MUSKRAT

PRODUCTION AND MANAGEMENT

CIRCULAR 18

FISH AND WILDLIFE SERVICE

UNITED STATES DEPARTMENT OF THE INTERIOR

ABSTRACT

The muskrat, largely an inhabitant of low, submarginal lands unsuited to agriculture, is the Nation's greatest fur resource, and the trapping and handling of its pelts has developed into an important and valuable industry.

Despite a high reproductive rate and a remarkable ability to maintain itself year after year under unfavorable conditions, the muskrat is subject to cyclic fluctuations. Periodic reductions in its numbers create considerable apprehension in trappers and others concerned about its welfare, and result in many requests for information regarding it.

This circular gives facts on the biology and ecology of the muskrat, and discusses basic principles of marsh management that underlie practical muskrat production. The material is based on many years of research by the author and numerous other Federal and State workers, and on experiences and observations of many owners of marshes in commercial muskrat production, muskrat trappers, and fur dealers.

MUSKRAT

PRODUCTION AND MANAGEMENT

BY

HERBERT L. DOZIER

CIRCULAR 18

United States Department of the Interior, Oscar L. Chapman, *Secretary*
Fish and Wildlife Service, Albert M. Day, *Director*

UNITED STATES GOVERNMENT PRINTING OFFICE : 1953

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 20 cents

CONTENTS

Note.—Dr. Herbert Lawrence Dozier died December 4, 1951, after the manuscript of "Muskrat Production and Management" had been submitted for publication. Final review for publication was completed by Frank G. Ashbrook.

MUSKRAT PRODUCTION AND MANAGEMENT

The muskrat is the most valuable wild fur animal in the United States. Increasing use of muskrat for fur and meat makes it desirable to assure perpetuation of this animal as a natural resource. Although injurious in some localities, it is for the most part an inhabitant of places unsuited for agriculture. Muskrats multiply much more rapidly than other fur animals, and because of habitat and general habits, they are better fitted than most animals of this class to maintain their numbers under the protection given them.

The harvest of muskrats in this country is six or seven times that of any other species of fur animal. In the past 5 or 10 years the take of muskrat pelts has averaged 18,000,000 to 20,000,000 a year, compared with 3,000,000 opossum, 2,500,000 skunk, 1,500,000 raccoon, 900,000 fox, and 700,000 mink. In some years top northern muskrat pelts have brought $4 to $4.55 on the market, but they usually average about $2.50. Southern muskrat prices run much lower, from 50 cents to $1.75.

Investigations on the biology of the muskrat were conducted from 1931 to 1934 by Frank R. Smith, as a cooperative undertaking by the Bureau of Biological Survey (subsequently merged into the Fish and Wildlife Service), the University of Maryland, and the Maryland State Game and Inland Fish Commission, on the W. A. Gibbs marsh near Church Creek, Md., and later on the Blackwater National Wildlife Refuge, Cambridge, Md. In the fall of 1937 these studies were resumed by the author on a broader scale, covering research on extensive inland and coastal marsh areas in the eastern seaboard and Gulf States, and continued to 1951.

The author gratefully acknowledges the direction and helpful suggestions of Frank G. Ashbrook; the valued assistance of Charles E. Kellogg, William S. Heit, Robert W. Allen, Leonard M. Llewellyn, Merle H. Markley, Carl Rossy, and Solomon R. Willey; and critical review of parts of the manuscript by Richard E. Griffith, Francis M. Uhler, Shaler E. Aldous, and O. Lloyd Meehean.

DISTRIBUTION AND HABITS

General Characteristics

The muskrat is essentially an overgrown meadow mouse with fur, feet, and tail adapted to an aquatic existence. There are no readily apparent external differences between the sexes; adults range from 2 to 5 pounds in weight and reach an over-all length of about 24½ inches. The prominent, thick tail,

FIGURE 1.—Hind foot of the muskrat. Left, dorsal view; right, ventral view.

covered with small, scaly areas and strongly compressed laterally, is an efficient rudder for swimming. Long, sharp claws serve admirably for digging and defense (fig. 1). The large hind feet, which can be turned sidewise to reduce resistance when the muskrat is swimming, are not webbed but have fringes of short, stiff hairs that also help in swimming. The dense pelage is practically waterproof—the long, stiff, glistening brown guard hairs closely interspersed among the short, soft, and exceedingly dense, gray underfur.

The muskrat has four protruding, chisellike incisors to cut its food, and heavy molars to grind it (fig. 2). The incisors grow continuously and are gradually replaced when broken. By closing its lips tightly around the protruding incisors and blocking the small opening between them with its tongue (fig. 3), the muskrat can gnaw and dig loose root material under water. Short, bristlelike hairs cover the lips and protect them from sharp grasses or other rough food plants. A deep cleft between the upper and lower lips lets the muskrat open its mouth wide and carry large mouthfuls of food or nest-building materials.

A pair of highly developed scent, or musk, glands are located under the skin in the lower inguinal region (fig. 4). These yellowish glands, much larger in the male than in the female, appear roughened or corrugated. They give off a pungent, musky odor that is particularly strong during the breeding season and accounts for the name "muskrat." The old Cree name "musquash" is still used in Canada and in continental European fur markets.

Distribution and Habitat

Two distinct species are recognized: the Newfoundland muskrat (*Ondatra obscurus*) and the com-

FIGURE 2.—Lower and upper parts of muskrat skulls, showing incisors and grooved molars.

FIGURE 3.—Mouth of the muskrat. Above, subadult with mouth closed; below, adult with mouth open revealing the cleft, hairy lips and tongue.

mon eastern muskrat (*Ondatra zibethicus*), of which there are 14 subspecies.

The fur of the muskrat varies in color from a dark, rich brown to a fulvous or reddish brown. Color variants, such as the white or albino muskrat, have been reported from the various races but are exceedingly rare. Fur dealers recognize only a dark, almost black variant of the common brown muskrat. These dark pelts represent a distinct black-and-tan color phase of the Virginia, or coastal, muskrat (*Ondatra zibethicus macrodon*), which is found in the tidewater region of the Atlantic coast from southern New Jersey to Pamlico Sound, N. C. During normal years they command a much higher price than the brown pelts, as there is a ready export market for the limited supply.

Of North American origin, the muskrat occurs throughout the greater part of the continent from Bering Strait and the northern tree limits southward to the Mexican Border. It is not found along the coasts of South Carolina or Georgia, in Florida, or in many parts of California in spite of apparently suitable habitat. It is absent or scarce in the Gulf States except in the coastal strips of Mississippi,

FIGURE 4.—Musk glands of male muskrat.

Alabama, Louisiana, and eastern Texas where large numbers occur.

The muskrat is seldom seen far from water. Occasional animals may be seen wandering in a field or along the highway but this is usually the result of drought, flood, the scarcity of food, or the breeding season. Its habitat falls in three natural divisions: (1) Small streams, river banks, creeks, ponds, lakes, and canals; (2) swamps; and (3) marshes.

In the first habitat group—rivers, lakes, ponds—no one favored food is abundant. The muskrats subsist on a variety of succulent aquatics, underground roots, and upland plants obtained in their overland forages. They live along watercourses with their nest dens located at the end of bank burrows. Such fresh-water conditions are characteristic of the group of North Central States—Michigan, Illinois, Ohio, Indiana, Iowa, and Wisconsin—that forms one of our largest muskrat-producing areas.

The swamp habitat includes low, timbered country, with dense stands, fluctuating water levels, and intermittent pools of still water—the sluggish streams bordered by thickets and dense stands of large trees. Conditions in general are poor for muskrat production in this type of habitat; and although the muskrat is protected from many of its enemies and escapes ready observation, it must depend for its food supply mainly on the marsh plants and limited stands of cattail that occur along the edges of the swamp and in the more open areas.

The most important type of muskrat habitat falls under the general term "marsh." Here are included the extensive fresh and brackish marshes of the coastal regions and the great inland freshwater areas of cattail and river and round-stemmed bulrushes. It is in the vast coastal marshlands that the muskrat is found in greatest number (fig. 5).

Some coastal marshes are diked, or enclosed with an earthen bank, with sluice gates at various points to permit some control of water depths (fig. 6). These marshes are called banked meadows to distinguish them from wild tidal marsh. When employed in muskrat production, such a marsh is kept wet enough to ensure a good growth of food plants. Properly flooded, diked meadows are said to produce more muskrats to the acre than any other type of marsh. This type of marsh management is most common along the New Jersey coast.

Tidal marshes are penetrated by a system of meandering rivers, small ditches, creeks, "guts," and numerous ponds. Most of the marshes along the coast and bordering the larger bays, like the Delaware and Chesapeake Bays, are largely saline. Their vegetation consists principally of big cordgrass (*Spartina cynosuroides*), saltmarsh cordgrass (*S. alterniflora*), saltmeadow grass (*S. patens*), saltgrass (*Distichlis spicata*), and dense stands of needlerush (*Juncus roemerianus*). These plants have little value as muskrat food.

Inland from the coast and bays, where tidal waters and the fresh-

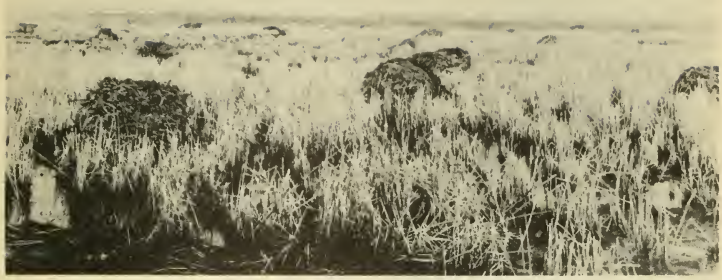

FIGURE 5.—The number of houses on this "three-square" marsh in Maryland indicates a heavy population of muskrats.

water runoff meet, slightly saline conditions develop. Extensive three-square (*Scirpus olneyi*, *S. americanus*) marshes interspersed with stands of cattail (*Typha* spp.), reed or "roseau" cane (*Phragmites communis*), and patches of big cordgrass (*Spartina cynosuroides*) result. Soils of these marshes are waterlogged or partially submerged, and living conditions for the muskrats approach the ideal. The three essentials required to sustain a maximum muskrat population are met: (1) An abundance of suitable aquatic vegetation for food and protective cover; (2) sufficient fresh or slightly saline water for swimming and proper sanitation; and (3) the most suitable type of bottom (peaty humus) in which to dig canals, underground tunnels, and runways.

Home of the Muskrat

Muskrats need little protection during the summer and live in the open marsh in almost any kind of makeshift shelter. In the fall when high tides arrive and cold weather approaches, they become very active, adding to their old houses or pushing up new ones, and digging runways and canals.

For survival, muskrats depend largely on concealment. They spend much of their lives in their underground tunnels and burrows, in their nests and feeding shelters, in swimming, and in digging and gnawing at the roots of various

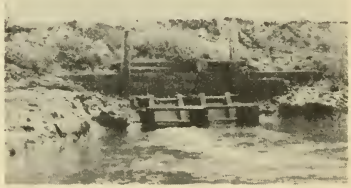

FIGURE 6.—Type of sluice gate commonly used in "diked-meadow" muskrat marshes in New Jersey.

FIGURE 7.—Clump of three-square bulrush (*Scirpus olneyi*). The fibrous roots are used extensively in house construction, and the larger, runner roots are highly prized by the muskrat for food.

aquatic or swamp plants. Consequently, their presence in an area is detected by the evidences of their activity rather than by observations of the animals themselves.

Nesting or dwelling houses

The muskrat nesting or dwelling house, also known as a bed or lodge, is constructed of the fibrous-root masses and stems of aquatic plants growing in the area (fig. 7). It may rest on the bottom of a shallow pond or on clumps of marsh grasses. Built by heaping up freshly cut material, the dome-shaped nesting house is distinguished by its large size, elliptical shape, and peaked or lopsided construction (fig. 8). The heights of the houses vary from 16 inches to 4 feet, depending on the supply of vegetation available, severity of the season, and fluctuations in the water levels. The walls are from 4 inches to a foot thick, and openings in them are closed with mud. This keeps the nest warm in winter and cool in summer. When an inhabited house is opened during the fall or winter, a dry well-lined nest, or chamber, is found above the water line with several "runs" down to plunge holes under the water.

Feeding shelters

The feeding shelter, or hut, is a place to which the muskrat can bring food and eat it protected from its enemies and from the weather. Several feeding shelters may be constructed near the dwelling house at convenient distances, their number and sturdiness depending on the need.

The feeding shelter is distinguished from the dwelling house by its smaller size, roughly circular outline, low height of 12 to 16 inches above water level, and more rounded and uniform shape (fig. 9). When it is opened a small central feeding platform containing plant

FIGURE 8.—Typical muskrat house in Maryland "three-square" marsh in winter, showing mud runway and fresh patching.

FIGURE 9.—Occupied muskrat house in "blue flag" cattail (*Typha glauca*) (right) with smaller feeding shelter marsh in central New York.

remains is usually found just above the water line (fig. 10). Several runs lead from it beneath the water. On the Atlantic coastal marshes where climatic conditions are less severe than on northern marshes, the tightly constructed hut is replaced by a flimsy feeding shelter. Open feeding platforms are used during the summer, and in more southern areas throughout the year.

Push-ups or breathers

Not to be confused with the feeding shelter which it resembles superficially, the push-up or breather is generally found in the frozen marshes of the northern States and Canada, and is confined to the deeper channels, rivers' edges, and lakes. As soon as ice forms in the fall, the muskrats start building push-ups by cutting holes in the ice about 4 or 5 inches across and pushing fibrous roots, waterweeds and other submergent vegetation through the openings. This is in marked contrast to the bulkier stems and leaves of cattails and other emergents they use in constructing feeding stations. A 12- to 18-inch mass is formed on the ice above the hole, and a cavity is made on the inside which the muskrats use as a shelter and breather. During severe weather they also are used as feeding stations. With the arrival of spring and thawing of the ice, the structure collapses.

Bank dens

Muskrats living along the edge of woods, stream banks, and drain-

FIGURE 10.—Feeding shelter with side cut away to expose feeding platform with remnants of winter shoots of "blue flag" cattail left by muskrat.

FIGURE 11.—Entrances to "pipe lead" tunnels at three levels in bank of tidal river, Maryland—at low tide.

age ditches often do not build houses, but burrow into the stream banks. Entrances to these burrows are usually under water most of the year. A burrow may have several entrances at varying depths built at different times to meet changing water levels (fig. 11). The tunnels lead back into a main burrow and then upward into one or more large nesting chambers which are well above water level. The larger burrows may have well-hidden surface openings that are kept loosely plugged and undoubtedly function as air vents.

The muskrat's habit of burrowing into dams, levees, canal banks, and other embankments to build its home often leads to serious damage—to the structure itself and to adjacent agricultural lands by flooding them or by draining waters from irrigated crops. Levees and dikes in rice fields of the South, in western irrigation projects, and in fish hatcheries are especially vulnerable to the burrowing activities of the muskrat. Muskrats often undermine shelled corduroy roads in the marsh country, making travel hazardous at times and road maintenance a constant expense.

Control of destructive muskrats must be in accordance with local regulations; the State conservation department should be consulted by the landowner before he attempts to remove the offending animals. Removal usually is by trapping, shooting, or digging the muskrats out of their burrows.

Food of the muskrat

The diet of the muskrat varies with the season and the plants available. Chiefly herbivorous, in some localities the muskrats may feed to a limited extent on crayfish, crabs, mussels, snails, minnows, and sluggish fish. These items are thought, however, to constitute a relatively minor and seasonal phase of their diet.

The muskrat's food is varied in summer, consisting of leaves and roots of many aquatics, such as the cattails, wildrice, arrowhead or duck potato, waterlily, marshaster (*Boltonia asteroides*), pondweeds (*Potamogeton* spp.), waterweeds

FIGURE 12.—Dense stands of saltmarsh bulrush, or coco (*Scirpus robustus*), favorite food of muskrats and waterfowl.

(*Anacharis* spp.), and occasionally smartweed. The inland freshwater areas, in which "coopers" or "blue-flag" cattail (*Typha glauca*), broadleaved or common cattail (*T. latifolia*), and burreed (*Sparganium* spp.) are major food plants, produce the largest muskrats and the best pelts. In some northeastern sections the European flowering rush (*Butomus umbellatus*) is being used in increasing amounts. Throughout the north central and northwestern United States the hardstem bulrush (*Scirpus acutus*) and the river bulrush (*S. fluviatilis*) are outstandingly important food plants. In the great muskrat-producing marshes of the Atlantic coast and of the Gulf of Mexico, the three-squares (*Scirpus olneyi*, *S. americanus*) and saltmarsh bulrush (*Scirpus robustus*) (fig. 12) are staple foods, and wherever the West Indian cattail (*Typha domingensis*) occurs it is highly relished.

In the winter, when plants are dormant (fig. 13) and ponds and marshes are frozen over, the muskrat lives mainly on the underground parts of plants. Unlike many other rodents, it does not store great quantities of food for this critical period and must depend on its ability to dive and, while submerged, dig and gnaw loose pieces of the roots and lower stems of aquatic plants.

Muskrats eat a wide variety of cultivated plants when available. They are especially fond of carrots, corn, raw peanuts, clover, alfalfa, soybeans, and wind-fallen apples, and will travel considerable distances from their dens, located along streams and ditches adjacent to farm properties, to obtain them.

Breeding

In the spring, patching of the old houses heralds the beginning of the breeding season and of preparations for the young. Although muskrats usually pair off and share the homemaking duties, they are not strictly monogamous. Trapping breaks up many families and members of both sexes readily accept new mates. At times the males are highly polygamous; this results in considerable fighting when one is searching for

FIGURE 13.—Clump of cattail cut from beneath the ice. The muskrat is especially fond of the green, dormant winter buds.

FIGURE 14.—Muskrat litter a few hours old.

a mate and invades another's territory. This is particularly in evidence in spring during the active mating period when muskrats frequently show bites and slash marks.

Mating takes place during the latter part of March. The gestation period is rather short, 28 or 29 days. The first, or early-spring, litters are usually born between April 27 and May 5—the period that is most productive in the total number of young born and that has the highest rate of survival of young. In northern areas, two litters, and occasionally a third, are produced a year. In Maryland, three litters a season are common, the third being born in August or September; on rare occasions a fourth litter may be produced very late in the year.

Spring and fall litters are usually born in small nests that are hollowed out inside the house, or bed, and lined with fresh shoots of very fine grass. In northern regions the nests are lined with finely shredded pieces of cattail. In summer, birth of the young may take place in more open situations or on rafts made of cattails, rushes, or grass; in brush piles; or in flimsily constructed nests thrown up just above the reach of high tide.

The size of the muskrat litter has been recorded as ranging from 1 to 13 young but evidently it varies with the race concerned. The common eastern muskrat (*Ondatra z. zibethicus*) averages 6 young throughout most of its range; the Virginia or coastal muskrat (*O. z. macrodon*) averages 4.4 young; and the Louisiana muskrat (*O. z. rivalicius*) averages but 3.85, seemingly compensating for this low number by producing as many as four or five litters a year.

Muskrats weigh less than an ounce at birth and are blind, almost naked, and helpless (fig. 14). During the lactation period the mammae, or teats, of the muskrat are retractile and the tips are somewhat recurved. When a nursing mother is disturbed she plunges under water, the young clinging to her; if some are torn loose the mother usually manages to retrieve them.

The young muskrats develop rapidly and their eyes open in 14 to 16 days after birth (fig. 15). Known as mice, they often begin to nibble on green, succulent vegetation be-

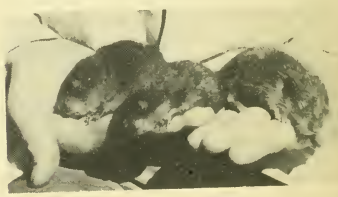

FIGURE 15.—At 15 days young muskrats have well-developed fur, and the eyes are just beginning to open.

fore they are weaned at about 4 weeks of age. By that time the incisors are well developed and can inflict pain. Growth is remarkably rapid but depends on the abundance and quality of their food, on water and temperature conditions, and on racial characteristics (fig. 16). In Maryland, a total length of nearly 18 inches and a weight of about 1¼ pounds may be reached at 7 months. Size of the muskrat at maturity may differ considerably between regions and between races. By the end of the trapping season, young of the first spring litter of the Virginia muskrat may not weigh more than 2 pounds 3 ounces, whereas in central New York those of the common eastern muskrat may reach slightly more than 3 pounds.

In spite of the belief of many trappers to the contrary, young muskrats do not mature sufficiently to breed during the year of their birth. By the next spring breeding season, however, young of the early spring litters have reached maturity. In Louisiana, where young have been found in every month of the year, it is possible that kits born early in January may mature and breed by the end of December; but confirmatory data on this are lacking.

DEVELOPING THE MUSKRAT RESOURCE

Large areas, formerly considered worthless except as waterfowl marshes are today being used to produce muskrats. With the increase in the value of muskrat fur, many areas totally unsuited for farming, even when drained, are yielding a greater income than adjoining, cultivated fields. A better understanding of the application of modern management practices to such properties has helped to stabilize muskrat production at a high level.

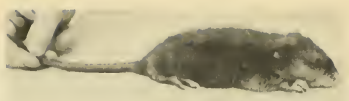

FIGURE 16.—A 2-months-old Maryland muskrat.

Good muskrat habitat is usually good waterfowl marsh. Both for waterfowl and for muskrats, tight or solid marshes are undesirable. The effect of muskrats on a waterfowl marsh is important. In their normal activities muskrats create ponds and keep channels open, but allowed to increase uncontrolled they deplete the vegetation and ruin the habitat both for waterfowl and for themselves.

Improving the Habitat

Controlling water levels

Maintenance of proper water levels is very important as muskrat populations are affected more by rapid changes in water levels than by changes in the type of marsh vegetation. Extreme fluctuation is damaging both to muskrats and to their food plants. A freshet, or sudden rise of water in the spring, often results in heavy mortality of the very young. Again, lowered water levels in late spring followed by intense and prolonged summer drought and high temperatures can stop breeding and lower the rate of survival of the young.

Quite often it is possible to divert sufficient water from larger streams and rivers to maintain small lakes and ponds. Extensive fresh-water areas have been created on some marshes by constructing dikes (fig. 17). Some elaborate concrete water-control structures and spillways may be necessary, but often earthen and rock dams will suffice—the excess water simply flows over the top.

Water-control structures should be designed so that water levels can be raised or lowered as the need arises. A temporary "draw-down" of the water to expose the soil during the first half of the growing season is one of the most effective methods of obtaining germination of the seeds of cattail and bulrushes and the establishment of the seedlings. The exposed soil should be kept moist and not permitted to dry out. Ponds are a conspicuous feature of coastal marshes and valuable in varying degrees to waterfowl, fur animals, and other wildlife. A good marsh is one having a ratio of about 80 percent vegetation to 20 percent open water.

On a tidewater marsh, the difference of a few inches in water levels has a marked influence on the plants and animals found there. Their natural distribution is governed by their ability to withstand varying degrees of intermittent and prolonged submergence and by their tolerance to different concentrations of salts or chlorides.

Brackish marshes extend along the Atlantic coast and the Gulf of Mexico—the result of the mixing of the salt waters from the sea and the

FIGURE 17.—Using a dragline to construct a dike with an impervious core of marl.

fresh waters coming down to the coast from the interior. Prolonged droughts and high temperatures increase salinity of the water in these marshes. Often not much can be done to correct such a situation, but all sources of fresh water such as runoff from woods, fields, and drainage ditches should be used. Unfavorable water conditions on a marsh can frequently be improved by diverting water from a nearby stream, or by a small amount of judicious diking, coupled with the use of deep wells, either free-flowing or pumped (fig. 18). In some instances dynamite-blasting of a series of small ponds and connecting ditches across a high, "tight" marsh encourages its use by muskrats. Care must be taken to avoid lowering ground-water levels that control the growth and distribution of essential food plants. Upper reservoirs or pools may be constructed to impound water that can be used to stabilize water levels in the lower ponds and marshes.

Level ditching is practiced extensively in the Gulf Coast marshes, not only to help control fluctuations in water levels but also to lessen difficulty of foot travel by trappers.

FIGURE 18.—This heavy concentration of houses on part of a Virginia tidal marsh, supplied by a windmill-pumped well during drought, illustrates the influence of fresh water on the distribution of the muskrat population.

Marsh walking becomes extremely difficult in thick growths of sawgrass, bullwhip, and reed. By opening up a series of connecting ditches, pirogues or narrow, flat-bottomed mudboats can be used, and traps set along the levees or ditch banks used by muskrats, raccoons, minks, and otters for feeding and travel lanes. The system of small ditches also carries off excessive storm and flood waters, but retains water during periods of drought. Care should be taken in ditch construction to prevent any general lowering of the water table on which the desired type of plant formation is so dependent.

It is wasted effort to attempt to drain soft, floating types of marsh, but "eat-outs," which are spots in the marsh denuded of vegetation by muskrats (fig. 19), should be temporarily drained. Otherwise they quickly deteriorate into stagnating muck flats or expanses of open water. Immediate drainage to remove stagnating water allows sunlight to reach the bottom and create better conditions for seed germination and revegetation. Neglected, these spots may take years to come back.

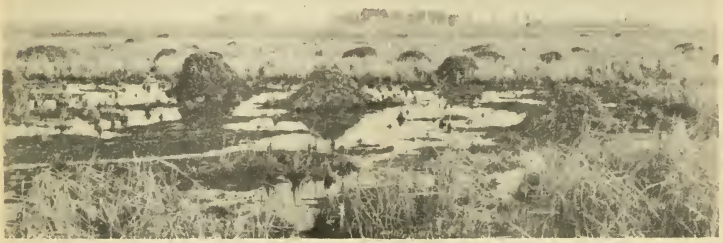

FIGURE 19.—Beginning of an "eat-out" on a Maryland marsh. Intense trapping should be started long before this stage is reached.

Drainage can be effected by cutting drainage ditches some 30 inches wide and deep to lead the water from the denuded spots. The use of blind or closed ditches prevents the intrusion of sea water in coastal marshes. After the areas have been satisfactorily drained, the ditch ends should be closed to raise the water levels again, or the marsh may be seriously damaged. Extreme care must be exercised in ditching a marsh so as not to alter the water relations and thereby favor invasion of the marsh by undesirable vegetation.

FIGURE 20.—Beneficial effect of burning "three-square" bulrush is apparent in this Maryland marsh, control-burned in February; on May 22 the burned-over areas were in full bloom, while new growth in the small, unburned part adjacent to the shell road (left) was just emerging.

Increasing the food supply

On marshes having water-control structures it is often possible to increase the supply of desirable muskrat food plants by manipulating water levels. Many undesirable plant competitors can be controlled by raising the water level a few feet and maintaining it for several months. The areas opened up by killing off noxious plants should then be planted, preferably in the spring, with such food plants as the cattails (*Typha glauca*, *T. latifolia*), the three-square bulrushes (*Scirpus olneyi*, *S. americanus*), saltmarsh bulrush (*S. robustus*), and the hardstem bulrush (*Scirpus acutus*). Pieces of roots with buds attached are transplanted into the muck at the edges of the impounded areas. The two exotics, water-hyacinth (*Eichhornia crassipes*) and alligatorweed (*Alternanthera philoxeroides*) have become established in recent years in the coastal marshes of Louisiana; and despite numerous attempts to control them by various mechanical means or by spraying with weed killers, they are fast clogging the extensive network of canals and bayous. In certain localities these weeds have increased to such an extent that they almost dominate the native plants. While water-hyacinth is scarcely touched by the muskrat, alligatorweed at times is used to a considerable extent, and in the Mississippi area often forms as much as 15 percent of the muskrat's diet.

Fire is an important factor in the ecology of any marsh, and controlled burning is an accepted tool in marsh management. It must be recognized, however, that a certain amount of cover is essential to protect the muskrat from its enemies. To the trapper in the old days burning merely meant easier trapping and more three-square. Marsh burning is beneficial in that it destroys the "rough" and prevents elevation of the marsh through peat accumulation (fig. 20).

FIGURE 21.—Several muskrat runs leading to the dwelling house were exposed when this "three-square" marsh in Louisiana was burned.

Marshes on the Atlantic coast are burned about the middle or the latter part of February. To burn in early fall would mean little cover for the muskrats until late spring. In the Gulf Coast marshes three-square is burned between October 10 and January 1 when the water is only a few inches deep (fig. 21). This helps maintain a supply of three-square bulrush, a favored food of the muskrats.

The beneficial effects of marsh burning appear to outweigh any unfavorable ones. Burning operations indirectly control insects that attack many of the favorite food plants of the muskrat, such as the widely distributed and very injurious lepidopterous stem borer of cattail (*Arazama obliqua*) and several leaf miners on three-square bulrush that often prevent normal seed setting over large areas. Productive muskrat marsh should never be burned during an abnormally dry spell, as root burns occur then, seriously altering the marsh structure and killing desirable vegetation. Deep burns can be used effectively in breaking up dense stands of the less desirable *Spartina patens*. During very dry periods, marsh fires result in the death of many rabbits and raccoons, and occasionally muskrats, minks, and otters. If there is some water on the marsh at the time of the fire the loss is generally slight. Fortunately, inhabitated muskrat houses are rather moist and chinked with mud, and do not burn readily; the only damage to them is a slight blackening and scorching of their tops.

Generally speaking, cattle and muskrats do not go well together. Cattle trample the muskrat houses and runways and frequently dam-

FIGURE 22.—Marsh raccoons prey extensively on young muskrats.

age the trap sets. Electric fences may be employed to control grazing. The extent to which grazing can be effective in opening up dense stands in marshes is questionable, owing to the soft muck bottom characteristic of such formations. At times cattle can be used to advantage in bulrush and giant cutgrass (*Zizaniopsis miliacea*), but this requires capacity grazing plus temporary drainage to be fully effective in deep marshes. Grazing heavy sawgrass (*Cladium jamaicense*) marsh, even in periods of moderate drought, is exceedingly difficult. In addition, the sawgrass is unpalatable except for the very tender new growth that follows a burn.

Controlling enemies of the muskrat

Foxes, raccoons, and minks may be economic liabilities in muskrat management. Where they are found the cause of serious loss, excess numbers of them should be removed in accordance with State laws, preferably by trapping during the open season. At this time their pelts are prime and bring the best prices. Some economic returns can thus be realized from the animals removed; at the same time undue pressure on the muskrat is reduced.

Wherever the mink is abundant it is rated the most serious enemy of the muskrat. In the marshes of the Atlantic coast the red fox and the marsh-dwelling raccoon exact a heavy toll, especially of the young (fig. 22). The raccoon is one of the worst predators in the Gulf Coast marshes, and it is also a bad trap robber. Over its range the coyote is reported to prey on the muskrat.

Marsh-owners and trappers in some sections report that the wild razor-backed hog at times has been such a serious drain on muskrat numbers—tearing open the houses and eating the young—that special hog hunts have been organized. The black snake, water moccasin, alligator, garfish, and snapping turtle account for many muskrats and on more northern marsh areas the pike and muskellunge are occasional predators.

Birds of prey to some extent feed on the muskrat. Chief of these are the red-tailed hawk, the marsh hawk, and the great horned owl; but the principal damage is to the trapped animals. The bald eagle has been charged with feeding on muskrats. Examination of an eagle's nest by one Maryland marsh-owner disclosed more than 40 muskrat traps in the nest, proving at least that this bird is a trap robber, like the "buzzard" and the crow.

Estimating Muskrat Numbers

Fluctuations in muskrat populations

In years of normal rainfall and temperature, muskrats may become

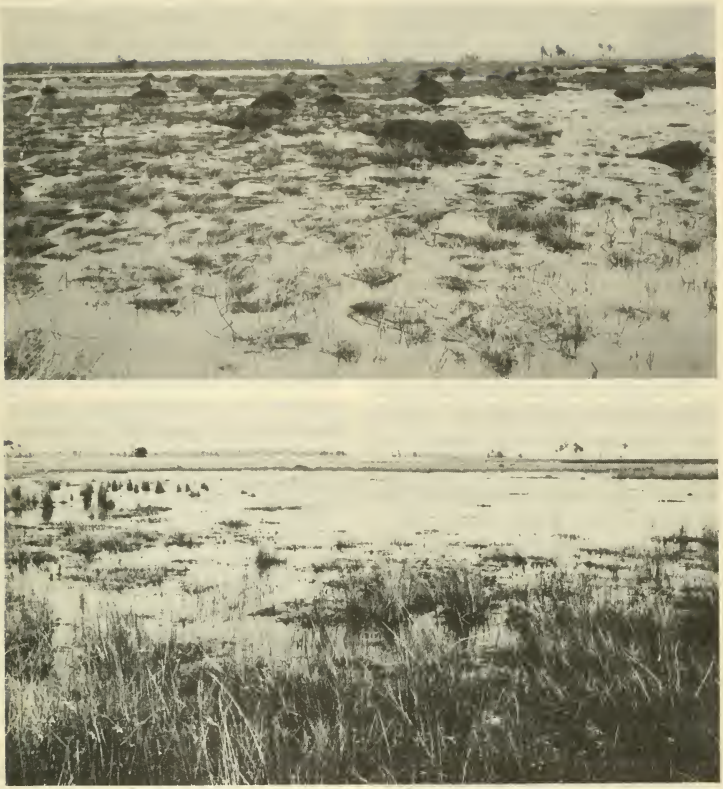

FIGURE 23.—Upper: Maryland marsh in March 1938, at the peak of the muskrat-population cycle as indicated by density of houses and badly eaten condition of the marsh. Lower: Same marsh at low of the muskrat cycle, April 1944.

so plentiful that they deplete their food supply. During these years of abundance their numbers build gradually to a peak, but not simultaneously over the country, and then abruptly decline (fig. 23). Such major fluctuations cannot be attributed to trapping variation. Canadian fur records accumulated over a period of many years show that fluctuations in muskrat populations tend to move in more or less definite 10-year cycles. More recent but incomplete records from various parts of the United States confirm the fact that distinct periods of abundance and scarcity exist, but indicate that the cycle in some instances is longer than 10 years. These cycles are not fully understood at present, but undoubtedly the two major factors responsible

FIGURE 24.—A Louisiana muskrat heavily infested with stomach worms.

for such radical decline in the population are disease and prolonged intense drought.

Drought brings about catastrophic changes for the muskrat. Thousands of small ponds, lakes, and pools dry up, and food becomes scarce. As water levels sink, the muskrats are forced from their homes and many die while searching for more favorable conditions. The supply of fresh water is reduced, and in the coastal marshes salinity increases as the runoff from the watershed fails. The normally fresh or slightly saline water is replaced by undesirable salt water from the sea.

Disease, too, takes its toll, often coupled with poor water conditions. Despite its reputation as a generally healthy animal, the muskrat is subject to numerous maladies, including lobar pneumonia, septicemia, enteritis, streptococcus infections, tumors, coccidiosis, tularemia, leukemia, lumpy jaw, and a skin ailment of fungous origin. In addition to these diseases, the species is host to some 65 parasites, mostly nematodes (fig. 24), trematodes, and cestodes.

"Lousy" muskrats are often reported by trappers, but examination usually reveals the presence of small mites instead of lice. Heavy infestations during the breeding season may result in the loss of many new-born litters. Muskrats with inflamed eyes are frequently encountered, and this condition also is caused by mites. If such animals are held for a few days in a pen or box, supplied with fresh water, and dusted with an insecticide, such as sulfur or rotenone, the condition often clears.

Coccidiosis is common in penned muskrats. This disease may be recognized by the reddened and inflamed appearance of the intestines and the presence of oocysts. The oocysts may be seen in the diseased tissue with the aid of a microscope. Coccidiosis thrives in the pollution that occurs on partly dried ponds and still-water marshes during droughts and it can greatly reduce a muskrat population in a few weeks. Where water levels can be controlled and fresh water is available, it is never a serious factor.

In some years epizootics, or outbreaks of disease over widespread areas, appear usually just before the opening of the trapping season. Thousands of muskrats die in a few weeks, and trappers working over such marsh areas may find numbers of dead animals with no sign of injury but in emaciated condition. The majority of sick muskrats, however, die unobserved in their underground runs. Old burrows and houses may serve as focal points, or centers of infection, and some marshes remain death traps with recurrent epizootics over a period of several years. Some of

these muskrat "wipe-outs" have been attributed to the paratyphoid organism, *Salmonella typhimurium*, by various workers, but it is now generally agreed that an unidentified virus is responsible for most of the loss. The hemorrhaged character of the lungs and intestines is the best indicator of the disease. The Peyer's patches of the small intestines are often conspicuously enlarged, and look like a mass of frog's eggs through the intestinal wall. Numerous gray necrotic spots are usually present on the liver.

Estimating muskrat populations

As the density of a muskrat population is constantly changing, an accurate estimate of the numbers present on a marsh is required each year for intelligent management. Practical estimates can be made fairly easily and accurately in late fall by counting the conspicuous, haycock-shaped houses, or beds, scattered over the marsh.

The house count is recognized as an excellent management tool for estimating anually the number of muskrats on an area, determining population trends, assigning areas to trappers and fixing their limits, and regulating trapping quotas. State conservation officials are interested primarily in drastic reductions or increases in the general population as a basis for shortening or lengthening the legal trapping season. The marsh manager needs such information to make trapper assignments and set trapping quotas. These counts also offer an excellent opportunity to make observations on the types of vegetation and cover, changes in the abundance of muskrat foods, and predation and disease.

House counts can be made from the ground or from an airplane and are most accurate after a killing frost has leveled the rank marsh vegetation. On the Atlantic coast the muskrats begin pushing up their houses in early September, with the arrival of the high tides. Construction of new houses and patching of the old ones continue through the first week in November. This is the ideal time for a count. At this time, theoretically, the maximum muskrat population, including the young-of-the-year, is present, and provides the truest basis for estimating populations and establishing trapping quotas.

Transects and counts from roadsides have been used by some technicians to estimate muskrat populations. Although acceptable on some areas, these methods generally are unsatisfactory.

Unquestionably, the most accurate population estimate can be made from the ground by a "strip" count, if trained personnel is available to cover the area adequately. The various units must be well delimited by natural boundaries or by markers. Reference to a field map of the area to be covered is useful as knowledge of the natural features is necessary for an effective survey. Weather and tides must be considered when choosing the time to make a count, but for comparative purposes the units should be

counted at approximately the same time each year and in much the same order.

In making a strip count the crew is lined up at the most logical starting point on the area to be censused. The men are placed about 50 feet apart—a convenient width of strip for each counter. The objective is to cover as wide a strip as possible, but the type and density of the vegetation determine this to a large extent, as all muskrat houses and feeding stations must be clearly seen. The two men on the outside lines are responsible for guiding the crew. Each counter moves down a strip and counts from himself to the man on his left or right, as predetermined, using a hand tally machine. The counters on the outside are responsible for marking the outer limits of the area by heaping muskrat-house material into small towers on the larger houses; these temporary mounds are readily discernible from a considerable distance.

The strip-count method must be modified in areas that are badly eaten out by the muskrats, or that are broken up by numerous ponds, creeks, or guts. If the topography is such that the strip-count method cannot be used, it may be advisable to assign a unit or a marsh to a single counter. Bank dens occurring along drainage ditches or streams in a strip being censused are included, but care must be taken to count only the main entrances to the dens. They are usually the larger entrances and have more signs of being used.

An aerial census provides a quicker and more-economical method of counting houses than does the ground count. Its accuracy can also be checked against photographs made during the flight (fig. 25). An aerial observer often covers in a few hours an area that would require a three-man ground crew several days. The strip count is generally employed in an aerial census—the pilot moving back and forth across the area being censused, in much the same manner as in the ground strip count. Boundary markers must be clearly visible from the air. On badly eaten areas the muskrat houses stand out clearly, but dense vegetation presents difficulties. With good visibility the larger houses can be seen from 800- to 1,000-foot elevations over a ¾-mile radius. After a snowfall, or when a count of individual trapping units is desired, lower-level observations at 200 feet or less become necessary. Counts

FIGURE 25.—Against the dark water, muskrat houses on this North Carolina coastal marsh appear as numerous white spots from the air. Count of the houses serves as a practical basis for determining the population.

can be made from the air in more-northern areas even when the marsh is covered with snow. In wind-swept areas the snow is quickly blown from the tops of the houses, making them stand out. Under more-moderate conditions, the warmth generated by the muskrats in an occupied house is sufficient to melt most of the snow from the crown of the house, while the feeding huts remain covered. In marshes that are burned early in the fall, as in the Gulf States, the straw-colored houses stand out clearly against the blackened, charred vegetation.

Determination of the muskrat population on the basis of the house count requires some knowledge of the number of muskrats usually found in an occupied house. The last litter of the season usually remains with the parents through the first winter and until the spring mating season begins. Observations of the writer indicate that the litter size varies with the race. The number of animals in a dwelling house will depend, therefore, on the average litter size of the race concerned and the survival rate at the time the house count is made.

The arbitrary count of five muskrats to a large house or bank den is frequently used as a conversion figure in estimating muskrat populations. This may be too low a figure for good years. When known, the average litter size of the race concerned is preferred to convert the number of inhabited houses, as determined in the house count, into population estimates.

Maintaining a Balanced Population

Controlling muskrat numbers by trapping

An important principle of successful muskrat management under natural conditions is that the annual crop be harvested at the right time both for maximum economic returns and for sustained yield. Muskrat populations cannot be carried over from year to year to build a huge crop for a single trapping season. High population densities are a danger signal and removal of the surplus animals is the key to successful fur-animal management. The majority of State and National wildlife refuges are managed primarily for waterfowl. The problem is to keep the muskrat in the status of an asset rather than a liability, and trapping excess numbers of this fur animal is necessary.

The productivity, or carrying capacity, of a marsh depends largely on the type and quantity of its vegetation and on the amount of its brood stock. There is also a direct correlation between the size and weight of a muskrat and the quality and abundance of food available to it. Under Atlantic-coast tidewater conditions, trapping should be undertaken when the population density reaches that of one house to the acre. A density of 2.5 dwelling houses an acre calls for immediate, intensive trapping to prevent serious eat-outs. Allowed to increase uncontrolled, muskrats will deplete the vegetation and cause the marsh to revert to open water and mud flats. The animals are then forced to migrate to sur-

vive. On a good marsh it is generally possible to remove two-thirds of the muskrats each trapping season and still reserve sufficient brood stock for a sustained annual crop, as muskrats are so prolific that it is extremely difficult to overtrap them during the comparatively short legal season.

The average number of muskrats trapped on an acre of the best type of Maryland marsh over a long period is 4 or 5, and catches of up to 10 animals to the acre under excellent trapping conditions have been reported. A Cameron Parish (Louisiana) marsh of 3,000 acres yielded 68,656 muskrats in 1946–47, or approximately 23 muskrats to the acre. The marsh had to carry 30 to 35 animals to the acre to make a catch of this size possible, and represented an advanced case of overpopulation. By the end of the trapping season the better parts of the marsh had been eaten out.

The "yield per house" has been found to be a much better indicator of trapping efficiency than the "yield per acre." An average of 2 muskrats to an occupied house is considered good trapping in view of the difficulties encountered in trapping, fluctuations in weather and tides, and movements of the animals. As a rule, an average of 2.5 muskrats per house can be removed without jeopardizing the breeding stock for the next season.

Trapping success is dependent on several factors: to a very great extent on prevailing weather conditions that at times seriously hamper the trapper, as well as the experience, energy, and reliability of the trapper. Each trapper should be assigned sufficient territory to assure him a reasonable and equitable return, but the unit should be small enough to permit thorough trapping. In general, 150 acres of good marsh is about all one man can trap efficiently in a normal season. Some years it may be necessary to double this acreage and also resort to spot trapping to attract the trappers.

Composition of the population

From a management standpoint it is highly desirable that the manager of a muskrat marsh, should know the proportions of mice, kits, subadults, and adults removed during the trapping season. It is from this information that he can determine the successfulness of the previous breeding season and the rate of survival of the young. An abnormally high catch of adults indicates little breeding during the previous season or a poor rate of survival of the young-of-the-year. An abnormally low proportion of adults indicates very close trapping or overtrapping in either the previous or the current year. Size is generally used to separate subadults from the adults, but alone it is not entirely reliable—there is considerable overlapping of weights and measurements in the two groups. Young individuals from better habitats are often larger and heavier than older animals from poorer areas. A combination of characters such as weight, length, thickness of skin, pelage or fur quality, and toughness in skinning, should be considered in determining age

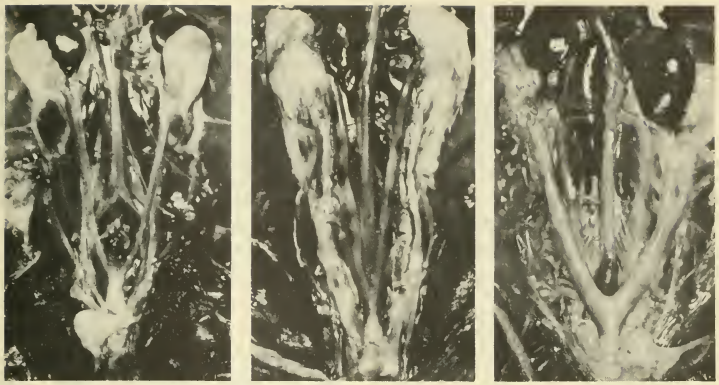

FIGURE 26.—Female reproductive tract of the Virginia muskrat (*Ondatra z. macrodon*). Left: Early-spring-litter subadult showing small, glistening, thin-walled uterine horns. Center: First-breeding-season adult showing pigmented placental scars of two litters, of three young and five young, as indicated by the relative size of congested areas. Right: Older adult almost ready for spring mating; horns slightly swollen, cream-colored, and with only an indication of pigmentation remaining.

groups. Kits have thin, papery pelts of a soft, downy quality. Tough, thick pelts unquestionably denote adults.

Internal examination of the reproductive tract will dispel any doubt about the age group to which a muskrat belongs. The condition of their reproductive tracts distinguish the productive females from the nonproductive (fig. 26). In muskrats that have recently produced young the mesenteries adjoining the horns of the uterus contain small areas of minute, congested blood vessels. Pigmented dark spots that occur on the uterine forks, or horns, represent placental scars, or sites of embryonic attachment. These scars remain distinguishable from the birth of the litter until the latter part of the following February when they start to disappear. By early March these scars usually have entirely cleared and the uterine horns have become cream-colored and slightly swollen in direct contrast with those of the subadult female, which are small, glistening, and thin-walled.

Since placental scars do not persist into the new breeding season, the productivity of the females can be determined only during the late fall and winter. Early in the trapping season the scars are distinct and can be counted, and the average number of kits to a litter determined. In many cases, the actual number of litters produced that breeding season can be checked by the comparative size and the distinctness of the pigmented spots. The spots vary for each of the litters, the smallest and the faintest denoting the oldest litter. Such a count can be a relatively accurate index for races that produce but

two litters a season and few young to the litter. In races that have large litters and produce three or more litters a season, a count of the scars becomes complicated and less reliable. Productivity of the females and the ratio of young-of-the-year to adults, as determined during trapping operations, indicate the trend in muskrat production on any particular marsh.

HARVESTING AND HANDLING THE MUSKRAT CROP

The extreme versatility of muskrat fur permits its use as a substitute for some of the more costly furs, and results in a continuous demand for it. There are more than half a million licensed professional trappers in the United States, and countless farm families find both sport and economic gain in trapping during the open season.

In the era of open lands and free trapping it was a question who could get there first, and most public lands were practically stripped of their fur animals. Trapping today is under State control and regulated by law. The legal season for trapping muskrats often runs concurrently with that for other fur-bearing animals, such as the mink and otter. Some northern States, because of heavy snow and ice, have a short season in the fall followed by another in the spring. In several States the period January 1 to March 15 has been found desirable. Except in an unusually hard winter, a season of this length provides some good trapping weather and the desired thinning of the fur-animal population results.

Muskrat pelts do not begin to prime until late November or early December, and generally are at their best the latter part of February. Fall trapping yields many small, flat, and unprime skins. Harvesting in early winter decreases winter kill from freeze-outs, food shortage, and disease. If the season is extended very late in the spring the trapper can deplete the breeding stock with bank, floating-log or other open-water sets. By this time, breeding has started and many pregnant females are taken and the pelts are less desirable as they are becoming "springy."

Some States set a limit of 250 traps to the trapper and require that a metal tag, with the name of the trapper, be attached to each trap. Registration of trap lines, which is required in the far North, reduces poaching and is an incentive to the trapper to leave sufficient brood stock for another year.

Traps and Trapping Equipment

Each trapper should be provided with the best types of traps to promote the greatest trapping efficiency. Steel traps Nos. 1 and 1½ are generally used to trap muskrats. There are several types of steel trap and the popularity of each varies with the individual trapper and the part of the country he comes from. The old Gibbs two-trigger trap is still widely used in Louisiana. A trap with strong spring action often breaks the legbone, so that the animal tears loose or wrings off, leaving a foot in the trap. "Stop-

FIGURE 27.—This New York trapper, standing beside a muskrat house on a badly eaten cattail-burreed marsh, is well equipped to trap on the frozen marsh.

loss" traps are usually equipped with a delayed-action overguard. When sprung, they hold the trapped animal in such a tight position that it cannot gnaw or wring loose and escape. Older-type traps that a trapper may have on hand can be utilized along river banks and in deeper water where the muskrat is quickly drowned by its struggles.

Traplines should be visited each day for the best results. When there is ice or heavy snow, warm clothing, rubber boots or waders, a long-sleeved glove, and an ax are necessary equipment (fig. 27). Ice grippers on the soles of the rubber boots help prevent falls on slippery ice. A long box rigged on sled runners helps in carrying traps and poles into the frozen marsh and in bringing a large catch out (fig. 28). Toboggans and snow-float sleds serve a similar purpose in deep snows and drifts (fig. 29). The spring thaw with its soft ice necessitates the use of lightweight boats equipped with steel runners (fig. 30). In Louisiana, the narrow flat-

FIGURE 28.—A box on runners is often used to bring in the catch from frozen marshes.

FIGURE 29.—Snowshoes, pack basket, ax, and snow toboggan are required equipment for trapping in heavy snow.

FIGURE 30.—Thaw-outs do not stop the trapper equipped with a lightweight boat such as this one, of white cedar with metal runners to protect the wood and make the boat easier to handle on ice.

FIGURE 31.—The Louisiana trapper uses a pirogue to carry him through the marsh and to bring in his catch; he may also use it for soaking and washing his traps before he stores them.

bottomed boat, or pirogue, is a necessity when trappers are following the network of small ditches and trails through the marsh (fig. 31). Where practicable, mudboats powered by inboard motors are used.

Traps rust badly, and if not properly treated and stored they last but a few seasons. At the close of the trapping season many trappers soak their traps in water for a few days, dry them, and remove the accumulated rust with a stiff brush. They then dip the traps for a few seconds in hot water to each gallon of which a quart of old crankcase oil has been added. Lastly, they dry the traps and store them in burlap sacks or in barrels.

Setting the Traps

The manner of setting traps depends on existing conditions and varies with the section of country in which the trapper is operating. An experienced trapper looks for certain signs of muskrat activity when deciding where to place his traps. These signs may take the form of narrow channels, or runs, through the marsh between nesting sites and nearby feeding grounds, air bubbles under the ice (fig. 32), bank burrows, plant cuttings, roiled or muddy water in leads, tracks (fig. 33), defecating posts (fig. 34), plunge holes, and houses and feeding huts. Newly constructed houses and old ones with fresh repairs usually indicate occupancy.

Knowledge of muskrat behavior helps the seasoned trapper. In general, muskrats are nocturnal and most active from dusk to about 11 p. m. and in early morning. Their diurnal activity seems to vary with race and geographic location. Tidewater muskrats feed most actively during floodtide and hole up in their nests at ebbtide. Muskrats of the Virginia and Louisiana races are extremely wary and are seen during sunlight hours only occasionally; those of the common eastern and Great Plains races show

FIGURE 32.—Air bubbles made by muskrats under the ice are a sign of muskrat activity and guide the trapper in setting his traps.

FIGURE 33.—Muskrat tracks in fresh mud. The lines are made by the animals dragging their tails at times.

considerable diurnal activity and traps set for them may be visited several times a day with good results.

Traps may be placed in the mud of the trail or runway slightly under water. As the muskrat runs or swims over the trap its foot usually strikes the pan and releases the spring and trap jaws. The trap is secured by a chain to a slender pole so that the animal cannot escape

FIGURE 34.—Muskrat defecating post. Their number in a marsh is an indicator of the size of the muskrat population.

FIGURE 35.—Floating-log trap set. Muskrats often use such logs as feeding platforms.

with it. When traps are set in the deeper leads or in open water, the struggling animals are pulled under and quickly drowned. Dirt mounds scattered along the edges of some of the main channels are attractive to muskrats for denning. Sets placed in approaches to these dens and along the leads into dike banks give excellent results.

A floating log (fig. 35), or one extending out into the water from the bank, is often used to support a few traps as the muskrats frequently use such locations as feeding platforms or as highways. Shallow notches, wide enough to hold several traps, are cut into the log, the trap chains fastened to the sides by staples, and the traps covered lightly with leaves, grass, or waterweed. Floating-board sets are good substitutes for logs—the traps being placed just beneath the water on attached, slanting boards.

In many States trapping inside a muskrat house, or setting a trap within 6 feet of it is prohibited by law. A distinction should be made, however, between the feeding hut,

FIGURE 36.—A favorite muskrat trap set in many northern marshes is under the ice at the entrance of the lead into the feeding shelter.

or shelter, and the larger dwelling house. Under frozen conditions one of the most productive sets is made by cutting through the ice into a lead to a feeding hut and setting the trap so that the pan is tripped as the muskrat enters the hut (fig. 36).

Sloping-board and shelf sets are used in some areas for trapping under ice. The length of the board depends on the depth of the water. In the sloping-board set, the trap is held in place by a small cleat and an arrangement of two or three nails about halfway up the board. A piece of bait, such as carrot, apple, or parsnip, is nailed to the board 2 or 3 inches above the trap. The board is then shoved through a hole in the ice at about a 45° slant until its lower end rests in the mud.

The shelf set is made by setting the trap on a right-angled shelf nailed to an upright board and shoved downward through the ice until it sticks firmly in the mud and both trap and bait are under water. Another under-the-ice set can be made by placing a trap in the crotch of a willow or dogwood sapling. When the spring break-up arrives, these methods are abandoned for the floating-board or other open-water sets.

Skinning Methods

It is advisable to skin muskrats as soon as possible after catching them. Skinning is more easily done while some body heat remains, and both skins and carcasses keep better if handled at once. Removal of the pelt requires careful cutting and pulling; and with a little practice it can be done quickly.

There are several methods of holding a muskrat while skinning it. Some trappers hold the animal in their laps; others place it on a board resting between their legs. Another method in common use is to start the skinning operation and then suspend the muskrat by its tail with a looped cord (fig. 37). In Delaware, a short, lengthwise slit is usually cut in the tail which is forced over a nail to suspend the muskrat. An old swivel-type No. 1 jump trap, nailed to a board, makes an excellent device for holding the animal firmly during skinning—the tail gripped in the steel jaws (fig. 38). A rather unique but surprisingly quick and efficient method is that of holding the muskrat by the tail under the heel of the boot and cutting from an underhand position (fig. 39).

In skinning, the muskrat should not be opened along the belly but should be cased, flesh side out, with

FIGURE 37.—The muskrat may be suspended for skinning by means of a looped cord about its tail.

the feet and tail removed. One of the quicker and better ways of skinning a muskrat is to pass the knife around the hind leg just above the hock in a circular cut, make a slit from that point up the middle of the leg to the base of the tail, around or across it, and down the other leg to the heel in reverse manner. The body is then pushed through and the skin pulled back peeling easily to the front feet (fig. 40). Strong pressure by the thumb and a quick yank pulls the skin loose from the front feet, leaving the fur side turned inward. While this method is fast, it can result in badly torn pelts. The skin should be carefully cut around the ears, eyes, nose, and lips to free it without tearing.

Preparing the Pelts

After the daily catch has been skinned, the pelts are usually too moist to stretch immediately. If a skin is stretched when wet the dried fur is thin and straggly in appearance and the pelt is graded down by the fur buyer. The skins should be suspended on nails or hooks overnight by the nose tip, fur side out. The following morning they are placed on fur stretchers fur side in,

FIGURE 38.—This New York trapper uses a swivel-type No. 1 jump trap, nailed to a board, to hold the muskrat firmly by its tail while he peels off the skin.

FIGURE 39.—In the underhand method of removing a muskrat pelt the tail is held firmly under the boot heel.

FIGURE 40.—Trappers on the Eastern Shore of Maryland prefer the "push through and pull" method of skinning muskrats.

and remnants of fat and flesh carefully removed (fig. 41). Flesh allowed to adhere to the skin invites tainting and decay; excess fat may make the pelt brittle and subject to grease burn.

In northern areas, where the muskrats usually are very fat, it is often necessary to remove the heavy layer of fat from the skin with a dull drawing knife or a specially devised, steel fleshing tool (fig. 42). The skin is placed on a form board held securely in a bench vise, and the fat removed with considerable downward pressure. The extra-thick, tough skins of these muskrats permit the use of such a tool. In Louisiana, the muskrats are smaller and usually not very fat. The common practice there is to rinse out the wet, muddy skins in a bucket and run them through a clothes wringer, fur side out (fig. 43). By this simple process most of the fat and flesh is squeezed out. The

FIGURE 41.—After the pelts have been cleaned of excess fat and flesh, they are placed on wire stretchers to dry.

FIGURE 42.—A dull drawing knife or a specially designed tool, as shown here, helps remove fat and flesh from the pelt.

skins are then shaken out and suspended by the nose on nails, racks, or barbed wire to dry before they are stretched.

The first stretchers were fashioned of thin boards or shingles cut the desired size and form, with a few tacks to hold the pelt in place to dry (fig. 44). Although cheap and effective, board stretchers have been almost entirely replaced by those made of heavy galvanized steel wire (fig. 45). Several types of metal stretcher are in use and all have the advantages of being rustproof and almost indestructible. Compared with wooden stretchers they give a more uniform stretch and permit quicker drying, and can be hung in tiers in a minimum of space (fig. 46).

Muskrat trappers along the Gulf Coast still use a very simple type of heavy-wire stretcher without a barbed, sliding crossbar. Optimum stretching of the pelts cannot be obtained; as a result of this, and the customary "slashing-across" method of skinning prevalent in

FIGURE 43.—A hand wringer is used by Louisiana trappers to remove blood, fat, and excess flesh from the skins.

FIGURE 44.—This view of the attic of W. A. Gibbs, pioneer trapmaker and marsh manager, illustrates the old method of drying muskrat pelts on wooden stretching boards.

FIGURE 45.—Two popular types of steel-wire stretchers.

that region, the pelts are easily distinguished by their short, cut-off appearance (fig. 47).

Many trappers use attics for drying pelts. For the best results, pelts should be dried in a cool, dry, well-ventilated room with a temperature of 50° to 60° F. Quick drying with a kerosene stove usually blackens the pelts and lowers their sales value. Drying can be hastened by placing the pelts in a small room equipped with a circulating fan; after about 3 days they can be removed, strung in bundles of 25, and hung in a shed for more leisurely completion of the drying process. Pelts exposed to rain or dampness mold quickly. In the southern States, good results are obtained by drying the skins on racks in the open air; but a hot sun will dry them too rapidly, causing them to shrink and, frequently, to grease burn.

Marketing the Pelts

Muskrat skins are universally case-handled and are dried with the flesh side out. The fur buyer can readily check primeness by the appearance of the skin. The degree of unprimeness is indicated by the amount of blue-black streaking or spotting which occurs in the unprime areas where the new hairs have not yet grown out of their follicles. Any cuts or tears can be easily detected.

Three types of muskrat pelts are recognized in the fur trade: (1) The brown, or northern; (2) the

FIGURE 46.—Muskrat pelts on modern wire stretchers hung in tiers to dry.

FIGURE 47.—Many Louisiana trappers hang the pelts on outdoor racks to dry. The short, squared-off appearance of the pelts is due to the skinning method and type of wire stretcher used.

black (a very dark or black color phase of the brown); and (3) the Louisiana, or southern.

There are several methods of grading muskrat pelts and few people sort them in the same way. They are usually classified according to (1) size group—mice and kits, small, medium, large, x large, xx large, and xxx large; and (2) season—fall, winter, and spring. They are further graded on condition, such as flats, damaged, and tainted, and on color quality.

In former years, many muskrat skins were home-tanned and made into caps, gloves, coat collars, and other articles. The process is very tedious and requires excessive hand labor, so that very little of this is now done in the home. Today, practically all pelts are tanned and dressed in the large centers of the fur trade: New York, Newark, N. J., St. Louis, Mo., and Seattle, Wash.

Burlap sacks have proved highly satisfactory for shipping muskrat skins. When large quantities of skins are shipped long distances to market, they are usually put in special presses and baled. The pelts must be thoroughly dry and the bales should be held in cold storage to prevent molding and grease burns.

Muskrat Meat as Food

Although the muskrat is trapped primarily for its pelt, its flesh is highly esteemed by many (fig. 48). Several million are eaten annually, but the poor utilization of this important source of meat represents an enormous waste—it could be made to yield an additional and profitable economic return to the trapper and marsh-owner. Muskrat meat can be sold cheaply as the additional labor required to prepare it for market is slight.

FIGURE 48.—A dish of muskrat, or "marsh rabbit."

In the retail markets of many cities in the East and Middle West, such as Philadelphia, Wilmington, Baltimore, Washington, Detroit, and St. Louis, there is a growing demand for muskrat meat. It is generally sold as "marsh rabbit" but no attempt is made to conceal the source of the meat. Muskrat meat is becoming more popular each season; and throughout the trapping season it is shipped to a number of large commission and produce houses. In the East it comes mostly from the lower Chesapeake Bay region, but occasional shipments have arrived in excellent condition from Louisiana and other distant points.

For years muskrat has been served in many of the leading hotels and restaurants of the larger cities under such names as "marsh hare" or "Chesapeake terrapin." The flesh is dark but fine-grained and, with a minimum of cooking, it is

always tender. The meat is usually soaked overnight in slightly salted cold water preparatory to cooking it.[1] The flavor has often been compared to that of wild duck and terrapin, but it has a distinctive gamy taste. Weak vinegar is used to reduce this wild flavor and to make the meat tenderer. However, some like the natural flavor of muskrat meat and prefer a limited amount of seasoning. To many, during the season, a Sunday dinner of muskrat is preferable to one of fried chicken. For thousands of trapper families in many sections of the country it is the best meat available for their daily diet. It is important to remove the musk glands as they may impart a strong musky flavor when cooked with the meat.

MUSKRAT FARMING

The increasing demand for muskrat fur has led to considerable public interest in the possibilities of raising this animal commercially in pens and fenced enclosures. Numerous artificial muskrat farms were promoted in various States during the period 1925 to 1930. Many persons were deceived by statements that muskrats could be produced profitably under such conditions, and the vast majority of these ventures proved unsuccessful. Caution should govern any attempt to raise muskrats in this manner.

[1] Dozier, Herbert L., Recipes for cooking muskrat meat, Wildlife Leaflet 229, U. S. Fish and Wildlife Service, Washington, D. C.

Raising Muskrats in Pens

Although muskrats can be raised on a limited scale in pens, it is not profitable. Reproduction under restraint is irregular and losses result from fighting, drinking polluted water, and the close handling necessary to raise the animals (fig. 49). After many generations of pen raising, muskrats still remain wild and easily excited. They never become tame enough to be handled or to be trusted.

The practice of pairing off the animals before the start of the breeding season should be followed as much as possible. After a muskrat becomes established in a breeding enclosure, it often resents the introduction of a strange animal, even of the opposite sex, and fatalities occur. In the early attempts at pen breeding considerable stock was lost in this manner, the female often being badly slashed and cut over the rump.

The investment required in equipment and stock, and the cost of food and labor, make it difficult to realize a profit on the sale of muskrats for the pelt value alone. Ranching operations, consequently, are lim-

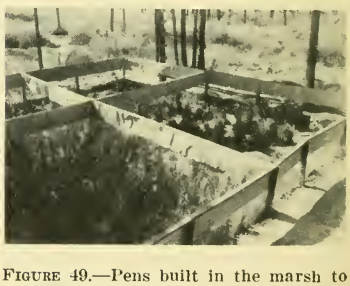

FIGURE 49.—Pens built in the marsh to study the breeding and feeding habits of the muskrat.

ited to producing animals to sell for breeding or restocking. At present, little is known of the possibilities of selective breeding of muskrats. Certain of the color mutations, particularly the black-and-tan phase, might possibly change the present picture and make pen raising of muskrats worth while if a strain of selective, persistent breeders under confinement develops.

Raising Muskrats on Natural and Fenced Areas

The landowner with a marsh, pond, stream, or swamp should consider the possibilities of raising muskrats as an added source of income. They require no special feeding—the plant life of such areas generally supplies an abundance of food—and they increase rapidly when given a minimum of attention and protection.

A marsh in which there is a pond with running water and a lush growth of bulrushes, cattails, waterlilies, and other aquatic plants, is ideal for muskrats. While a heavily wooded swamp has the necessary water, usually it does not produce sufficient food for a large muskrat population. There is scarcely a farm, however, that does not have drainage ditches, or a small amount of low, submarginal land, or a creek which yields muskrats.

Unless forced to leave because of floods, droughts, or hunger, muskrats as a rule remain fairly close to their feeding grounds and homes. Large muskrat-producing areas, therefore, do not usually need to be fenced. Natural boundaries, trespass laws, and continuous surveillance tend to control poaching.

Fencing may be advisable in some instances but is costly on large areas. It reduces poaching, prevents the escape of the animals, and, when correctly done, reduces predation. Galvanized, 1-inch mesh, 16-gage wire is suitable and lasts for years except under salt-water conditions. Sinking the fence from 10 to 12 inches below the surface is usually sufficient on dry ground; in marshes and swamps it must go much deeper. Steel posts are satisfactory on high, dry land, but wooden or concrete posts are more serviceable in muck or on wet ground.

Supplemental feeding may be necessary in fenced areas, where food is limited. Muskrats are fond of corn, either dried or green, carrots, cull apples, crimson or scarlet clover, raw peanuts, alfalfa, Swiss chard, Jerusalem artichokes, cabbage, lettuce, curly kale, vetch, kudzu vine, and sunflower. Turnips, sweet potatoes, parsnips, beets, squash, pumpkins, and red clover are accepted at times but are not greatly relished.

Farm Ponds in Relation to Muskrats

In a properly constructed and well-managed farm pond, muskrats will usually provide an additional source of income without interfering with other uses of the pond. Muskrats dig in the banks or dam primarily to make dens and they select the steepest slopes and the heaviest vegetation. The banks of the pond should always be cut to a

slope steeper than that of the dam wherever soil conditions will permit, and root stock of durable food plants should be used to provide a dense vegetation covering. The watershed or flow into the pond, as well as the size of the spillway, should be adjusted so that the water level remains fairly constant, with a rise of not more than 6 or 8 inches.

Stocking Depleted Areas

Some part of practically every section of the United States is adapted to the raising of muskrats. There are many extensive areas on which few or no muskrats occur, owing in most cases to outbreaks of disease, destructive floods, high tides, overtrapping, or prolonged droughts at some previous time. Many of these areas have the necessary food and water and, if stocked with muskrats and carefully managed, could be made to pay the owner good dividends.

Muskrats should be stocked only after careful study. The wide variation between the several races requires serious thought on the many angles involved: differences in size, color and pelt quality, litter size, reproductive capacity, adaptability, and temperament. The possible introduction of parasites and diseases must also be considered.

Many commercial shipments of muskrats for stocking purposes have been made in past years to various parts of the United States and Canada, as well as to points in the Old World. Some have been desirable and successful, others have had poor or questionable results. One firm in Maryland sold some 50,000 wild muskrats for restocking purposes between 1915 and 1944. Undoubtedly, the size of some of those shipments greatly reduced local muskrat populations.

The introduction of 22 pairs of muskrats (*Ondatra z. zibethicus*) from Michigan to the Tule Lake (Calif.) area in 1930 and their rapid increase in less than a decade (31,252 were trapped in the 1939–40 season on the Tule Lake National Wildlife Refuge) is an outstanding example of the effectiveness of restocking when combined with good management. About 700 pairs of muskrats involving both the brown and the black-and-tan color phases were placed on a 1,500-acre marsh near Moyock, N. C., in 1936; more than $5,000 worth of pelts were trapped off the area 3 years later. The muskrats came from near Church Creek, Md., and were of the same race, *Ondatra z. macrodon*, as those that had formerly occupied the North Carolina marsh. The financial returns would probably have been even greater had only the black-and-tan color phase been released, as the "Maryland black" normally commands a better price than the brown.

LIVE-TRAPPING MUSKRATS

Numerous attempts to obtain muskrats for stocking purposes directly from trappers during the open season have had disappointing results. Animals caught in steel traps usually tear loose and injure a leg or the shoulder muscles so severely in struggling to escape that they finally die. Skinning re-

FIGURE 50.—Left: Collapsible wire trap used in live-trapping muskrats, placed in bank lead to a den. Center: Same type of trap set on top of a muskrat house. Right: Muskrat caught in a Gibbs net trap.

veals the bruised, bloodshot areas beneath the skin. When caught by a toe tip or by the tail and not unduly exposed to sun or cold, a muskrat usually recovers; but those trapped by the foot or the leg nearly always lose it, even though they survive the shock and infection which follow.

Live-trapping of muskrats is often exceedingly difficult, especially under summer conditions. Despite careful handling there is usually considerable mortality in the traps from exposure or injury, and such animals must be skinned for the pelt. A variety of live traps have been used but none is completely satisfactory. The most successful and widely used is a collapsible, rectangular, treadle-type, wire trap that can be used in bank leads and runways or on top of muskrat houses (fig. 50). Baits of carrots, apples, and corn are often used, but in southern marshes where food is ample the year-round, they are less effective.

On some marshes where bank muskrats are present, it is possible to dig out the burrows and take uninjured animals. In clay hardpan, with little or no peat, and a maximum water level of 4 inches, stopping up the runs and breaking open the houses is often the most practical and economical method. The rough vegetation should be burned off, all runs plugged, and the surrounding tunnels stamped in. The nest material is cleared away with a potato digger to reveal the plunge hole, and the muskrats are easily caught when they stick their noses above water for air.

Handling Live Muskrats

High mortality generally accompanies attempts to hold and transport live muskrats (fig. 51). Except in cold weather, the animals cannot be held in any numbers in an

FIGURE 51.—Pen for holding muskrats temporarily in the field when live-trapped. An elevated, dry compartment prevents undue exposure. Note manner of holding the muskrat. (Courtesy Idaho Fish and Game Department.)

enclosure without serious loss from fighting. During the winter quite a number can be allowed to use the same run after a few days of adjustment; as many as 15 or 20 adults have been seen curled up on top of each other inside a nest box during periods of low temperatures. As spring and the breeding season approach this is impossible without fighting.

Despite careful handling many live-trapped muskrats are lost and the reasons are not always readily apparent. Particular attention should be given to the following points:

1. Muskrats are handled most easily by carefully picking them up by the tail near the tip; avoid sudden jerks which can dislocate the vertebrae and result in paralysis of the hind quarters.

2. The region about the nose is especially sensitive to the slightest blow; death may result from fracture of the delicate bone structure and from concussion.

3. The muskrat cannot stand long exposure to extreme temperatures above water. Intense sunlight, heat, or cold can cause death very quickly.

4. Many muskrats die from non-apparent injuries sustained in traps, such as internal bruises and torn tissues.

5. The muskrat usually is not a vicious animal when properly handled, but it is highly excitable; and animals from the same litter often seriously injure each other when excited. It is remarkable how easily one can with its sharp incisors kill another.

Banding and Tagging

Experimental studies to determine the radius of spring dispersal, normal range and mass movements, growth rates, and longevity, require the banding or eartagging of the trapped muskrats before their release. Of all the types of bands tried by the various investigators, the Achilles-tendon method of attachment has proved the best. Most banding methods can cause serious injury and even loss of the muskrat, and have been discarded in favor of eartagging (fig. 52). The Aldous holding device has greatly simplified the process. By this in-

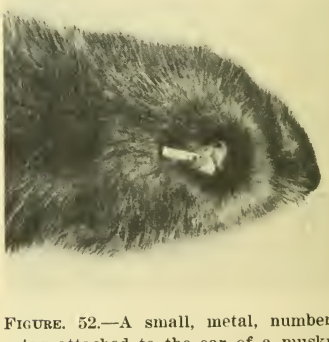

FIGURE. 52.—A small, metal, numbered tag attached to the ear of a muskrat is generally used in experimental studies.

genious device, the muskrat can be held firmly by gentle pressure on the plunger, the ears pulled through the wire netting, and the tag quickly attached, without unduly squeezing or bruising the animal and without risk to the operator. A small, numbered eartag, made of aluminum or preferably Monel metal, is in general use.

Identification of Sex

For efficient management and restocking, recognition of the sex of the muskrat is essential. No valid criteria of color or size exist for the sexes, but the sex of an adult muskrat can be determined by palpation. The animal is picked up by the tail and lowered until its front feet rest on a firm surface such as a board or table. Held in this position for a few moments, it usually calms down (extreme caution is necessary in handling the muskrat, for it is very agile and will turn and bite quickly). The sex can then be determined by palpating the genitalia. A protuberance, or urinary sheath, is present in both sexes; it lies on the ventral midline, anterior to the anus, and covers the penis in the male and the anterior rim of the vaginal entrance in the female. The relatively long and solid penis of the adult male can be felt within the sheath. The protuberance in the male is long and somewhat rounded; in the female it is less conspicuous, more pointed, and comparatively short. The vaginal opening is often difficult to see in nonbreeding females; it may be covered by a vaginal closure membrane. In adult females during the breeding season the vaginal opening is prominent.

The most convenient criteria for determining sex in muskrats are (1) distance between the anus and the protuberance, and (2) presence of hair over a portion of this area which is known as the perineum. In the male the perineum is long and is covered with hair; in the female it is short and the anterior part is hairless.

Shipping Live Animals

The shipper of live muskrats must see that the animals are well crated to insure arrival at their destination in a good condition. Shipping crates should be made of 20-gage sheet metal or of wooden boxes lined with hardware cloth or netting to prevent the muskrats from gnawing their way out (fig. 53). Each muskrat should be shipped in a compartment of approximately 10½ x 8½ x 10½ inches. Separating the animals keeps them from injuring each other by fighting, which results from incompatibility and the excitement

FIGURE 53.—Metal cages such as these have proved very satisfactory for shipping live muskrats.

caused by jolting in transit and moving of the crate at transfer points. Each compartment should have a securely fastened water container and sufficient nest material or straw to prevent exposure. Muskrats are especially susceptible to pneumonia while in transit. Crates should be labeled "Keep out of sun and away from intense heat." Shipments should be made during cool weather whenever possible, as animals suffocate easily during periods of intense heat.

Several ears of dried corn, a few carrots, and a head of cabbage or lettuce placed in each compartment should be ample food for a muskrat traveling a long distance. Successful shipments have been made in this manner from Maryland to Louisiana, across the continent, and to foreign countries. If muskrats are moved by car or truck, care must be taken to prevent their suffocation or asphyxiation by exhaust fumes.

RECOMMENDATIONS

A high, sustained annual yield is the primary objective of commercial muskrat production. To attain this objective close adherence to the following basic principles of marsh management is necessary:

Maintain water levels at a depth conducive to the best growth of desirable muskrat foods, such as the cattails and bulrushes. A direct correlation exists between the abundance and quality of food present on a marsh and the number, size, and weight of the muskrats produced there. In general, both the muskrats and their favorite food plants require rather shallow water. Under northern conditions the water must be deep enough to prevent winter freeze-outs. An ideal water condition is one in which three-fourths of the marsh is covered by water 18 inches or less in depth, with numerous deeper ponds, holes, and ditches interspersed throughout the marsh.

Maintain stable water levels. Extreme fluctuation in water levels is very damaging to muskrats and other wildlife, as well as to their food plants. Water-control structures should be so designed that the water levels can be raised or lowered as the need arises.

Use all sources of fresh water, such as rainfall and runoff from fields, woods, and drainage ditches. Muskrats generally prefer fresh to slightly saline water. Prolonged droughts and high temperatures increase salinity. In the Gulf Coast region the most-productive muskrat areas are the brackish-water, three-square marshes. Storms and high tides often destroy the favorite food plants of the muskrat and exert a harmful effect on the animals themselves.

Use controlled burning judiciously. Although an important factor in muskrat production, controlled burning must be done only when the water level in the marsh is such that deep root burns will not result to desirable food plants. At least 3 inches of water should be present over most of the area at time of burning. Burning may be used to remove the "rough" and to open up dense stands of undesirable emergents, such as sawgrass (*Cladium jamaicense*).

Remove the annual crop of muskrats at the right time and in amounts compatible with the numbers present on the marsh. An estimate or census, should be made each year, just before the legal trapping season, as a basis for planned removal of the surplus and determination of population trends. Muskrat crops cannot be held over a long period for harvesting in a single season. Whenever their density reaches one dwelling house to an acre, trapping should be undertaken. A density of 2.5 houses an acre calls for immediate heavy trapping; if action is delayed at this time "eat-outs" invariably result in spite of intensive trapping later. To maintain a proper balance between the muskrats and their environment, approximately two-thirds of the population should be removed each year.

Analyze the composition of the catch made during the trapping season. Sex ratios and distribution of the age classes of the trapped animals provide an excellent index to population trends. An abnormally high take of adults indicates little or no breeding that season or poor survival of the young. A low proportion of adults is indicative of close trapping or overtrapping in the preceding or current year.

Select trappers carefully. Trappers should be experienced, reliable, and energetic. Trap lines should be run daily, preferably early in the morning. Knowledge of the habits of the muskrat and suitable equipment are necessary to efficient trapping.

Assign to a trapper only as much acreage as he can manage; and make the catch quota liberal enough to avoid undertrapping. The "yield-per-house" is a much better measure of trapping efficiency than the "yield-per-acre." Overtrapping can occur under some situations, but it has been the experience of trappers and marsh-owners generally that it is almost impossible to overtrap a normal muskrat population. It is far better to overtrap an area than to undertrap it.

Keep populations of predators, as foxes, raccoons, and minks within reasonable limits. The annual drain on the muskrat by predators may become very serious. Their control will lead to larger muskrat crops and a reduction in the number of damaged pelts. By removing such animals during the legal trapping season additional revenue can be realized from the sale of their pelts.

Drain "eat-outs" promptly. To correct "eat-outs," drainage ditches, usually about 30 inches wide and deep, should be cut across the marsh to carry the water from the denuded areas. This permits the sunlight to reach the mud bottom and creates better conditions for seed germination and the survival of any pieces of rootstalks remaining. Closed or blind ditches are preferred and should be so constructed that salt-water intrusion is prevented in coastal marshes.

Use cattle grazing cautiously. In general, muskrats and cattle do not

go together; the cattle continually trample the muskrats' nesting houses and runways and damage trap sets. Grazing has been used at times to open up dense stands of bulrush and giant cutgrass to produce better muskrat and waterfowl areas, but this requires capacity grazing plus temporary drainage to be fully effective in "deep marshes." Conditions in heavy sawgrass formation make it exceedingly difficult for cattle to graze, and the foliage, except tender new recovery growth in burns, is very unpalatable.

U. S. GOVERNMENT PRINTING OFFICE : O—1953