plentiful is capable of doing such extensive damage to the cat-tail flag in the marshes as to require a number of seasons for it to recover, was a charge made by Mr. S. C. Vanderbilt. An area which he pointed out to me as one of the most conspicuous examples of such destructive work was a four- or five-acre patch immediately adjoining the area referred to previously under the head of spacing. All this part of the marsh it will be recalled, had been protected from trapping for a few seasons for the maintenance of breeding stock. Vanderbilt's contention was that the shortness of the trapping season prevented him from taking a sufficient number of muskrats in this area to
keep their numbers within proper bounds; that trapping conditions here were usually not favorable after the trapping season opened in the fall, and did not become so until after the season closed in the spring. During the winter, he maintained, the muskrats destroyed the root system on such an extensive scale that no flag appeared the following summer.

On July 23, when I first visited this area, I found it for the most part covered with a dense mat of lodged flag of the previous season (figs. 71, 87), with a scant sprinkling of new growth. Adjoining the denuded area and bordering Black Creek, which flows through this marsh, was a luxuriant stand of the present season’s flag, among which occupied muskrat houses were just as plentiful as in the denuded portion. Upon my return to this marsh on August 16 I found that a considerable amount of new flag had appeared over the bare patches, and the muskrats were busy nightly feeding upon these new shoots.

After an examination of this and other areas where similar conditions, said to be due to the same cause, existed, I am by no means satisfied that the devastation had been caused entirely or even largely by the muskrats. In digging up root-stalks and underground stems at random in a number of places in these areas I found that new shoots had started in every case; and the generous sprinkling of new sprouts which had made their appearance in the latter part of the summer was further evidence that the root system was alive and sound. Moreover, if the roots had been destroyed by the muskrats to the extent necessary to have caused the conditions as charged, one might have expected to find them generally undermined and destroyed. But this was not the case. While one would frequently step through into underground tunnels, there was no indication that tunnelling had been any more extensive here than in adjoining areas which had a normal stand of flag. It is possible that the destruction might have been brought about if the muskrats had concentrated their efforts on this area when the new flag first started to grow in the spring, and had devoured the young shoots as fast as they appeared; but it is my own opinion that the delay—for such it would seem to be—in the growth of the cat-tails here may be attributed in considerable part to another cause, namely, too much water in the spring and early part of the summer. The many shallow, flagless pools found in the same areas, persisting year after year, suggest at least such a possibility. Although many of these pools
dry up in the latter part of the summer they do not become covered with a growth of cat-tails, presumably because it is too late in the season. Indeed the more or less flagless areas mentioned may represent the beginnings of such open-water pools, which, it would seem, must be more or less dependent upon seasonal conditions for their duration. However, so far as any damages to the cat-tail flag may be due to muskrats, they are obviously preventable by rotation of closed and open territory or by concentrated trapping in the over-populated parts during the regular open season. It now seems to be a case merely of over-protection in that particular locality.

**STATUS OF THE MUSKRAT IN THE PRINCIPAL LOCALITIES EXAMINED**

On the basis of my own observations and the statements of the principal trappers and fur buyers, the present status as to habitats and numbers of the muskrat may be summarized for the localities named, as follows.

*Big Bay Swamp and Cicero Marsh.*—These are excellent muskrat habitats which each year yield a good return to the trappers. Their productiveness is in large measure due to the well regulated system followed by the trappers in the areas controlled by them.

*Cazenovia Region.*—There are no extensive swamps or marshes here, most of the trapping being done on streams, lakes and ponds. This territory, I was informed, had been over-trapped so that muskrats are not nearly so plentiful as the natural conditions warrant.

*Homer Region.*—Muskrats are now scarce along the creeks of this vicinity. Mr. Fred Newcomb, local fur buyer, gave as the reason the excessive trapping that was done during the period of the war and following. Men and boys who trapped took full advantage of the high prices of that period and kept after the animals relentlessly. If a trapper could get but one muskrat a day he would still be earning good wages, and some trappers would bring in only four or five skins in a week. Mr. Newcomb believed that a closed season on the muskrat for two years would be beneficial.

*Little York.*—Conditions here were similar to those of the Homer region, and due to the same causes. Mr. Frank Pender declared that only in the past year has the muskrat shown signs of recovering from the effects of over-trapping.
Kirkville.—In this district muskrat trapping is done in the old Erie canal, Green Lake, Chittenango Creek, Cowaselong Creek, and on what is known locally as Douglas ditch. Along the old canal occur many patches of cat-tails and other marsh vegetation offering suitable habitat, and signs of the muskrat were common so far as my observations extended. Farmers in the neighborhood told of a considerable number of muskrats having been taken each season, in the aggregate; but I was informed that the two principal trappers of this region secured only about 220 muskrats during the past season, and since their trapping grounds included a large area this figure would seem to show that the species is not plentiful in that district.

Meridian.—A great deal of excellent muskrat habitat is found in the territory south and southeast of Meridian, in such localities as Otter Lake, Parker's Pond, Black Creek, Mud Pond and many other marsh- and swamp-bordered waters in this region. From what was seen, however, it was clear that in all these localities the numbers of muskrats were far below the capacity of the habitats to support.

Golah.—This district embraces the junction of the Honeoye River with the Genesee. Log Pond in this vicinity was the most suitable muskrat locality seen, but its possibilities have largely been destroyed by pasturing. A few muskrats were found to occur along the Genesee and Honeoye Rivers and on small tributaries. On the tributary streams especially, outside pasture areas, some fairly good muskrat conditions were found, and signs of the animals were quite common; but according to local residents the best muskrat grounds here also have been greatly depleted in recent years by the thoroughness of the trappers.

Byron.—Conditions here are very similar to those about Golah. A certain number of muskrats are found on all the streams, and some trapping is done by the farmers' boys; but long stretches of the creeks are pastured and the grass is cropped close clear to their edges. Here and there sedgy fringes occur, but on the whole there is not much to encourage a considerable muskrat population.

Montezuma Marsh.—The portions of this vast marsh examined were its northeastern limb or extention, from a point about two miles southwest of Montezuma, northward around Howland Island; and the northwestern limb, with its ramifications, for seven or eight miles of its north and south extent in the vicinity of Savannah.
The main body of the Montezuma marsh, according to S. C. Vanderbilt, does not now produce more than about one-tenth of its former quantity of muskrat fur. This is a result partly of drainage and partly of disregard for conservative methods of trapping.

Of the two extensions of the marsh personally examined by me, the more eastern one was found to contain a large total area of excellent muskrat habitat, but much of the broad zone of cat-tails bordering the rivers of this territory, namely the Seneca and the Clyde, was too well drained to be suitable for muskrats except on the stream borders. The great extent of shore line, however, can accommodate a large muskrat population. At present from all indications the numbers are relatively small.

The more western extension of the marsh, locally known as “the sink hole,” and the streams connected with it were the best-stocked muskrat territory met with. This was due in part to its very favorable natural conditions, but principally to the fact that much of this marsh was controlled by men who made muskrat trapping more of a business and who therefore had an eye to the maintenance of the supply. One of these trappers in particular appreciated the basic importance of conservative methods, keeping certain parts of his marsh entirely closed to trapping in order to ensure a permanent stock of breeding animals. This practice, combined with properly regulated trapping outside the protected areas, had given results of a very positive nature, apparent to any observer. The conditions here stood out in marked contrast to those in many other localities equally well adapted to muskrats but in which no attention to conservation had apparently been given.

**SOME GENERAL ECONOMIC CONSIDERATIONS**

The Muskrat as Human Food.—The use of muskrat flesh has not been given the consideration it deserves in many parts of the country, although it has long been known as a palatable human food. Lantz (‘10, p. 21) tells of its general use among the early colonists of this country who had learned the Indian method of cooking it, and of its extensive use in more recent years even among people of refined tastes. The chief markets for muskrat meat are in the large eastern cities, and Lantz (p. 22) mentions as an example that in February, 1907, a single dealer on Dock Street in Philadelphia sold about 3,000 muskrat carcasses a week. He states also that muskrat was said “to be a favorite dish at dinners given by church
societies in Delaware and Maryland, and annual muskrat banquets are a feature with certain gun clubs in the West. Those of Monroe (Mich.) Marsh Club have been celebrated for many years."

The prices for muskrat carcasses have been variable, ranging at different times and places from 10 or 15 cents to 25 cents apiece.

That muskrat flesh is desirable human food is attested by a number of writers, and if popular prejudice wears off it will doubtless in time come into general use in many places where it is now held in contempt. In some eastern markets it is said to retail under the name of "marsh rabbit," but without attempt to conceal its true nature. In other places more fanciful names are bestowed upon it and the disguise may thus be more complete and the psychological effect less to be dreaded, without detracting in the least from the flavor. Shiras ('21, p. 202) states that "For years it has been served, highly seasoned and flavored, under the name of 'Maryland terrapin' without exciting any suspicion on the part of connoisseurs, who pay a fancy price for it."

Any unfavorable opinions as to the flavor of muskrat meat, according to Lantz (p. 23), probably are due to carelessness in skinning the animal or to lack of proper knowledge or skill in cooking the meat. In skinning, care should be taken not to allow the hair side of the skin to come in contact with the flesh, and not to cut into the musk glands. These glands can be removed along with the skin, and any other subcutaneous glands should be trimmed from the flesh.

The following recipes for preparing muskrat for the table are quoted by Lantz (p. 23) and are worth repeating here. The first is credited to Forest and Stream (Vol. 50, p. 368; 1898), the remaining three to George T. Bowen, caterer, of 440 West Biddle Street, Baltimore.

1. Soak the carcass over night in cold water or let it freeze in the open air. Cut in pieces ready to serve and place in a pot with a few slices of salt pork. Add water enough nearly to cover the meat and stew slowly until about dry—say, for an hour and a half. Pepper and salt to taste while cooking.

2. *Fried muskrat.* Wash the muskrat thoroughly and cut in quarters. Let it lie in salt water for an hour or more, then wash, dry with a cloth, and season. Dip the pieces in a prepared egg batter and dust them with flour or meal.

Place the lard in a frying pan and let it get hot. Then put in the muskrat and fry very slowly for an hour. Prepare a gravy
of milk, butter, flour, and parsley, and season to taste. After it thickens pour it over the cooked muskrat.

3. *Roast muskrat.* Wash the meat thoroughly, let it lie for an hour or more in salt water, and then wash again.

Put it in a pan with water, salt, pepper, butter, and a little onion; sprinkle flour over it, and baste it until it is thoroughly done.

4. *Stewed muskrat.* Wash the meat thoroughly, cut it in pieces, and let it lie in salt water for an hour. Then wash it again, put it in a sauce pan, and season with butter, salt and pepper to taste.

Let it simmer slowly, and when nearly done put parsley and a little chopped onion into it. When entirely done thicken with a gravy of flour and water, as for stewed chicken.

If the gamey flavor should be undesirable it is recommended that the meat be soaked over night in salt water.

**Possibilities of Increasing the Muskrat Fur Supply.**—In the early part of this paper reference was made to the great quantity of muskrat fur produced by New York State. The annual levies on the muskrat numbers have consequently been very heavy, and in many ways it may seem not a little remarkable that any of the animals remain at all. The main reason for their successful existence, as before stated, lies in the animal’s own fecundity, vigor, and high degree of adjustability to conditions as it finds them, and, last but not least, in the abundance of streams, lakes and ponds, marshes and swamps, canals and reservoirs with which this state is so generously provided. Having these important advantages the animal has succeeded in carrying on in an otherwise quite unequal struggle. Now, in our belated awakening to the desirability of increasing our yearly output of fur and of insuring a permanency of supply, these same natural advantages of both the animal and its habitat are at our disposal to be used toward the desired end.

While I can speak only of those parts of the state which I have actually visited, I believe it would be a fair statement to say that the suitable muskrat areas in New York State are not at the present time producing one-half as much of this kind of fur as their acreage and habitat conditions warrant; and probably not more than a third of the quantity that they could be made to produce with proper management and due attention to elementary principles of conservation, not by a few but by all who trap or own or control suitable territory. Evidence of the success of intelligent management is readily seen in territory of trappers who have followed such
a practice, but unfortunately their number is small. As before remarked it is usually the man who controls sufficient territory to trap on a large scale who is the better conservationist in a matter of this kind, since for him so much depends on it. Nevertheless the small-scale trapper would benefit proportionately by the same kind of methods. In many localities visited there was an abundant supply of all the material requirements of the muskrat, but the animals themselves were relatively few, and this for no other reason than that of excessive trapping. No areas had been set aside as sanctuaries or undisturbed propagation centers so that an adequate breeding stock could be maintained from year to year. The next year's supply was dependent entirely upon such individuals as by chance escaped the trap.

On the other hand there were many localities in which streams, ponds, or other waters having considerable possibilities for muskrats were rendered practically barren by pasturing; the grass was cropped short clear to the water's edge. It is true that muskrats occurred even here but they were few compared with what might have been the case had the banks been lined by dense growths of grass, sedge, shrubbery, and other vegetation. Examples of this kind of stream are shown in figures 48 and 50. In the foreground in the first may be seen a sedgy bay which under unpastured conditions would have furnished a good home site for at least one family of muskrats; and in fact the animals had had a den here in one of the larger hummocks, but it had been destroyed by the trampling of cattle. Long stretches of streams with similar conditions may be found in many other localities.

In marked contrast to these bare situations are the borders of unpastured streams which may be flanked by cultivated fields or hay lots, but with an intervening margin of wild grasses, weeds and shrubbery, as in figures 52 and 53. The increased signs of muskrat in places of this kind are immediately noticeable.

The argument will probably be advanced here that the stream borders are more valuable as pasture land than as a muskrat habitat. This may seriously be questioned. The amount of vegetation of important grazing value growing along the immediate stream margins is often negligible; but even at best it is a question whether the farmer would not receive greater returns from such stream margins if they were reserved as muskrat habitat than if used for grazing purposes. The portion of a stream necessary for watering purposes is relatively small and if what is not needed in this way
were fenced off and kept as a muskrat habitat, it probably would pay for the extra fencing required in two or three seasons if not less. Where more or less marshy shores occur the question of food supply would largely be solved in a season or two of undisturbed growth of the vegetation.

Much might be done in the matter of supplying the muskrats with food and in attracting the animals to the place by planting along the banks such vegetables as carrots, turnips, parsnips, pumpkins, wild rice, sweet corn and others. Quantities of apples which yearly go to waste along the roadsides could well be used as muskrat food. Henry Landers and J. L. Rogers, of Brewerton, informed me that they had sowed cat-tail seeds in suitable places in their trapping territory. The same could be done to advantage by many others who have similar grounds at their disposal. It would devolve upon each owner to study the possibilities of his own particular stream, pond, marsh, or swamp, and suit the measures to the conditions. In many situations small dams might profitably be built to create more favorable conditions of water.

Muskrat fur is quite certain to remain in popular esteem for years to come and to command a market price sufficient to make the question of conservation and management of the animals a matter worthy of serious thought. This receives added emphasis in the statement of the former secretary of the Raw Fur Dealers' Association, Mr. Joseph Buff, that at the present time about 70 per cent of all the money from raw furs in this state goes to the farmer and the farmer's boys.

**Local Conditions Affecting Trapping.**—Trapping laws on fur-bearing animals generally are, and should be, governed by a proper consideration of such important questions as the time of breeding of the species and the season when the skin is prime. While these two periods do not coincide they not infrequently overlap and are influenced more or less by latitude, altitude, and climatic differences. It is evident therefore that in any territory of sufficient extent and geographic diversity these physical differences will be reflected in some degree in the beginning or duration of the seasonal changes in the animals themselves. General recognition of these facts may be noted in the trapping laws of different regions of the country, and sometimes sections within the area of a single state may be sufficiently unlike to justify certain appropriate modifications of the trapping regulations.

Aside from such factors as are important for biological reasons,
however, there not infrequently are various conditions of purely local significance which have to do with the matter of gathering the fur crop. These are mentioned only because they are of more or less concern to many trappers, influencing or determining their attitudes toward trapping laws, and also because the problems of the trappers are not generally known or appreciated by the non-trapping public.

Neighboring trappers may sometimes entertain entirely different views as to what constitutes the proper kind of trapping regulations, merely because of diversity of individual interests, due largely or wholly to differences in the character of their respective muskrat grounds and the extent to which these are affected by seasonal weather conditions. One man finds the trapping conditions in his territory to be at their best in the early part of the open season, or even before the opening date; his neighbor finds that in his territory the break-up in the spring offers the best opportunity, and that usually the legal season closes before the best time has arrived. The first naturally is in favor of fall or early winter trapping, with an earlier opening date; the other favors spring trapping, with a later closing date. Neither may be able to do much trapping in the winter nor at the time when it can best be done by the other, and so would just as soon see these periods closed. This view need not necessarily be held for any unneighborly reasons, but merely because the very local nature of the case is frequently overlooked by the trapper, who is intent primarily upon his own personal interest.

Again, the man who makes a considerable business of trapping may feel that the season is too short and should be lengthened at both ends. He wants to be able to reap the fullest possible harvest from his muskrat grounds, but thinks that he cannot do so because his best periods of trapping are closed. When this trapper is one who by proper management maintains a well-stocked territory which can afford larger annual dividends than he can get within the open season as it is, he is inclined to consider the law unjust in that he is denied the fruits of his own efforts.

A somewhat different local aspect may be illustrated in the case of two trappers whose trapping grounds consisted mainly of swamp and marsh where, it was said, the stage of the water in the fall or winter season was insufficient to insure drowning of many of the muskrats caught at those times. These muskrats would twist their legs off and escape; and 90 per cent of such animals, they
estimated, would perish. For this reason a spring trapping season only was advocated by these men, and they would limit it to about forty days with the closing date not later than April 10. This closing time was suggested by their long experience that at about that date at the latest, pregnant females begin to be caught in numbers in their traps. Prior to that period only about 10 per cent of their catch consists of females, which is due principally to their practice of not setting traps near muskrat houses. In a case like this the motive is commendable and in the interests of conservation, yet here, too, the reference is mainly to a local situation.

The satisfied trapper is also heard. He may be one whose territory is of sufficient variety to permit him to carry on more or less trapping throughout the open season, or again, his trapping operations are not extensive enough for him to be greatly concerned one way or another. Less common is the view expressed by one trapper that, while the season usually closed before the watercourses in his locality opened up sufficiently for the most successful trapping, he considered this rather an advantage in that it tended to prevent too heavy a drain on the breeding stock.

Suggestions to Trappers for the Better Handling of Skins.—For the following suggestions I am indebted to Mr. Joseph E. Buff. They are matters of simple and easily corrected details which should be carefully heeded, since they involve but little extra effort on the part of the trapper and bring their own reward in increased returns from the sale of the skins. They are frequently disregarded by many trappers, through mere carelessness.

First to be guarded against is the temptation of taking skins before they are prime. This means at the same time careful observance of the law, but it frequently happens that many skins taken at the beginning of the open season are not yet prime, and in that case the trapper can well afford to delay his trapping operations for a time. In regard to prime skins the most important suggestion has to do with their stretching and drying. Too many trappers do not use stretching boards that are properly and evenly tapered, with the result that many skins are torn or split in the process of removal from the board. The boards should have the correct length, width and taper for the animal in question. For muskrats these dimensions should be: length 20 inches; width at the base 6 inches, tapering to the head and measuring 4.5 inches at the shoulder.
The boards should if possible be made of kiln-dried basswood, which will hold its shape. Such boards with proper care will last for years. Factory-made boards are preferable because of their uniformity.

Skins should never be dried on willow stretchers, for this method does not permit of uniform and thorough drying, and tainted skins are the result.

The animal should never be skinned from the head, as practiced by some trappers.

Attention to these small but important details, Mr. Buff declares, will add from 10 to 15 per cent to the income of the trapper from his furs.

**Musk rat Farm ing.**—So little has been done along the line of muskrat farming that the full possibilities of this industry remain for the future to determine. The American Fox and Fur Farmer magazine for February, 1924, page 8, in a quotation from the Hunter-Trader-Trapper, states that "There are probably less than thirty muskrat farmers in the United States, and while the sporting journals carry advertisements of rats for sale, there were very few orders filled this last spring.

"... Aside from the Michigan breeders there is a muskrat industry in Ohio, one in Pennsylvania and one in Connecticut. By industry is meant one individual farmer." A well established colony of one Michigan farm is said now to have about 125 muskrats.

While muskrats have been found to thrive "and breed in very narrow quarters," according to Lantz (p. 16), nevertheless, as suggested by that author, raising the animals in this way on a commercial scale is not to be advised. Where the range is ample and the natural conditions are suitable there is probably no method of muskrat farming superior to that of the preserve. The question here is largely one of guarding against poaching, and of maintaining a sufficient breeding stock. Food and water supply furnish no problems, the animals are self-supporting, and fencing is usually not necessary so long as their needs are provided for. Where muskrat areas of this sort are owned or controlled by different individuals who cannot agree to cooperate for the common interest, it may be necessary to establish fences; yet in such marshes and swamps as occur in many sections of New York the initial outlay and the cost of upkeep of effective fences would doubtless be considerable. Where streams flow through these marshes or swamps, as is often the case, the difficulty would be
much increased owing to the depth of the ooze and to the occurrence of an annual flood stage. Because of these various difficulties the least expensive method in such cases would be for the persons concerned to enter into a mutual agreement and then respect each other's rights. The same applies of course in general to the streams outside of marshes and swamps, although here the difficulties as a rule may be much less. In situations where the object of a fence would be merely that of retaining the animals it might be dispensed with entirely, and a sufficiently large stock encouraged to remain by means of a plentiful supply of food, water and other requirements of comfortable existence.

In the case of smaller ponds or patches of marsh it may be necessary to enclose them entirely in order to guard against the migration of part of the stock, if an attempt is to be made to maintain their numbers at maximum capacity. Fencing in such instances will involve fewer obstacles, the main points to be observed being to have the proper size of mesh, to set the fence well back from the water's edge, and to sink the wire far enough into the ground to prevent the animals from digging under. An overhang should always be provided, for muskrats have considerable climbing ability; this is more important than increased height of the fence. Under more restricted conditions of this sort it may become necessary or advisable to supplement the natural food supply with vegetables of various kinds, and to guard against the development of any unhealthful conditions that might arise as a result of excessive numbers for the size of the area.

Given the primary requirements of sufficient and permanent water supply, food, and proper habitat conditions, there is no reason why anyone so inclined may not, with due regard to precautionary measures already mentioned, successfully raise muskrats in enclosures. If the initial breeding stock is not already present, a few pairs may be purchased or taken in season from outside territory. The average trapper, farmer, or farmer’s boy in a region where muskrats are common, may be trusted to have sufficient practical knowledge of the animals and their requirements of life to make no very serious mistakes at the start, and he should have no hesitation in making experiments along this line of fur farming. Where so little is known that is supported by well established facts of experience and experiment, as is true in the case of intensive methods of muskrat farming, one man's judgment may be as good as another's. By commencing on a modest scale no grave
risks need be incurred in such an undertaking, and a surer foundation may be laid for later expansion.

The question will probably arise as to how many muskrats a given area may be expected to yield. This of course depends upon the character of the habitat, food supply, and the space requirements of the animals. In good marsh or swamp territory it would probably be conservative to say that five or six pairs of breeding animals to the acre, together with the season's progeny, could be supported during the summer months. Winter conditions would, however, have to be taken into consideration, and the number of muskrats that would need to be taken off as soon as the fur became prime in the early winter would largely be determined by the food supply available for that season. This might amount to a half or more of the entire stock; then, excepting the necessary breeding quota, the remainder could be trapped off in the early spring.

It is to be understood that the estimate of numbers made in the preceding paragraph refer to enclosed areas where the animals are prevented from distributing themselves at will. Whether such a number per acre would be a fair average for a larger area, as in the preserve method of muskrat farming where the animals would be free to roam as they pleased, is uncertain. Lantz ('17, p. 17) mentions by way of example a 1300-acre tract of marsh in Maryland on which, in two seasons, a total of over 12,000 muskrats was taken, or an average of more than 9 to the acre for the two-year period. This was the number of animals secured, but what fraction of the whole it represented is not known. Another instance given by the same author is that of a 5000-acre marsh near Lake Erie, under the control of an Ohio hunting club, where 5000 muskrats were taken in a single month. Whether trapping was continued is not stated, and here again, while the average per acre is low, we know nothing as to what percentage of the whole population the number taken represented. In certain protected marsh areas which I saw in this state, I am quite certain that an estimate of as many as ten breeding pairs to the acre is no exaggeration.

The idea of the high rate of increase of the muskrat is an attractive one, and doubtless it will be extensively used as an outstanding argument in behalf of muskrat farming. It is best to keep in mind, however, that even though the animals should possess this high breeding potential, many factors will enter in to keep the actual numbers of muskrats in a given area, open or enclosed, much below
The figures that one may arrive at by simple arithmetical computation. We may point to the rapid recovery of the muskrat population in some depleted localities as evidence of their remarkable fecundity; but by the same token we should expect other localities to be literally overflowing with the creatures. After all, it is not the number of young that are born each season that count, so much as the number that live to reproduce their kind. There is little doubt that muskrat farming can be developed into a successful industry; there is likewise little doubt that the surest way to success here, too, is by a gradual approach, without undue expectations of quick and fabulous returns.

**GENERAL SUMMARY AND CONCLUSIONS**

It has been pointed out in the foregoing pages that the muskrat is, all things considered, the foremost species of fur bearing animal in New York State at the present time. Its commercial standing makes it an important source of income to a large number of farmers and other country folk who engage to a greater or less extent in trapping. It constitutes an annual crop harvested from lands and waters which, except for this one item, are largely or wholly non-producing. It plays a large part, after leaving the trapper's hands, in the various branches—such as dyeing, dressing and manufacturing—of one of our biggest industries, an industry in which thousands of our citizens find employment.

The natural vigor and adjustability of the animal as a species make it one of the important possibilities in any program aiming to increase the fur supply. Little or nothing has as yet been done in a scientific way to determine what may be expected from intensive muskrat farming. But successful artificial propagation of the animal must depend to a great extent upon a previously acquired adequate body of facts in regard to its habits of life in the freedom of its normal environment.

While the total annual crop of muskrat fur produced by New York State is of imposing proportions, it is quite certain that it represents but a fraction of the quantity that the total area of suitable habitat is capable of producing in present conditions, with proper management.

Intensive trapping has depleted the supply in many localities and is curtailing the year-to-year numbers of breeding animals, so that the yearly increment for harvesting as fur is relatively small. To increase and maintain the margin of breeding stock is the first
essential in increasing our yearly output of fur, and this is a matter that rests largely with the trappers themselves. Although experiments in muskrat farming by intensive methods are to be encouraged wherever they may be properly undertaken, the more immediate, more certain, and less expensive results will come to the average trapper from careful observance of simple and well known laws of conservation, and the application of thoughtful management to the resource in such natural habitats as he may own or control, where the muskrat already exists and thrives.

From the purely scientific viewpoint the muskrat offers a no less interesting object for study of instincts and behavior than does the more renowned beaver; the habits of the two are in most respects very similar. We have as yet little knowledge of an exact nature in regard to some of the most important phases of the life history of the muskrat, such as, e.g., its reproductive capacity under varying conditions; and in regard to many of its habits and its relations to its environment a great deal still remains to be learned.

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A CONSTRUCTIVE FUR PROGRAM

The present Bulletin is devoted to a rather intensive but preliminary study of the muskrat, the most important fur-bearing animal in the State. This is the continuation of the original policy of the Roosevelt Wild Life Station to study fur-bearing animals as a part of its effort to help make non-agricultural lands productive. The raw furs of the State produce each year under present conditions about one million dollars, and there is every reason to believe that this amount could be increased very greatly if intensive research were conducted on these animals, including studies of their food, breeding habits, diseases and enemies, and leading to the discovery of methods of increasing their numbers, particularly by extensive or preserve methods, which are particularly appropriate for waste lands.

The leading native fur-bearing animals of the State are, first of all, the muskrat, followed by the raccoon and skunk, and in recent years, the beaver. Of course there are other species which are today of minor significance but which might well be made much more important, just as the status of the beaver has been changed by years of protection under the preserve method. The fisher, marten and otter today lead a precarious existence, and need prolonged protection and careful study in order to be restored to their rightful place in a constructive fur program.

THE PERMANENCE OF THE FUR INDUSTRY

The permanence and stability of the fur industry depends ultimately upon a sustained supply of raw furs, and the more of these that can be produced here in the State as a home industry, the better. New York is particularly well located for the production of valuable furs. There is not only about half the State, or about 15,000,000 acres, which is non-agricultural land, and is therefore at present relatively wild and unproductive, which nevertheless may be made to produce a valuable crop of fur, but in addition we have a favorable climate and a superior quality of wild fur. This is particularly true of the muskrat.

The rural districts are much influenced by the annual revenue derived from the raw fur crop, which comes in during the fall and winter season. At the same time the fur manufacturers in the city
must have this raw material for their industry. Thus the rural and
urban interests here supplement each other, and both are mutually
concerned in a fur conservation policy.

The essence of the conservation of fur-bearing animals consists
in maintaining a reasonable amount of breeding stock, and harvest-
ing each year the normal increase and surplus. There is no more
reason for exhausting this valuable breeding stock than there is for
killing off an excessive number of the breeding domestic animals,
fish, or game. Such a method only depletes the capital stock of the
industry and undermines its prosperity and permanence.

THE LEADERSHIP OF NEW YORK IN FUR
CONSERVATION

New York State holds a very strategic position in the conservation
of fur-bearing animals. Not only are the laws concerning their con-
servation considerably above the average of those in many other
states but there are leaders in the fur industry, including raw fur
dealers, and the manufacturers, who are alert not only to the desir-
ability, but to the absolute necessity of conservation methods. Fur-
thermore, New York City is the center of this industry for the world;
and with this concentration there have also developed broad views
of the relation of the fur industry to permanent conservation policies.
Leaders in the fur industry estimate that the annual financial turn-
over of the industry reaches about one billion dollars. Its prosperity
in New York City is thus not dependent upon the raw fur products
of this State alone but mainly upon the raw material and the general
welfare of the whole industry. Therefore any contribution which
the Roosevelt Wild Life Station may make to constructive fur
conservation policies is not simply of local State interest but is of
value to the industry as a whole. Furthermore, the Station's activi-
ties and investigations are not restricted by law to this State but
may and have been conducted elsewhere, as in the Rocky Mountains.

However, before any comprehensive program for the conserva-
tion of fur-bearing animals can be carried out in a manner com-
mensurate with the importance of the industry to the State, it will
be necessary for the Roosevelt Wild Life Station to acquire addi-
tional facilities. In the past the Station has been dependent largely
on gifts of funds and expert services to carry out its investigations,
as in the Adirondacks, in Estes Park and in the Yellowstone on the
beaver; and before extensive experimental studies can be made,
tracts of land, together with a permanent staff, must be acquired,
and adequate funds for publication will have to be provided.
THE ROOSEVELT WILD LIFE MEMORIAL

As a State Memorial

The State of New York is the trustee of this wild life Memorial to Theodore Roosevelt. The New York State College of Forestry at Syracuse is a State institution supported solely by State funds, and the Roosevelt Wild Life Forest Experiment Station is a part of this institution. The Trustees are State officials. A legislative mandate instructed them as follows:

"To establish and conduct an experimental station to be known as 'Roosevelt Wild Life Forest Experiment Station,' in which there shall be maintained records of the results of the experiments and investigations made and research work accomplished; also a library of works, publications, papers and data having to do with wild life, together with means for practical illustration and demonstration, which library shall, at all reasonable hours, be open to the public." [Laws of New York, chapter 536. Became a law May 10, 1919.]

As a General Memorial

While this Memorial Station was founded by New York State, its functions are not limited solely to the State. The Trustees are further authorized to cooperate with other agencies, so that the work is by no means limited to the boundaries of the State or by State funds. Provision for this has been made by the law as follows:

"To enter into any contract necessary or appropriate for carrying out any of the purposes or objects of the College, including such as shall involve cooperation with any person, corporation or association or any department of the government of the State of New York or of the United States in laboratory, experimental, investigative or research work, and the acceptance from such person, corporation, association, or department of the State or Federal government of gifts or contributions of money, expert service, labor, materials, apparatus, appliances or other property in connection therewith." [Laws of New York, chapter 42. Became a law March 7, 1918.]

By these laws the Empire State has made provision to conduct forest wild life research upon a comprehensive basis, and on a plan as broad as that approved by Theodore Roosevelt himself.

Form of Bequest to the Roosevelt Wild Life Memorial

I hereby give and bequeath to the Roosevelt Wild Life Forest Experiment Station of The New York State College of Forestry at Syracuse, for wild life research, library, and for publication, the sum of ....................... , or the following books, lands, etc.
Map 1. Showing the chief localities examined in the region of Meridian and in the northeastern portion of Montezuma Marsh. (Traced from Weedsport quadrangle, U. S. Geological Survey topographic map, unnecessary details being omitted.)
Map 4. Portion of the northeastern limb of the Montezuma Marsh, locally known as the "Sink Hole," and other localities examined in the region of Savannah. (Traced from Clyde quadrangle, U. S. Geological Survey topographic map, unnecessary details being omitted.)
Map 4. Divisions of New York State based on the experience of Mr. Joseph E. Buff, Syracuse fur dealer and former Secretary of the Raw Fur Dealers' Association of New York, the dotted lines representing the boundaries of the sections furnishing the different sizes of muskrat skins indicated.
1. The Control of Blood-sucking Leeches, with an Account of the Leeches of Palisades Interstate Park........Dr. J. Percy Moore.
3. Acanthocephala from the Fishes of Oneida Lake, New York........
   Dr. Harley J. Van Cleave.
4. Current Station Notes..................................The Director and Editor.

1. The Ecology of the Plankton Algae in the Palisades Interstate Park,
   Including the Relation of Control Methods to Fish Culture......
   Dr. Gilbert M. Smith.

1. The Status of Fish Culture in Our Inland Public Waters, and the Role of Investigation in the Maintenance of Fish Resources......Dr. William C. Kendall.
2. Current Station Notes..................................The Director and Editor.

1. The Relation of Wild Life to the Public in National and State Parks........................................Dr. Charles C. Adams.
2. The Big Game Animals of Yellowstone National Park......................Edmund Heller.
3. The Food of Trout in Yellowstone National Park......................Dr. Richard A. Muttkowski.
4. Current Station Notes..................................The Director and Editor.

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