THE ECONOMIC IMPORTANCE OF THE MUSKRAT IN VIRGINIA, WITH PARTICULAR EMPHASIS ON MONTGOMERY, A MOUNTAINOUS COUNTY

by

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Thesis submitted to the Graduate Faculty of the
Virginia Polytechnic Institute
in candidacy for the degree of
MASTER OF SCIENCE
in
WILDLIFE MANAGEMENT

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June, 1951
Blacksburg, Virginia

Figure 1. Common muskrat (Ondatra zibethica zibethica)

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ACKNOWLEDGEMENTS

The writer greatly appreciates the assistance of the following organizations and individuals on various phases of this project:

Without the financial aid of a fellowship from the Virginia Agricultural Experiment Station, it would have been impossible to conduct a survey of this type. The writer is indebted to Dr. Henry S. Mosby for securing this fellowship, and for contributing greatly toward the organization and supervision of the project. Drs. C. F. DeLaBarre and H. S. Mosby both critically reviewed the final manuscript and advanced many helpful suggestions throughout the course of this investigation. Professor A. B. Massey was extremely helpful on the botanical aspects of the project, and contributed much toward its completion. Thanks are given , who gave generously of his time on the original organization of this project. Special thanks are due the numerous trappers and fur dealers, most of whom would probably wish to remain anonymous, for their assistance. These people were most cooperative on all phases of the study, and assisted in gathering much of the data. Of particular help was , Shawsville, Virginia, who personally gathered most of the muskrat harvest records from Montgomery County.

and kindly granted permission to work on the Island Farm and Powhatan Hunt Club Marshes respectively. , trapper, on the Island Farm Marsh and , trapper on the Powhatan Hunt Club Marsh, were both very helpful in gathering sex ratios and pelt data from these two areas.

Game Technician kindly showed the writer over several marshes before the final selection of study areas was made. My fellow graduate students have been of great help in giving their interest and advice; they are: , , ,

, , , ,

Special thanks are due who gave considerable help on many phases of the project. Drs. W. L. Threlkeld and J. M. Grayson identified endoparasites and ectoparasites respectively. Dr. Henry S. Mosby very generously made several photographs available for use in this report.

INTRODUCTION

The muskrat has long occupied a prominent position in the fur industry of North America. Unfortunately, many people, other than those in the fur industry itself, do not realize the importance of furbearers in the commercial history of this nation. During the early settlement of the country, furs were one of the chief items of exchange, and it was primarily the quest for more furs which led to the exploration and settlement of the West. It seems extraordinary that many of our furbearers have not become extinct under the pressure of persistent trapping, but despite adverse conditions, the fur trade has managed to survive.

The heavy pressures of trapping in combination with an exploitation and destruction of suitable habitat have taken their toll, however, and many of our more valuable animals, such as the fisher and marten, have become exterminated over much of their former range. In view of the steady decline of the more valuable fur species, legislative action has been taken in most states to protect these vanishing species. The fur industry, on the other hand, was forced to resort to the muskrat, a fur which, while present in abundant numbers, had previously been given very little consideration.

The muskrat has become more and more important in later years as the natural beauty and quality of its fur became recognized. That the muskrat may still be found in abundant numbers throughout most of its range, is amazing. The present abundance is largely due to its great fecundity and adaptability to changing environmental conditions,

characteristics which are a prerequisite if a wild animal is to survive and flourish in the world today. At the present time, the position of the muskrat as the most important single fur species in the country is unchallenged, with all indications pointing to the fact that it will become even more important in the future. Many of the states, including North Carolina, Texas, and Louisiana, recognize this fact, and now have full time projects devoted to the muskrat. In Virginia, Game Technician D. J. Wooley did a small amount of work on marsh improvement and its effect on the muskrat population. Other than this, no specific work has been done on muskrats in the state.

In other sections of the country, numerous studies have been made of the muskrat, including several ecological and life history investigations. Most of these studies have been concerned with those muskrats inhabiting marshland. With the exception of Errington's extensive studies in Iowa, very little work has been done on stream-dwelling muskrats. It was this past lack of stress on stream investigation which activated this project. The objectives of the project are fourfold: (1) to determine the annual muskrat harvest in a county of southwestern Virginia; (2) to determine the economic value of the annual muskrat harvest in a county in southwestern Virginia; (3) to determine, in so far as possible, those factors which limit a greater harvest of muskrats in southwestern Virginia and; (4) to compare the economic returns from muskrat in a southwestern Virginia county with the economic returns from muskrat in an eastern Virginia county or counties. It is hoped that data obtained in this investigation will serve as bases for

management recommendations which might increase the annual muskrat production on Virginia streams and marshes and which might, in some measure, bring recognition to, and stress the importance of, one of our most valuable animals.

REVIEW OF LITERATURE

Extensive investigations of the muskrat have been made in several sections of the country. Published data and investigations of the muskrat in Virginia are entirely inadequate, if not nonexistent. Previous work in Virginia has been definitely limited in scope, being devoted almost entirely to habitat improvement and development. Virginia Game Technician D. J. Wooley, in cooperation with United States Fish and Wildlife Service personnel, studied the effects in certain eastern Virginia marshes of ditching and blasting on marshes to create and improve existing muskrat habitat. So far as could be determined, the results of Wooley's studies have not been published.

Dozier (1945), working at the United States Fur Animal Field Station in Maryland, probably made the most comprehensive investigation to date of the Virginia muskrat (Ondatra zibethica macrodon). His data were principally confined to trapping season sex ratios, age ratios, weights, and color variations. These data would seem to indicate that sex and age ratios were significant criteria for regulating the muskrat trapping season in Maryland.

Dozier (1950), working with the common muskrat (Ondatra zibethica zibethica) found that excessive weights on the Montezuma Marsh, New York, could be directly correlated with the type and availability of the predominant food plants. Numerous other investigators, including Errington (1941), Stearns and Goodwin (1941), Takos (1947), and Bellrose (1950), have made studies of the food plants eaten by muskrats. Most of these data indicate that muskrats eat primarily the plant which is most

readily available, despite the fact that it may not be the most desirable as a food. Takos' (1947) work is outstanding in that it gives quantitative measurements of the food plants utilized by muskrats.

Kellogg (1947), limited most of his work to an economic investigation of the value of muskrat pelts from different sections of the country. His data on the effects of season on the grade and quality of muskrat pelts are very complete, having been taken from numerous Federal Wildlife Refuges throughout the country. No definite information on the relative monetary value of different grades of muskrat skins has been collected. Such data, however, would be extremely valuable, in regulating trapping seasons and could be readily obtained by allotting sufficient quantities of a specific grade of skin and offering numerous such lots at public auction where a correlation might be made between grade and value.

Anderson (1948), presented a very good analysis of the effect of habitat improvement on an increased muskrat production. It was found that level ditching in marshes in Wisconsin resulted in an increase in muskrats trapped per acre, net return per acre, rate of interest earned on capital invested, and the return per hour of labor spent in skinning, trapping, and fleshing muskrats.

A study similar to the investigation here reported was carried out in Colorado by Yeager, Denney, and Hamnit (1949), in which a statewide fur resources inventory was made. Their data were derived largely by interviewing trappers, and are presented for all furbearing species in the state.

Dr. Paul L. Errington of Iowa State College has undoubtedly made a more exhaustive and comprehensive study of the muskrat than has any other single individual or organization. His work has been largely devoted to population dynamics, and is extremely valuable to this study in that he has principally considered stream-dwelling muskrats. It is unfortunate that a majority of the muskrat research work has been confined almost entirely to marshes.

It is hoped that this investigation, dealing primarily with muskrats from small streams, will contribute something to this neglected phase of the ecology of the muskrat.

STATUS OF THE MUSKRAT IN VIRGINIA

Distribution of the Muskrat in Virginia

The two subspecies of muskrat which occur in Virginia are among the most widespread mammals in the state and it is likely that they occur in varying numbers in every county of the Commonwealth. The Virginia muskrat (Ondatra zibethica macrodon) is known to inhabit the Coastal Plain, Piedmont Plateau, and northeastern Blue Ridge Mountain regions inland to Washington, Rappahannock County, in northern Virginia and to Nelson County in central Virginia. Future collecting in the southwestern Piedmont Plateau will probably extend the range west and establish a definite line of intergradation along the Blue Ridge with the common muskrat (Ondatra zibethica zibethica).

The range limits of the common muskrat have not been definitely determined, but it is probable that the range of this race will be found to include the entire Allegheny Mountain region. There is probably a line of intergradation with Ondatra zibethica macrodon along the Blue Ridge.

There are specific records of Ondatra zibethica macrodon from the counties of: Arlington; Brunswick; Charlotte (Charlotte Court House); Accomac (Chincoteague); Norfolk (Dismal Swamp); Fairfax (Dunn Loring); Fairfax (Falls Church); Spottsylvania (Fredericksburg); Gloucester; James City; King and Queen; Norfolk (Lake Drummond); Westmoreland (Pope's Creek); Prince William (Quantico); Richmond (Rappahannock River

opposite Tappahannock); Henrico (Richmond); Charlotte (Roanoke Creek); Nansemond (Suffolk); Norfolk (Wallaceton); Richmond (Warsaw); Warwick; Rappahannock (Washington); King William (West Point); and York (opposite West Point).

There are specific records of Ondatra zibethica zibethica from the counties of: Bath; Montgomery (Blacksburg and Prices Fork); and Highland.

These records, in conjunction with specimens personally examined by the writer, form the basis for the distribution map shown in Figure 2. It should be emphasized here that many or all of the counties shown in Figure 2 without specific distribution records probably have muskrats present.

In the state, the Virginia muskrat (Ondatra zibethica macrodon) is undoubtedly more abundant within the limits of its range than is Ondatra zibethica zibethica within its narrow confines. This is probably a matter of habitat suitability, as the eastern race is largely confined to extensive marshes which are capable of producing heavy muskrat populations. The western race, on the other hand, is limited to a much less desirable type of habitat in the mountainous region of the state. Economically, the eastern race is undoubtedly the more important of the two, largely through its superiority in numbers. Fur dealers are of the general opinion that the western race is superior to the eastern race from the standpoint of fur value. It has been the experience of the writer that the western race possesses a denser, more uniformly colored, and generally superior fur, than the eastern race. Evidence would seem to indicate that the western pelts bring a higher average price on the market than the eastern pelts. This greater value per pelt for the Western Virginia muskrat (O.z.zibethica)

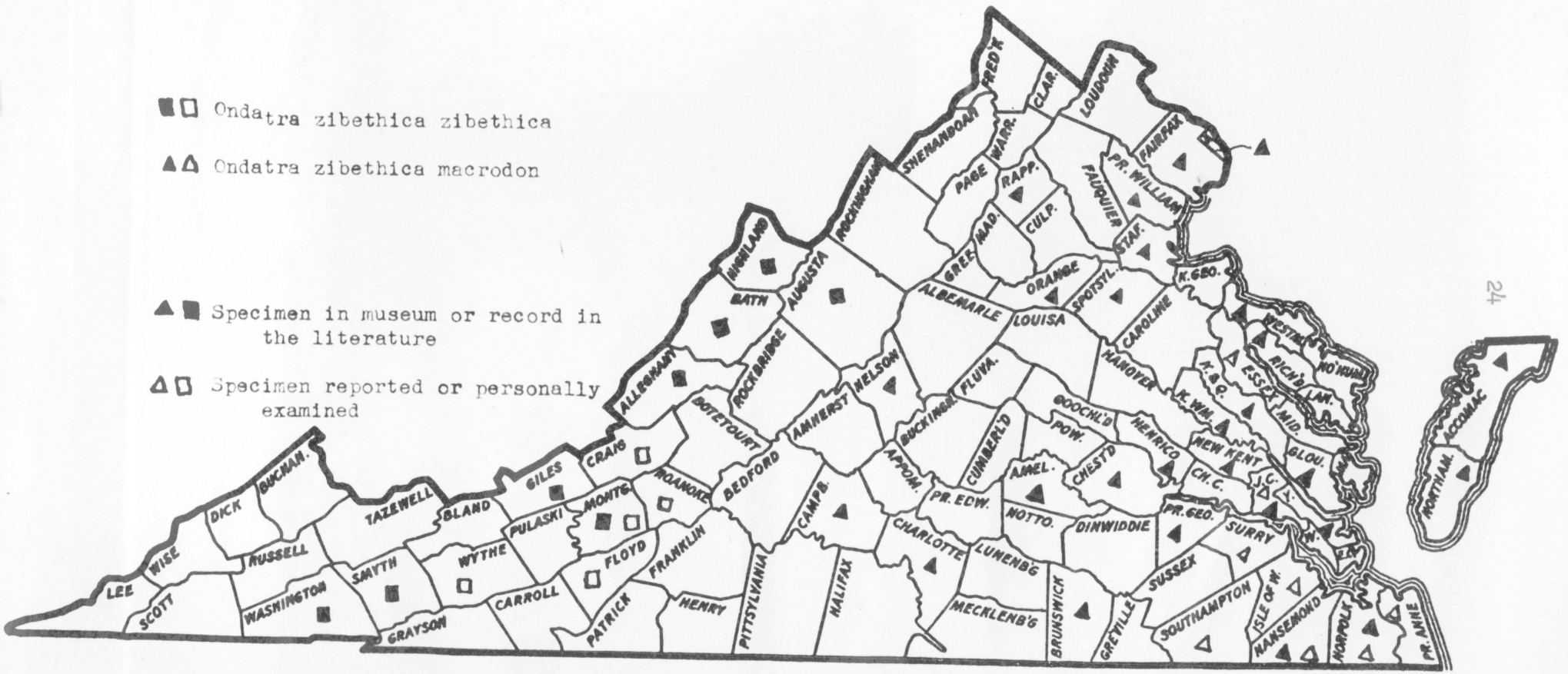


Figure 2. Map showing the distribution of the two subspecies of muskrat in Virginia

may be due to environmental, rather than genetic, differences, but a more complete investigation will be required before any definite statement can be made.

History of the Muskrat in Virginia

Historical references to the muskrat in the literature would seem to indicate that the animal is among the states oldest known mammals. The first published description of the muskrat was made by Captain John Smith (1612), who wrote, "Mussacus is a beaste of the forme and nature of our water rat, but many of them smell exceedingly strong of muske." There is little doubt but that this statement was used to refer to our present day muskrat. Although not now occurring in its former numbers, the muskrat was apparently one of our most abundant mammals during the early development of the country.

Patton (1938), gave a comprehensive summary of the history of the muskrat in Virginia. He has the following to say: "in a field report (1895), Dr. A. K. Fisher considers the muskrat common along the ditches and Lake Shore at Lake Drummond, Dismal Swamp, E. A. Preble (field report, 1909) rates this species common along Pope's Creek, Westmoreland County, and states that many were trapped in 1909. Along the streams in the lowlands near Massies Mill, Nelson County, muskrats were considered common (D. E. Lantz, field report, 1909). Howle (1915), writes that he caught 89 muskrats about 1901 along the James River while trapping for beaver. In Fairfax County, J. H. Riley of Falls Church says that fur trappers have greatly depleted the number of these animals in recent years (field report, 1920). Lewis (1937 unpublished) writes that muskrats are locally common along water courses and in swamps in Amelia, Brunswick, and Norfolk Counties."

Importance as a Furbearing Animal

Muskrat trapping in the state became a very important business during the early part of the twentieth century. Marshes which had previously been considered as almost worthless land, now began to produce an income in the form of muskrat pelts. Many of these areas were purchased at the turn of the century for $0.50 to $0.75 per acre. During the fur boom immediately following World War I, these same marshes produced an annual income of $5.00 to $25.00 per acre. At present day pelt prices, an income of $3.00 to $15.00 per acre from muskrats can be realized from these areas. A majority of the marsh owners now recognize the value of their property, and annually lease their trapping rights. A few marsh owners have become sufficiently interested in their marshland to instigate some management practices for increasing the annual muskrat production.

A large part of the annual muskrat harvest in Virginia has been taken from the numerous small streams and rivers throughout the state. It is this type of habitat which consistently yields a substantial profit to the amateur trapper. Among this latter group of trappers are found farmers, schoolboys, mill workers, and numerous other groups of people, many of whom trap muskrats for recreation as well as the monetary returns which they derive.

As is to be expected, the numbers of muskrats in different localities exhibit considerable annual variations. This condition is reflected by the trapping records from any one locality over a period of years. Local reports would seem to indicate that there are con-

siderably fewer muskrats in many areas than were found in these areas in previous years. This reduction in number may be attributed to many factors, chief among which would be unregulated trapping and a complete lack of management. The annual muskrat harvest data would indicate that the streams and marshes of Virginia are not producing the number of muskrats which they should produce. It is conceivable that under reasonable management, these thousands of acres of marsh and miles of stream in the state would produce an annual crop several times greater than at present.

It is evident that, under intensive trapping and poor management, many of the state's furbearers would be seriously reduced in numbers. An outstanding example of this serious depletion in numbers is the otter, which was in danger of being exterminated from the state at one time. It is encouraging to note that statewide regulations have enabled this animal to increase to a point at which an open trapping season is again feasible.

Methods of Gathering Fur Harvest Data

Many of the states have individual systems for tabulating their annual fur harvest. Some of these systems are more complete and more accurate than others. Virginia requires that all persons dealing in raw furs possess a license issued by the Virginia Commission of Game and Inland Fisheries. Trappers are not required to report on fur taken, but all dealers are required to make a report on furs purchased. These reports are submitted to the Game Wardens by local fur dealers.

Table 1 is a sample form of the type submitted by local fur dealers.

Table 1. Annual report of Mr. C. E. Smith, Fur Dealer, Shawsville, Virginia, for the 1949 - 1950 trapping season

Animal	No. bought	Average price per skin	Total
Muskrat	414	$1.35	$558.90
Opossum	107	0.20	21.40
Skunk	70	0.50	35.00
Mink	41	15.50	635.50
Gray fox	8	0.25	2.00
Red fox	4	0.50	2.00
Raccoon	61	0.50	30.50
Weasel	6	1.50	9.00
Totals	711		$1294.30

It has been the experience of the writer that such records are very poorly kept, and do not reflect any high degree of accuracy. Manyfurs are bought and sold by persons who admittedly do not keep records of their transactions. No shipping tag is required in Virginia for those furs which are shipped out of the state. Furs disposed of in this manner subject the total to some inaccuracy. It is felt, however, that despite these various factors, the system used in Virginia at least gives the trend of the number of furbearers trapped annually.

Iowa uses a system which permits a fairly high degree of accuracy in computing the number of furs taken during the season. Under Iowa

conservation laws, a license is required of all persons who deal in raw furs. At the close of the trapping season, a report of all furs purchased must be sent directly to the Conservation Commission, on forms provided for that purpose. Furs shipped out of the state must bear tags which state the number and kind of furs being shipped. These tags are obtained only upon application to the Conservation Commission.

North Carolina uses a system similar to that of Virginia in that fur dealers have to report to the Conservation Commission on the number and type of pelts which they buy. It is believed that a system similar to that used in Iowa would be a decided advantage in Virginia. It would certainly enable responsible persons to evaluate more accurately the value of the furs harvested in the state.

Fur Harvest for Virginia

Virginia, as does most of the states, has records of the approximate annual harvest of fur from the state. Because of the system used in gathering these data, they are necessarily subject to a good many inaccuracies. The system which is currently in use in Virginia will be discussed in another section of this report.

Table 2 is a tabulation of the fur harvest in Virginia for the period 1938 - 1948, based on records submitted, according to law, to the Virginia Commission of Game and Inland Fisheries by the licensed fur dealers of the state. The monetary value of the harvest was calculated by multiplying the number of skins each year by the average price of that skin for the year in question. It may be seen from Table 2 that muskrats

Table 2. Volume and value of the furs handled by licensed Virginia furbuyers for the year 1948-1949 and for the 10 year period 1938-1948

Species	1948-1949 harvest Volume	Value of 1948-1949 harvest Value	10 year period 1938-1948 1938-1948 harvest Volume	10 year period 1938-1948 Value 1938-48 harvest Value
1/ Muskrat	169,293	$320,000	1,511,950	$2,570,315
2/ Skunk	62,939	40,000	695,263	705,000
3/ Mink	4,413	67,000	50,503	606,036
4/ Raccoon	17,676	8,500	141,720	220,000
5/ Opossum	45,548	10,200	807,492	201,900
6/ Fox, gray	4,889	5,000	83,622	80,000
7/ Weasel	1,542	1,600	28,593	29,000
8/ Otter	332	6,640	1,520	22,800
9/ Fox, red	1,811	1,000	13,461	26,900
10/ Bobcat	146	250	1,578	3,000
Totals	308,879	$460,190	3,335,702	$4,464,951

comprised over half of the value of Virginia's fur for the period 1938 - 1948. These data, which reflect the volume and value only of the pelts handled by licensed Virginia fur dealers, indicate that Virginia trappers receive approximately one half million dollars annually from the sale of raw pelts. Consideration of the total fur industry of the state, including both in-state and out-of-state fur buying, would increase this figure appreciably. If one considers the potential fur producing habitat of the state, these figures appear to be woefully inadequate.

Muskrat Harvest for Virginia

Virginia ranks thirteenth in the country in annual muskrat production. Table 3 presents incomplete data on the muskrat catch in Virginia by years for the fifteen year period, 1935 - 1949. It may be seen from these figures that, with the exception of one year, there has been little fluctuation in the number of pelts harvested annually during the period. Unfortunately, the information for 1946 and 1947 is incomplete, but the average number of muskrats taken annually for the remaining years is presented.

It should be emphasized here that the number of licensed trappers does not reflect the true number of trappers in the state. This is true because land owners are not required by law to purchase licenses. Also, there is, of course, some illegal trapping in the state. The number of muskrats taken as presented in Table 3 is based only on licensed fur dealers reports, and does not include out-of-state sales.

These figures, therefore, are not strictly accurate. It is believed, however, that both sets of data are accurate enough that they indicate the trend of licensed muskrat trapping in Virginia annually.

Table 3. The reported muskrat catch in Virginia from 1935 - 1949, showing the average catch per licensed trapper

Year	Trapper Reporting (Licensed)	Muskrats Taken	Per cent of change	Average number per licensed trapper
1935	1980			
1936	1785			
1937	2932			
1938	2311	132, 950		58
1939	1997	165, 005	+ 25	83
1940	1980	150, 976	- 9	76
1941	1960	124, 347	- 18	63
1942	2067	100, 416	- 19	49
1943	1539	124, 586	+ 24	81
1944	2231	242, 739	+ 95	108
1945	1981	133, 820	- 45	68
1946				
1947		167, 718		
1948	2471	169, 293	+ 1	69
1949				

It may be seen from the preceding discussion that the muskrat has, and still does, occupy a position of relatively great economic importance in Virginia. Despite the fact that muskrats furnish Virginia trappers an income of a quarter of a million dollars annually, little is known about the animal in the state. This project was designed largely to determine as much as possible about the muskrat in Virginia, and more specifically, its economic value in certain selected areas.

METHODS AND PROCEDURES

Objectives and Reasons for This Investigation

It is a well-known fact that muskrats reach their highest population levels in extensive marsh areas. As a rule, those muskrats inhabiting small streams are rarely considered in a muskrat management plan.

In Virginia, a large percentage of the annual muskrat harvest is taken from the extensive marshes of Eastern Virginia. However, if the complete picture could be presented, it would probably be found that the number of muskrats trapped from small streams in the state was equal to the number trapped from the marshes.

It was believed that an extensive study on a relatively limited area would show that the muskrat harvest from small streams was more important than is generally realized. As will be brought out in this report, the number of muskrats which small-stream trappers catch in Virginia make such trapping very profitable. In order that similar data might be derived from the marsh type of habitat, two marsh areas in Eastern Virginia were studied during this investigation. As will be shown later in this report, income derived from small stream muskrat trapping is comparable, considering the size of the operation, to trapping on the larger marshes of Eastern Virginia.

If one examines the annual muskrat harvest figures from Virginia, it may be seen that these figures are not excessively high. It would

appear that muskrat production is not as great as it might be, particularly on the small stream type of habitat. Apparently there are some factors operating against muskrats which tend to limit their reaching maximum populations. One of the objectives of this project was concerned with determining what these factors are and how they might best be controlled.

When this project was initiated, it was anticipated that a management program for muskrats on small streams might be recommended on the basis of data obtained. It was believed, also, that it could easily be demonstrated that small streams would produce a good income for the farmer and other part time trappers. It was with these objectives in mind, that this project was carried to completion.

THE INVESTIGATIONAL AREAS

Selection of Areas

In the original selection of study areas, several factors were taken into consideration. The first, and most obvious reason for selection was, of course, convenience of location. Since the primary study area was to be a county of southwestern Virginia, it was decided that accessibility should be the determining factor in selecting this area. Montgomery County naturally appeared to be the most likely area, since the base of operations for this project was located within the county. The county may probably be considered, at least roughly, as being typical of the mountainous section of Virginia.

It was decided that two marsh areas of different types in Eastern Virginia should be selected as study areas. The main criteria in selecting these areas were: (1) that they should be of approximately the same size; (2) that close cooperation could be gotten from the marsh owners and trappers; (3) that the two areas should represent different types of marshes and; (4) that a relatively good muskrat harvest was trapped from the areas annually. On the advice of one of the Virginia Game Technicians who had made a statewide marsh survey, the Island Farm Marsh in Richmond County and the Powhatan Hunt Club Marsh in James City County were selected as most nearly meeting these requirements. Both of these areas are approximately 250 miles from the home base, but since they were visited only periodically, travel presented no great problem.

Location of Study Areas

Montgomery County is located in southwest Virginia, in the second tier of counties from the West Virginia line. It comprises an area of 251,776 acres, or about 393 square miles. It is bounded by Giles and Craig Counties on the north, by Roanoke and Floyd Counties on the east, by Floyd County and Little River on the south, and by Little and New Rivers on the west.

The Powhatan Hunt Club Marsh is located approximately three quarters of a mile above the mouth of the Chickahominy River on Gordon's Creek in James City County. It is owned by the Powhatan Hunt Club of which Mr. C. W. Montgomery of Mannboro, Virginia is president.

The Island Farm Marsh is located in Richmond County immediately across the river from Tappahannock, Virginia. U. S. Highway 360 passes through the marsh, with the larger portion of the area lying on the east side of the road. The marsh is controlled by Mr. Alec Mallory of Warsaw, Virginia.

Description of Study Area I

Topography

The greater part of Montgomery County lies within what is known as the "Valley of Southwest Virginia," which is continuous with the great limestone belt, or limestone valley extending from New York to Alabama. The county is characterized for the most part by a strong surface relief, especially in the northern and eastern parts, where

mountain ridges and steep, broken areas abound. The topography of the southern portion is somewhat less severe, consisting of the rolling valley type, which in the extreme southern section runs into the dissected upland known as the Floyd-Carrol-Grayson plateau. The western and central parts of the area where the surface is hilly to rolling have the slightest relief of the county. Elevations above sea level vary from 1,200 to 3,500 feet with an average of 2,250 feet. The general direction of the mountain ranges, ridges, and hills is northeast to southwest.

The two principal drainage lines of the county are Little and New Rivers and tributaries in the south and west, respectively, ultimately finding their way into the Gulf of Mexico; and the North and South Forks of the Roanoke River with their tributaries in the east, flowing into the Atlantic. The divide, or watershed, separating these two drainage systems extends across the center of the county in a general north and south direction.

Climate

The climatic conditions of Montgomery County are quite typical of the middle-east mountain section. The winters are usually about four months long; January and February, the coldest months, having a temperature of about 31 degrees Fahrenheit. The summers are ordinarily warm, with frequent thunderstorms. The nights of late spring and early summer are generally quite cold.

The rainfall is well distributed throughout the year, especially so throughout the growing season. June, July, and August usually have the greatest amount of precipitation.

The mean annual monthly and seasonal precipitation and temperatures are presented below in Table 4. These data are based on records of the Weather Bureau Station at Blacksburg, Virginia.

Table 4. Mean monthly and annual precipitation and temperature for Montgomery County, Virginia

Month	Temperature (Degrees Fahrenheit)	Precipitation in inches
January	33.3	3.25
February	34.2	3.05
March	42.7	3.49
April	50.6	3.19
May	59.8	3.64
June	67.6	4.23
July	71.2	5.09
August	69.9	4.10
September	64.6	2.99
October	53.4	3.06
November	42.6	2.14
December	34.6	3.13

Soils

Montgomery County lies chiefly within the great valley region of southwest Virginia. This region, as already stated, is a section of the great limestone valley which runs from New York to Alabama. On each side of this limestone valley, which is from 5 to 10 miles wide, rise various mountain ranges composed of the harder or mountain-forming rocks, such as sandstones and conglomerates. These ranges generally extend in a well-defined northeast and southwest direction. The county is properly called a limestone area, since that formation covers approximately two-thirds of its extent. The upland soils of the region are residual in character and follow more or less closely the underlying geological

formations from which they are derived. Local conditions and modifying agencies over smaller areas have contributed to a variety of less important soil types, as has also the intermingling of disintegrated material of two or more formations. The small marginal areas of overflow areas along the courses of the larger streams present the only recent alluvial soil of the county. The various soils and soil conditions, climatic conditions, amount and distribution of rainfall, and the natural productiveness of the limestone soils, combine to render the area well adapted to a diversified agriculture.

The soils of the county were last officially mapped in 1907, at which time twenty three types were established in the area. The soils are now being retyped and it is likely that the original classification will be changed completely.

Evaluation of streams as muskrat habitat in Montgomery County

In order that other data might be systematically gathered, it was essential that the streams in the county be given some rating as to their suitability for muskrats. In view of this, a habitat evaluation survey was carried out.

All of the streams in the county were located on topographic maps, and then visited in the field by the writer. Two months were spent in the field during 1949 - 1950, getting the locations of the streams in mind and becoming generally familiar with them. The locations of all of the major streams in the county are shown in Figure 3.

The stream surveys were designed primarily to gather data for each area as to (1) major plant species present; (2) seasonal utilization of

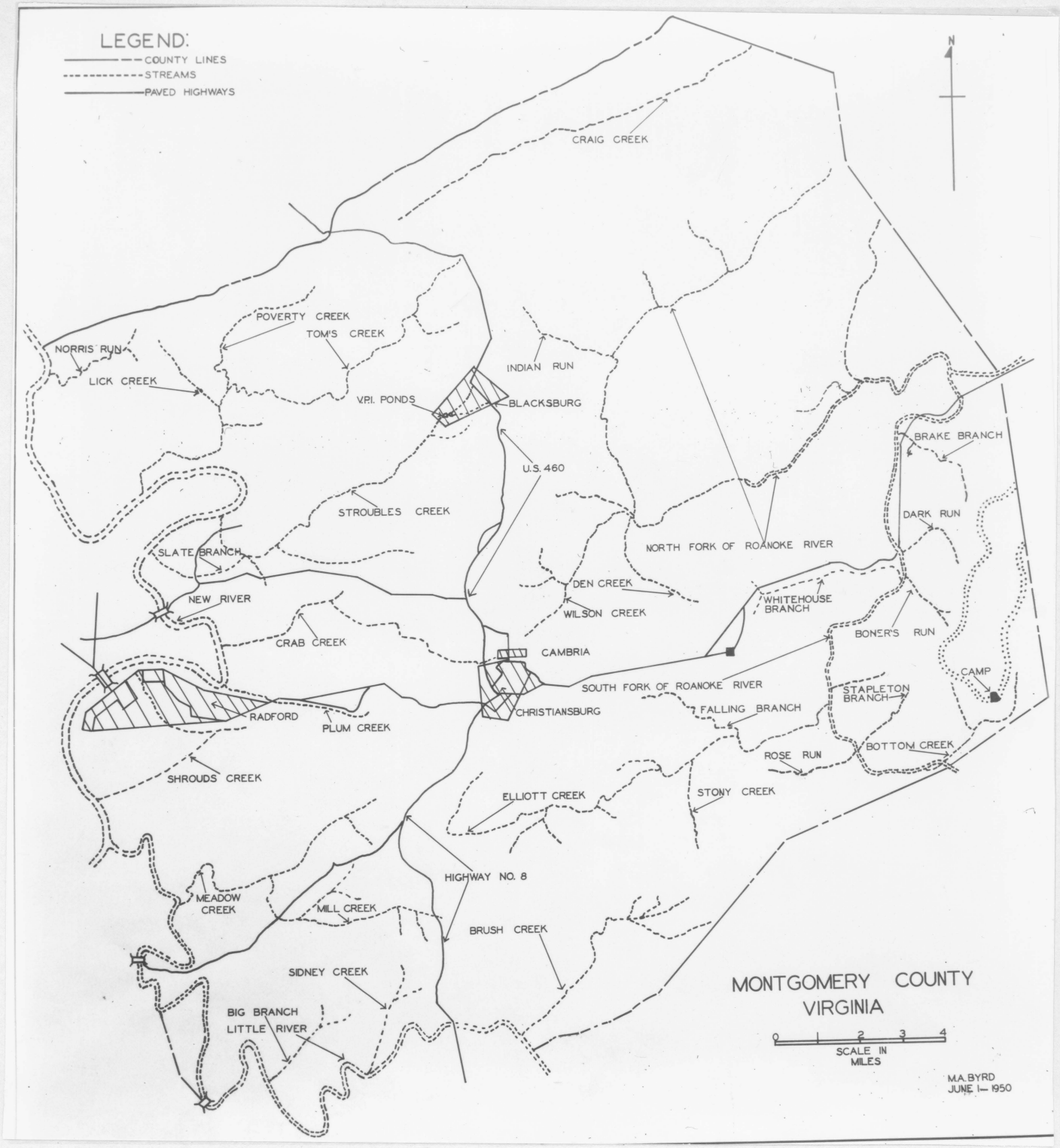


Figure 3. Map showing the location of the major streams in Montgomery County, Virginia

these plants by muskrats; (3) portion of plant utilized; (4) nature of the banks and; (5) water supply on the area.

Data were gathered by systematically covering the streams on foot. Vegetative data were recorded on a tally sheet of the type indicated in Figure 4. The procedure used was as follows: using the tally sheet, ten-foot square plots were taken at infrequent intervals along both sides of the streams. These plots were measured from the bank of the stream to a point ten feet out from that bank. If any emergent aquatics occurred in the stream immediately adjacent to the edge of the plot, they were included in that plot. It should be emphasized here that these vegetative studies were not intended as strictly quantitative measurements. These plots were not laid out at random, but were taken through the different cover types occurring on the streams. It was found that there were no major differences in the species present in any one cover type. It was hoped that the final results would indicate the trend of the feeding activities through the various seasons of the year, rather than an actual measurement of the foods eaten through the year. Results of the food habits study are presented in the appendix of this report.

On the basis of the data gathered in the above survey, an outline was written up for each stream. The outline proved to be extremely beneficial as a basis for doing other work on the streams. Results of the stream surveys indicated that the water areas of the county could be classified into 5 major groups. Table 5 shows the major areas under consideration with their total length in miles or area in acres. The

Stream Vegetation Survey

Area ---------- Observer ----------

Location ---------- Weather ----------

Date ----------

Plant Species	Abundance in Area			Degree of Utilization by Muskrats			Portion of Plant Utilized
	Abundant	Common	Scarce	Heavy	Medium	Light	

Miscellaneous Notes:

Utilization:

None - Complete absence of utilization by muskrats in any plots
Slight - Evidence of muskrat utilization on 1 - 40 per cent of the plots
Heavy - Evidence of muskrat utilization on 40 - 100 per cent of the plots

Measurements Used

Scarce - Plant occurs on less than 10 per cent of the plots
Frequent - Plant occurs on 10 - 75 per cent of the plots
Abundant - Plant occurs on 75 - 100 per cent of the plots

Figure 4. Sample form of the type used in the stream vegetation survey.

Table 5. Water areas of Montgomery County, Virginia, showing length in miles or area in acres, and their classification as muskrat habitat

Name of Water Area	Length in Miles	Area in acres	Muskrat habitat classification*
Norris Run	4.0		5
Lick Creek	1.75		5
Poverty Creek	6.75		5
Craig Creek	15.0		5
Tom's Creek	12.0		1
New River	28.0		2
Stroubles Creek	10.0		1
Slate Branch	2.50		4
Crab Creek	9.0		1
Plum Creek	4.75		1
Shrouds Creek	4.0		1
Meadow Creek	6.0		1
Mill Creek	4.75		4
Big Branch	3.0		1
Little River	22.0		2
Sidney Creek	3.0		4
Brush Creek	5.50		4
Elliott Creek	9.0		1
Stony Creek	2.0		4
Falling Branch	5.0		4
Rose Run	1.50		4
Stapleton Branch	2.0		4
Bottom Creek	2.50		5
Wilson Creek	4.0		4
Den Creek	2.50		4
Boner's Run	1.0		4
Whitehouse Branch	3.50		1
Dark Run	1.50		4
Indian Run	2.50		4
Brake Branch	2.50		4
North Fork of the Roanoke River	21.0		2
South Fork of the Roanoke River	14.0		2
Shawdow Lake		1.00	3
Virginia Polytechnic Institute Ponds			
(Upper)		1.68	3
(Lower)		5.55	3

* See text for explanation of habitat classification.

table also indicates the muskrat habitat rating of the streams based on the following classification:

(1) Slow moving streams with steep, heavily vegetated banks. These streams are capable of producing maximum muskrat populations. Areas of this type are rated as the best muskrat habitat in the county.

(2) Rivers which are subject to extreme fluctuations in water levels, but which do produce a fair harvest of muskrats in some sections. These areas are good habitat but do not approach the productivity per unit area which is found in the classification above.

(3) Small ponds which have the environmental conditions necessary to produce a good muskrat crop with the exception of an adequate food supply throughout the entire year. These areas produce a small annual harvest of muskrats and are here rated as fair muskrat habitat.

(4) Small branches of main streams which serve principally as breeding areas, but which do, in some cases, have a small overwintering population. These areas are similar in productivity to the small pond type of habitat, but when considered from the year round standpoint must be given a habitat classification of poor.

(5) Swift, rocky, mountain streams which do not show any of the environmental conditions necessary for the production of muskrats. These areas are entirely unsuitable as muskrat habitat.

Table 6 summarizes the mileage of the streams in each of the habitat classifications.

Table 6. Total number of miles and number of acres of water area in each muskrat habitat classification; Montgomery County, Virginia

Habitat Classification	Length in miles	Area in acres
1	85.0	
2	61.25	
3		8.23
4	30.0	
5	40.25	
Totals	216.50	8.23

Representative streams of each habitat classification are shown in Figures 5 through 9. It may readily be seen that it would be very difficult to cover intensively 216.5 miles of stream. For this reason, only a part of the streams in the county are considered in sections of this report. It was felt unnecessary to include a description of every stream in the county in the report, but a brief description of several of the more important streams in the county are included in the Appendix.

After each stream in the county had been covered, the percentage of that stream passing through the major cover types, cropland, pasture, and woodland, was compiled. These percentages are tabulated in Table 7. It may be seen that 67 per cent of the stream mileage in the county passed through woodland. It was found that those sections of stream which passed through woodland usually supported a relatively low muskrat population. Twenty-nine per cent of the stream mileage passed through pasture land and four per cent through cropland. As

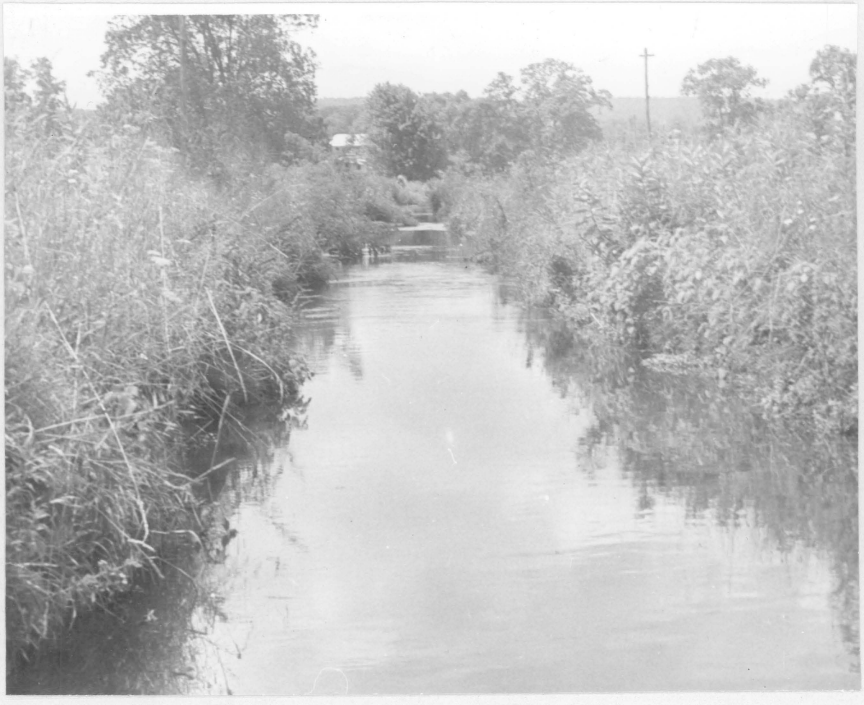


Figure 5. Stroubles Creek. This creek is typical of habitat classification 1, and supports maximum muskrat populations

Figure 6. New River. This stream is typical of habitat classification 2. These larger streams are subject to extreme and sudden fluctuations in water level, conditions which limit muskrat production.

Figure 7. Virginia Polytechnic Institute pond, typical of habitat classification 3. Ponds such as this lack an adequate winter food supply to support a high muskrat population throughout the entire year.

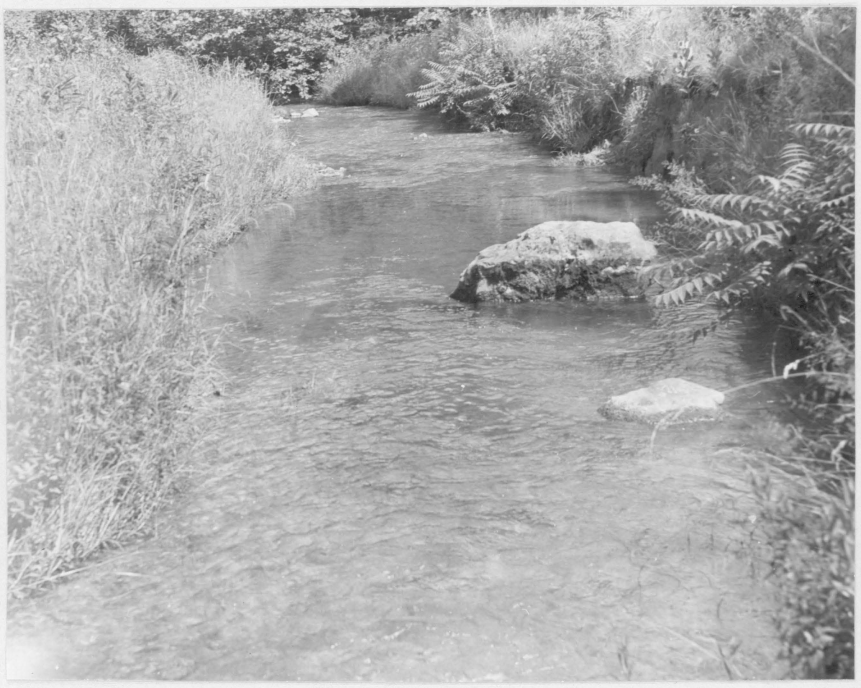


Figure 8. Indian Run, a branch of the North Fork of the Roanoke River. This stream typifies habitat classification 4, and does not support a muskrat population throughout the year.

Figure 9. Bottom Creek, representative of habitat classification 5. This is a typical, swift, rocky, mountain stream which has none of the environmental conditions necessary to support a muskrat population.

Table 7. Percentage of the streams in Montgomery County which pass through the three major cover types

Stream	Percentage of stream passing through the different cover types		
	Cropland	Pasture	Woodland
Norris Run	0	0	100
Lick Creek	2	0	98
Proverty Creek	2	3	95
Craig Creek	0	3	97
Tom's Creek	15	75	10
Indian Run	0	90	10
Stroubles Creek	0	70	30
Crab Creek	0	40	60
Plum Creek	0	65	35
Shrouds Creek	0	10	90
Meadow Creek	5	65	30
Mill Creek	0	50	50
Big Branch	5	20	75
Little River	10	15	75
New River	30	20	50
Sidney Creek	0	5	95
Brush Creek	5	20	75
Stony Creek	0	5	95
Elliott Creek	0	40	60
Falling Branch	0	0	100
Rose Run	0	0	100
Bottom Creek	0	0	100
Stapleton Branch	0	0	100
Wilson Creek	0	40	60
South Fork of Roanoke River	0	70	30
Boner's Run	0	10	90
Brake Branch	0	10	90
Dark Run	0	0	100
Den Creek	10	50	40
Wilson Creek	5	15	80
Whitehouse Branch	15	70	15
North Fork of Roanoke River	25	50	25
Bradshaw Creek	5	35	60
Total	134	956	2210
Average	4.0	29	67

would be expected, the highest muskrat populations were found on those sections of the streams passing through the latter two cover types. No attempt has been made to elaborate on the environmental conditions on the streams, as this can largely be determined by an examination of the stream position in the above habitat classification system.

Description of Study Area II

The Island Farm Marsh comprises an area of 1095 acres. This marsh is sometimes spoken of as a high marsh, which indicates that at high tide it is not covered by water. The marsh is largely protected from the full force of the Rappahannock tide by a sea wall of bay berry, wild cherry saplings, and pokeberry plants. The predominant vegetation in the marsh is three square (Scirpus olneyi and Scirpus americanus), cordgrass (Spartina cynosuroides), and cattail (Typha angustifolia). The marsh has a series of small fresh water ponds and islands of loblolly pine (Pinus taeda) scattered through it. The relationship of the major vegetative types may be seen in the map shown in Figure 11.

The salinity of the Rappahannock River at this marsh is approximately 17 per cent normal sea salinity. To facilitate making house counts at a later date, the entire marsh was cover mapped. A cover map of the area is shown in Figure 12. It was found that the marsh could be broken down into six major cover types, an explanation of which is given below:

CC - Cropland - Not included in the 1095 acres of marsh

PP - Isolated islands of Loblolly pine (Pinus taeda)

RR - Unproductive area of Juncus spp. and Carex spp.

DD - Small strip of Spartina cynosuroides and Myrica cerifera. This type occurs only as a small strip along the beach.

TT - Cattail area composed largely of Typha latifolia and Typha angustifolia.

SS - This is the largest and most productive type in the marsh. The vegetation is principally Scirpus olneyi and Scirpus americana, with some Peltandra virginica and Lemna minor.

In 1933, an August tidal wave covered the marsh completely, and in some places destroyed the vegetation. These areas naturally revegetated themselves and there have been no major environmental changes on the area since.

The following table shows the acreage and percentage of the total area made up of each cover type.

Table 8. Acreage in the different cover types on the Island Farm Marsh, Richmond County, Virginia

Cover Type	Percentage of the total area in the cover type	No. of acres in the cover type
CC	Not included	—
PP	12	130
RR	10	110
DD	1	10
TT	14	150
SS	63	695
Totals	100	1095

Figure 10. Island Farm Marsh, looking east. Note the relatively heavy concentration of muskrat houses in the Scirpus olneyi type.

Figure 11

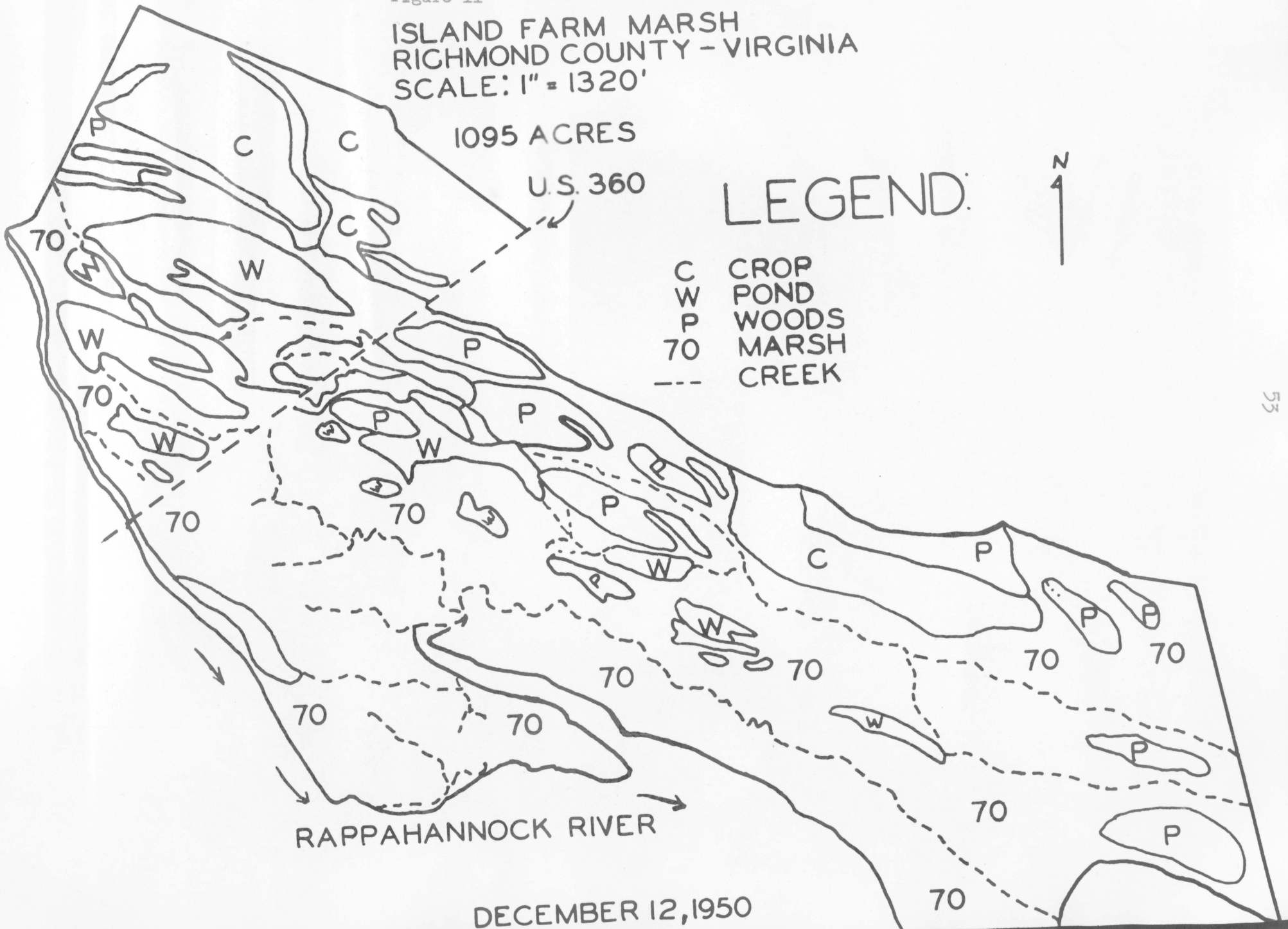
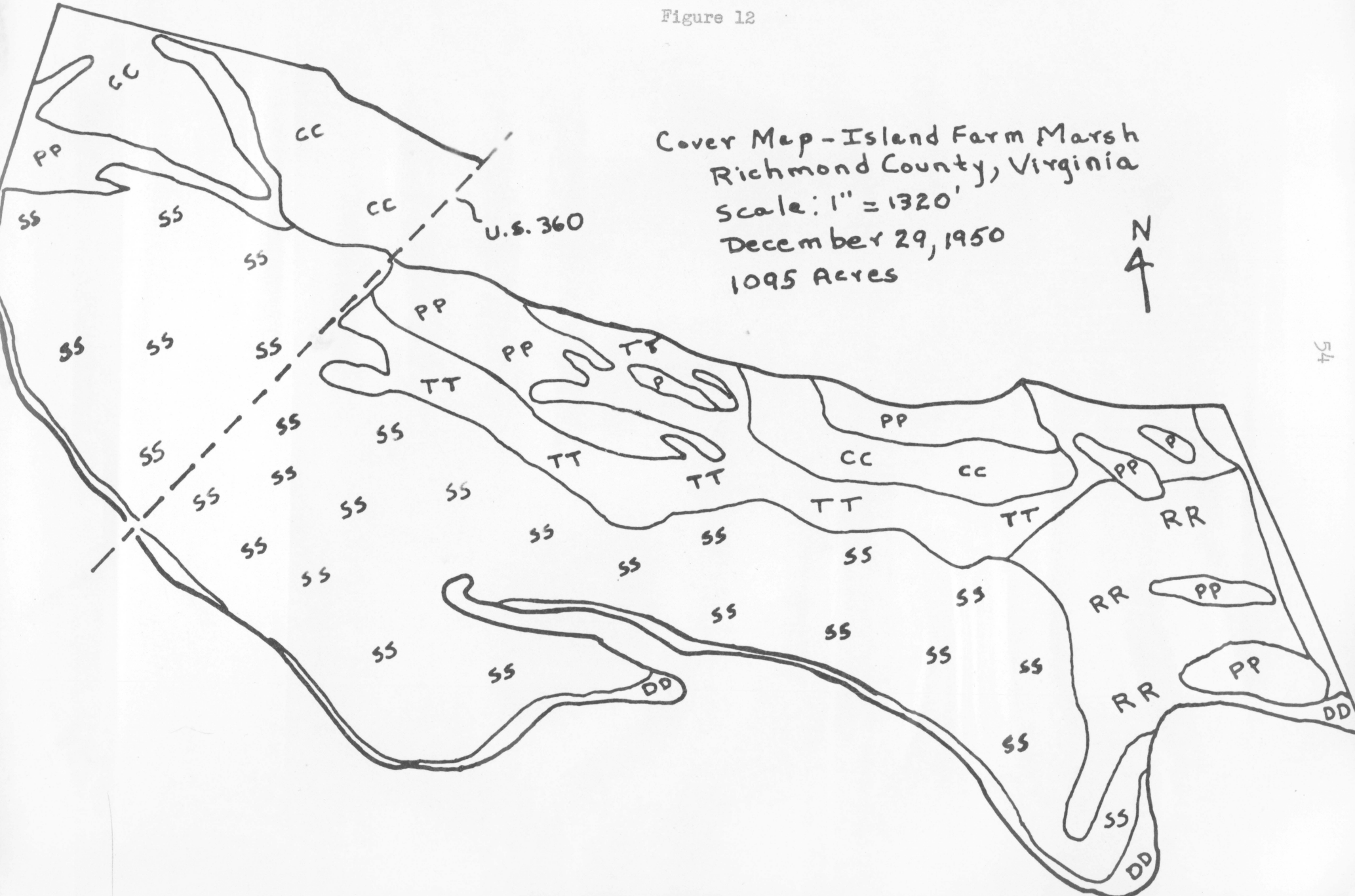

ISLAND FARM MARSH
RICHMOND COUNTY - VIRGINIA
SCALE: 1" = 1320'
1095 ACRES
U.S. 360
LEGEND:
C CROP
W POND
P WOODS
70 MARSH
--- CREEK
N
RAPPAHANNOCK RIVER
DECEMBER 12, 1950

Figure 12


Cover Map - Island Farm Marsh
Richmond County, Virginia
Scale: 1" = 1320'
December 29, 1950
1095 Acres
N
U.S. 360
CC
PP
SS
TT
RR
DD

Description of Study Area III

The Powhatan Hunt Club Marsh comprises an area of 1000 acres. The marsh is of the type that is generally referred to as a low marsh in that it is exposed to the air only during the low stages of the tide. The bottom is mucky and extremely soft, usually not supporting the weight of a man.

The water in the marsh is approximately 0.42 per cent normal sea salinity. It may be seen from this that the water in the Powhatan Hunt Club Marsh is almost neutral at the present time. All water samples which have recently been collected in the marsh may be considered fresh, but the salt content is appreciably greater than the normal fresh waters found farther up the river, indicating that when a prolonged drough reduces the volume of water coming down the James and Chickahominy Rivers, the tide will bring much more brackish water up the Chesapeake Bay. Studies along the Potomac indicate that it takes several years following such an influx of salt before the bottom soil is washed free from the high degree of brackishness. This undoubtedly accounts for fluctuations of abundance of the big salt marsh cordgrass (Spartina cynosuroides). The year following an influx of brackish water should usually bring an increase in Spartina which might persist until the next influx of brackish water if the interval was not too long, or the floods which flush out the marshes were not too severe.

The marsh was surveyed by boat to determine the principal plant species on the area. There is an apparent scarcity of corn reed

(Spartina cynosuroides) at the present time. Present vegetation indicates that the water is too fresh for Spartina to make its maximum growth, for this giant grass is typically a brackish marsh plant. The dominant plants on the marsh at present are:

arrow-arum - Peltandra virginica
pickerel weed - Pontederia cordata
wild rice - Zizania aquatica
giant cutgrass - Zizaniopsis miliaceae
rice cutgrass - Leersia oryzoides
swamp dock - Rumex verticillatus
smart weed - Polygonum spp.
three square - Scirpus americanus
soft stem bulrush - Scirpus validus
river bulrush - Scirpus fluviatilis
Grass cutting sage - Panicum virgatum
Narrow leaf cattail - Typha angustifolia
mallow - Hibiscus moscheutos
touch me not - Impatiens biflora
dayflower - Commelina virginiana
corn reed - Spartina cynosuroides
tide marsh water hemp - Acnida cannabina
reed grass - Phragmites communis var. berlandieri
sedge - Carex lacustris
spike rush - Eleocharis ovata - palustris

Among the submerged plants are:

coontail - Ceratophyllum demersum
pondweed - Naias flexilis
leafy pondweed - Potamogeton foliosus
curly muckweed - Potamogeton crispus
water weed - Elodea canadensis
water star grass - Heteranthera dubia
wild celery - Vallisneria spiralis

There are traces of arrowhead (Saggitaria latifolia) and iris (Iris versicolor). Pickerel weed appears to be the most heavily utilized food by muskrats on the marsh.

There are sometimes excessively high tides on this marsh during the spring and summer. During 1950, there were no such tides, and as

Figure 13. Powhatan Hunt Club Marsh. Note that the marsh is here covered by considerable water. Vegetation is principally pickerel weed (Pontederia cordata) and some wild rice (Zizania aquatica)

a result, the muskrats on the area apparently had one of their best breeding seasons. The marsh was heavily utilized by waterfowl throughout the fall and winter seasons. It is for its waterfowl and sora hunting that the area is of its greatest importance.

As will be discussed later in this report, most of the muskrats on the marsh live in bank dens. As may be seen in Figure 13, there are few places in the marsh proper which are high enough to be habitable by muskrats.

CHARACTERISTICS OF THE MUSKRAT IN VIRGINIA

Taxonomy of the Species

Under the name of mussascus, musquash, or ondatra, there are numerous references to the animal in the literature of the period succeeding the early 1600's. Linneaus (1766), gave the muskrat an independent taxonomic position, placing it in the genus with the beaver and giving it the name, Castor zibethicus. The specific name, zibethicus, has been used for the form from Eastern Canada and the Northern United States by most systematists to the present day. The Linnean specific name has been associated between 1788 and 1840 with no less than eight generic names.

From time to time various mammalogists have described forms of muskrats from many parts of North America, giving them specific or subspecific rank as the limited material before them seemed to justify. Seventeen names have been thus proposed, and with the idea of determining their respective validity and importance, and of mapping the ranges of the recognizable forms, a study of the large collections of skins and skulls of the muskrats in the United States National Museum was undertaken by Hollister (1911).

The genus was generally considered monotypic up to 1890, when Mearns described a new form from Camp Verde, Arizona, as Fiber zibethicus pallidus. During the next thirteen years eight new muskrats were named. Merriam (1897), described Fiber macrodon from the Dismal Swamp of Virginia. No more names were proposed for existing species until 1910,

when, as a result of the systematic revision of Hollister (1911), three recognizable forms were described; O.z.zalophus from the Alaska peninsula (1910), O.z.mergens for Nevada (1910), and O.z.cinnamominus from Kansas (1910). Tiedemann (in Hollister, 1911) proposed the generic name, Ondatra, for the animal.

There are at present 14 subspecies of Ondatra zibethica recognized in North America, with some systematists giving rivalicius and obscura specific rank. It is with two of these subspecies, O.z.macrodon and O.z.zibethica, that we are primarily concerned in Virginia.

Description of the Species

The following description of Ondatra zibethica zibethica and Ondatra zibethica macrodon are based on the work of Hollister (1911).

Ondatra zibethica zibethica

Type Locality - New Brunswick; eastern Canada

General Characters - Size large; tail long; color dark; skull large, with zygomata not broadly spreading anteriorly; molars of medium size.

Color - Upperparts mummy brown, darkest on head; back glossy; sides chestnut to hazel. The darker color on back is due to the blackish overlying hairs, the color of the fur being much like that of sides. Underparts like sides but paler, approaching tawny, shading to whitish on throat and belly; a small spot on chin and hair of wrist and heel blackish; lips straw yellow; underfur light slay gray; nasal pad and tail black; feet dark brown; nails pale straw to brown.

Measurements - Table 9 is a summary of flesh measurements of 132 specimens from different counties of southwestern Virginia. It should be borne in mind that these are average measurements and include subadult as well as adult animals.

Table 9. Average flesh measurements of 132 specimens of Ondatra zibethica zibethica from three southwestern Virginia counties. (All measurements in millimeters)

Locality	Number Averaged	Total Length	Tail	Hind Foot
Montgomery County	106	574	252	82
Floyd County	14	564	253	83
Giles County	12	572	250	81

Ondatra zibethica macrodon

Type Locality - Lake Drummond, Dismal Swamp, Virginia.

General Characters - Size largest in the genus; colors rich and bright; normal pelage with much red in fresh and worn state. Skull large and massive; teeth large.

Color - Like zibethicus, but lighter and brighter, with less black. Upperparts Prout's brown, darker on nose, head, and back; sides varying from grayish brown to russet; underparts from broccoli brown or drab to bright cinnamon rufous. Specimens in perfectly fresh pelage have very little of the bright russet tinge which specimens take on later in the winter and spring. Spring specimens, before the summer molt has commenced, are often especially bright and rich colored above and below.

Measurements - Table 10 summarizes the flesh measurements of 253 specimens from five eastern Virginia counties. These also are average measurements, and include subadult as well as adult animals.

Table 10. Average flesh measurements of 253 specimens of Ondatra zibethica macrodon from five eastern Virginia counties (all measurements in millimeters)

Locality	Number Averaged	Total Length	Tail	Hind Foot
Richmond County	97	612	275	89
James City County	88	619	272	86
Southampton County	26	621	276	88
Norfolk County	33	618	269	88
Nansemond County	9	610	274	85

The small discrepancy in size between these two subspecies of muskrats apparently has no noticeable effect on their fur value. As previously mentioned, Ondatra zibethica zibethica usually has a somewhat better quality fur than does Ondatra zibethica macrodon. Evidence would seem to indicate that this is not due to any size differences, but rather, to other factors.

Distribution in Montgomery County

Distribution of the muskrat in Montgomery County is governed principally by the suitability of the existing habitat. The present distribution of the muskrat in the county was determined by systematically

covering each stream by either foot or boat. All existing signs of muskrats, such as droppings, tracks, cuttings, and burrows were noted, and the occupied habitat was determined on this basis. Figure 14 shows the distribution of the muskrat in the county as determined by the above survey. It should be realized that this map deals only in generalities. There is, of course, considerable ingress and egress of individuals on some of the streams. These movements are usually local, and do not at all effect the general distribution pattern in the county.

The muskrat is fairly evenly distributed over a majority of the county with the exception of the extreme north and east sides. Topography here becomes a limiting factor, as the streams are extremely swift and rocky, and, as a consequence, offer little in the way of muskrat habitat. Most of the streams in the southern portion of the county are also limited in the amount of suitable muskrat habitat which they provide. Muskrats are here present in moderate numbers only.

Those streams lying in the central and western sections of the country support the heaviest muskrat population. This is largely a habitat condition, as many of the streams have steep banks with few rocks, offering optimum muskrat habitat for this section of the state. From an economic standpoint, it is decidedly more advantageous for a trapper to operate on streams in these sections of the county.

The data indicate that approximately 75 per cent of the annual muskrat harvest from the county is trapped from streams in the central and western sections. There are, of course, relatively high catches from some of the other streams, but the consistently high catches come from the above-mentioned regions.

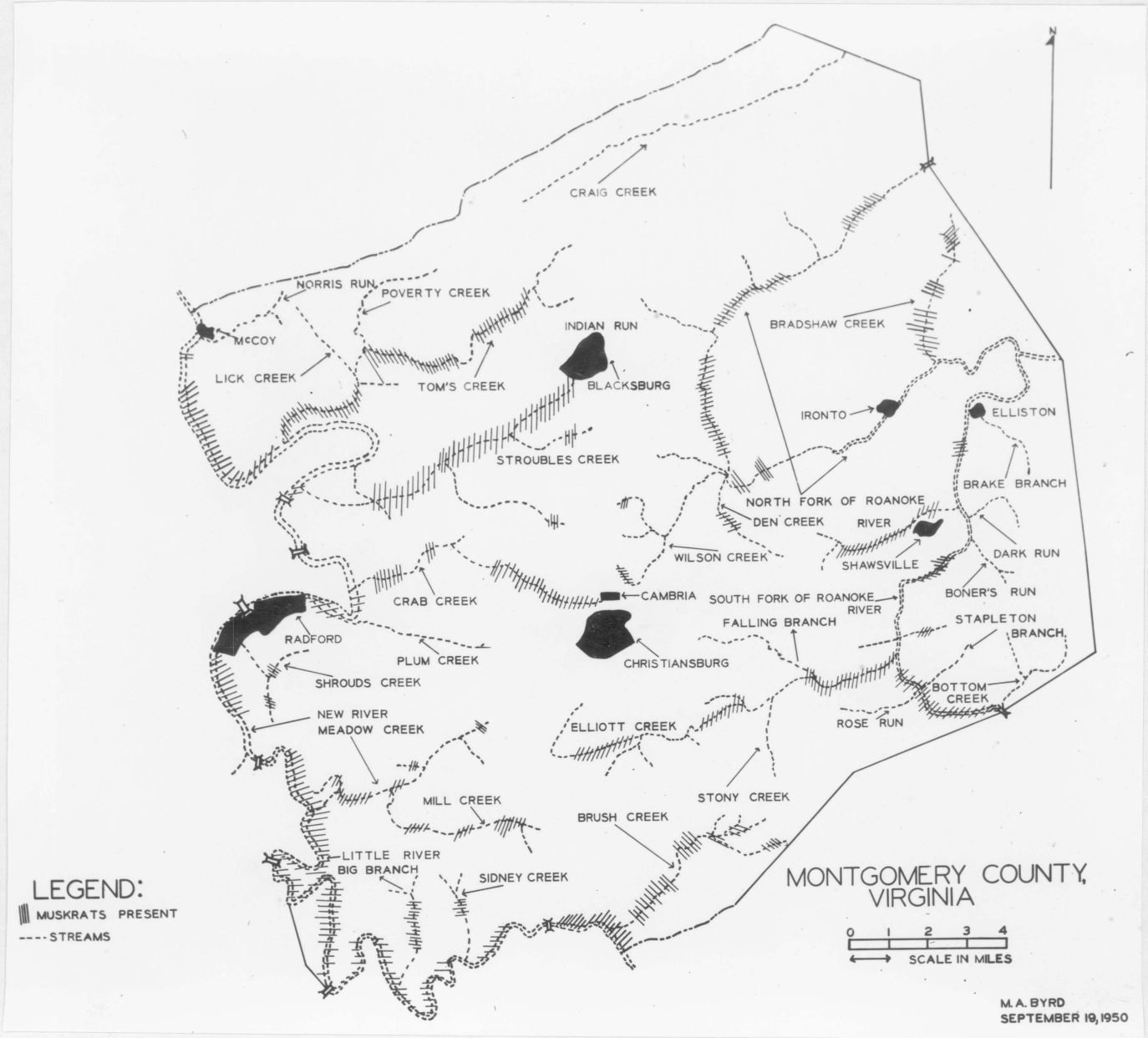


Figure 14. The distribution of the muskrat in Montgomery County, Virginia, based on systematic coverage of all streams by boat or by foot.

Breeding Habits

There are few or no scientific data on the breeding habits of the muskrat in Virginia. Limited studies have been conducted in other areas, however, on gestation periods, number of young per litter, and number of litters per year.

Seton (1910), considers it fairly well established that the male muskrat is monogamous in his breeding habits. Others, particularly trappers, refute this statement, and believe that the male muskrat is polygamous. No definite data were gathered on this point during this investigation. The gestation period of the muskrat fluctuates considerably, but is normally of 28 to 30 days duration (Errington, 1937). Litters average three to six young each, with two litters per year being the general rule. Errington (op. cit.) found that three litters per year does not seem to be of infrequent occurrence, and in one instance found incomplete but strong evidence of a fourth litter.

The length of the breeding season naturally varies with the section of the country. As a general rule, the season runs from late February through September, or occasionally October. In the more southern states, such as Louisiana and Texas, there is evidence that breeding may continued throughout the year.

During early February, 1950, twelve female muskrats were examined in Currituck County, North Carolina. All of these animals had swollen and inflamed vaginal openings, indicating that they had entered a breeding condition. If this were true, then a large number of females

should be pregnant and give birth to young during the first two weeks of March. This would apparently justify the statements of many trappers who claimed that they were catching large numbers of pregnant and nursing females during the legal open trapping season which closes on March 15. One very reliable trapper on the Powhatan Hunt Club Marsh claims to have caught pregnant females during early March. A trapper even reported catching a young rat of the year on March 14. There was no definite evidence to support this, and the writer is inclined to regard this report with some scepticism. The trapper on the Powhatan Hunt Club Marsh also furnished fairly conclusive evidence of three litters in one year for a single female. He observed an adult female with young during the latter part of March at a den just below his residence. During May, a female with young of approximately the same age as the previous litter, was again observed at the same den. The logical assumption was that this was the same female with her second litter of the year. The female, supposedly the same, was again seen in July with a litter of the approximate age as the preceding two. It is not inconceivable that even a fourth litter might have followed.

The above evidence would seem to indicate that the first litter is born about March 15 - April 1 in eastern Virginia. On June 12, 1950, a small muskrat was caught by hand on Stroubles Creek in Montgomery County. The estimated age of this animal was six weeks, which would indicate that it was born during the last week of April. If this assumption was correct, breeding probably starts in the county during the latter part of March. In view of altitudinal and climatic differences, one would

normally expect the breeding season to begin three weeks to a month later in the mountainous section of the state than in the eastern section.

Observations of twelve young muskrats of estimated age in Montgomery County would seem to indicate that litters were born in late April, mid-July, and mid-August, 1950, and there is strong reason to believe that some litters were born during late September or early October. This latter period probably resulted from the unseasonably warm fall weather. Several very immature muskrats were trapped in early December by preseason trappers. These animals were classed as kits, and apparently were about eight weeks of age. The fur was decidely of a type characteristic of a juvenile animal.

The writer on several occasions has observed young muskrats in Southampton County during May and July. This might indicate that the litter dates in Eastern Virginia are approximately early April, mid-May, and early July.

More precise knowledge of the breeding habits of the muskrat in Virginia would be of value in regulating the trapping season. Actually, it makes no difference whether a female is caught in March after becoming pregnant, or in December before becoming pregnant, unless that female is more susceptible to trapping in March. If this be the case, then an earlier trapping season would greatly aid in increasing the number of muskrats trapped, and consequently, the income derived from muskrat trapping. The primary objective of any wildlife management plan is to make the maximum use of our wild animal populations which is compatible with their continuous maximum production. As regards the muskrat in

Virginia, information is sorely needed as to any differences in catch by sex at various periods of the trapping season and exact breeding date information. It is believed that a study of the relationship of differential sex catchability to the season should be undertaken, as well as a definite establishment of the breeding dates of the muskrat in Virginia. These facts might serve as a basis for management plans which could greatly increase our annual muskrat harvest.

Predation

According to Errington (1943), predation on muskrats by various animals may often reach spectacular and serious proportions. With the possible exception of man, the mink appears to be the worst enemy of the muskrat. Dearborn (1932), listed muskrat remains in 65.92 per cent of 297 food-containing mink carcasses obtained in Michigan during the winter of 1930 - 1931. Hamilton (1940), reported a muskrat incidence of 49.33 per cent for 300 mink scats collected in the summer of 1939 from the Montezuma Marsh of central New York. Numerous other investigations have revealed an equally high percentage of occurrence of muskrat remains in mink droppings.

Other workers have indicated that a large number of predators feed upon muskrats at one time or another. Included in this predatory group are the raccoon, marsh hawk, bobcat, water moccasin, and muskellunge. Karl Bednarik, while working at the Ohio Cooperative Wildlife Research Unit, found evidence that the ordinary barn rat (Rattus norvegicus) was preying heavily on juvenile muskrats during June and July.

No evidence of rats (Rattus norvegicus) preying upon muskrats was noticed during the course of this investigation. There are, however, numerous rats on most of the streams of Montgomery County. Many trappers reported catching these animals in traps which they had set for muskrats. The writer had two muskrats, believed to have been attacked by barn rats, severely damaged in traps. It is quite possible that predation by rats on young muskrats does occur in the county. Conclusive evidence of this could be obtained only by intensive observation during the months of June and July. There was no evidence that this type of predation occurs in the marshes of Eastern Virginia.

The only specific instances of predation on muskrats in Montgomery County were seen on the North Fork of the Roanoke River. Two dead muskrats were found on this stream by a trapper from Shawsville, Virginia. Both animals were apparently killed and partially devoured by mink.

The writer was unable to spend enough time in the Eastern Virginia marshes to make any definite observations on predation. Numerous reports were received, however, of predation on muskrats by raccoons. In several marshes, raccoon tracks and droppings were noticed on and around muskrat houses. Everyone interviewed was of the opinion that raccoons were killing muskrats, but only one trapper actually claimed to have seen a raccoon in the act of opening a house and killing the occupants. This trapper, caretaker on the Powhatan Hunt Club Marsh stated that "while walking through the marsh during the first part of June, I observed a dark animal on top of a large muskrat house. Upon

approaching this house, I identified the animal as a rather large raccoon which ran off through the marsh. The top of the muskrat house had been broken open, apparently by the raccoon. Inside were four small muskrats, three of which were dead of bites through the neck. The fourth animal was still alive, but had been dropped by the raccoon as I approached the house." This would seem to be fairly conclusive evidence that raccoons do kill muskrats. Numerous trappers reported seeing large numbers of houses which had apparently been opened by raccoons.

Limited observations would seem to indicate that predation on muskrats does not reach economically important levels on any of the three Virginia study areas. Trapper reports seem to justify saying that the raccoon is a serious predator, but further work is needed to substantiate this report. It is quite possible that locally predation may be a serious economic loss to the muskrat industry, particularly when many young are killed in the nest.

Parasites

Very few workers have devoted full time to parasitological studies of the muskrat. The available information relative to parasitism in the muskrat is very meager if one considers the economic value and importance of the animal.

Leidy (1858) was one of the first workers to mention a parasite from the muskrat, when he reported Monostomum affine. Barker (1911 - 1916), made several investigations, involving descriptions of eight new species of flukes, two new tapeworms, and three new nematodes. Meyer

and Reilly (1950), summarize from the literature the work of several investigators in three sections of the country. These investigations, dealing with a significant number of hosts and species of helminths, have added greatly to our knowledge of the distribution and ecology of the species of muskrat helminths.

A review of the literature reveals a total of 55 parasitic species occurring in the muskrat. These species are comprised of 29 trematodes, 8 cestodes, 12 nematodes, and 6 arthropods.

Meyer and Reilly (1950), during the 1946-1947 trapping season, examined 127 muskrats (33 for both helminths and arthropods, 71 for helminths only, and 23 for arthropods only) from Maine, and recovered 7 species of trematodes, 2 species of cestodes, 2 species of nematodes, and one species of arthropod. Only one muskrat was found to be entirely free of parasites, and two others harbored only Acarina.

No part of this investigation was devoted solely to gathering data on the parasites of Virginia muskrats. Several instances of parasitism were noted, however. Almost all of the muskrats which were trapped in Montgomery County, and which were examined by the author soon afterward, were found to be heavily infested by external parasites. Specimens were sent to Dr. E. W. Baker, Washington, D. C., who identified them as mites, Laelaps mutispinosus Banks, of the Family Laelaptidae. Apparently these mites do not cause any harm to the host animals.

All muskrats which were trapped by the author were opened, and the viscera examined. During January, February and March, 1951, several animals were found to have their livers heavily encysted with tapeworms.

Dr. W. L. Threlkeld, Virginia Agricultural Experiment Station, identified these parasites as a strobilocercus form of Taenia taeniaeformus Batsch. Hegner, Root, Augustine, and Huff (1938), have the following to say of this parasite: "it is a very common cestode of the cat and has been reported from a large number of wildcats. Its larval stage, or bladder worm, generally known as Cysticercus fasciolaris of rats and mice is a Strobilocercus. Neither the adult worm or the larva is of economic importance, but the larva is of particular interest because of its association with sarcamatous growths in the liver of the rat. Under natural conditions it is frequently found enclosed in such tumors. Large numbers of cases of sarcoma of the rats liver have been produced by feeding them onchosperes of the species. The tumors arise from the encapsulating tissue surrounding the parasite." Rausch (1946), reports finding this parasite in the liver of 4 out of 70 muskrats from Iowa. These, also, were encysted in the livers of the animals. Apparently these worms do not harm the animals to any great extent. In Iowa, a percentage of infestation of 6 per cent was obtained, while on Stroubles Creek a percentage of infestation of 31 per cent was found. The limited amount of time spent on parasitological work during this investigation precluded the establishment of any host-intermediate host relationship for this parasite. Figure 15 shows a muskrat liver infected with nine encysted tapeworms, Taenia taeniaformis.

It is obvious that a species such as the muskrat, in which the population density often becomes very great, offers a good chance for heavy parasitic infestation. It may become necessary, in some cases,

Figure 15. Muskrat liver from Montgomery County, Virginia, infested with numerous encysted Taenia taeniaformis

to manipulate environmental conditions so as to eliminate the intermediate hosts for these parasites. Limited observations during this investigation, however, would seem to indicate that parasites do not pose a serious threat to the muskrat population on the Virginia study areas.

Disease

Disease, in its most serious aspects, can completely eliminate a muskrat population. Dr. Paul L. Errington of Iowa State College has worked considerably on a hemorrhagic epizootic disease in Iowa. This disease, often of infrequent, spasmodic occurrence, has caused serious losses in Iowa muskrats. In many instances, all of the muskrats on specific marshes and streams have been completely killed out.

Penn and Martin (1941), recorded a high frequency of occurrence of procephaliasis in the Louisiana muskrat (Ondatra zibethica rivalicia). Shillinger (1938), reports infestations of muskrats with coccidiosis, and claims that such infestations are influenced by fluctuating water levels. Other workers have found evidence of disease outbreaks in muskrats in various sections of the country.

No indications were found of any serious disease in Montgomery County during this investigation. Three animals were found dead on Stroubles Creek and the V. P. I. ponds. Autopsies revealed that these animals had died of pneumonia, probably a secondary infection resulting from the loss of a leg in a trap. This disease was probably induced by extreme shock, suffered as a result of the loss of the leg. It would be interesting to know to what extent delimbed animals die as a result of secondary complications.

No evidence was found of disease on any of the eastern Virginia marsh areas. There have been reports in past years of disease outbreaks, apparently similar to those in Iowa. During one or two years, according to trappers and others, the muskrat population on Long Island in Back Bay was practically eliminated by a disease outbreak. Trappers reported finding many dead animals during this period, but unfortunately, no data were gathered by competent individuals.

The trapper on the Powhatan Hunt Club Marsh reported finding a large number of muskrats dead in their houses during the winter of 1948. He believed that these animals froze to death. Weather reports would seem to indicate that the temperature was never low enough during this period to justify such a belief. It is more likely that these animals died as a result of a serious disease outbreak, although no sick animals were reported. It was interesting to note that this same condition prevailed on many of the marshes along the Chickahominy, Pamunkey, and Mattaponi Rivers during that year.

It is obvious that disease, when it manifests itself as in Iowa, may often reach serious economic proportions. In Virginia, it is possible that disease may have caused serious economic losses to trappers on some marshes. In general, on the three Virginia study areas, disease does not appear to be of economic importance, but intensive study during periods of low muskrat populations may refute this statement.

Color Variations

Dozier (1948) has done considerable work on the color variations in muskrats. Most of his work has been concerned with the Virginia

muskrat (Ondatra zibethica macrodon), and he considers color variations from the genetic point of view.

There are two general color phases in the Virginia muskrat-- the "browns" and the "blacks". The normal color phase of this race is a rich brown with russet and red tinges. While there may be considerable differences, both trappers and fur buyers class these as "red" or "brown" muskrats. A black color phase occurs commonly throughout the range of the race, and in some Virginia marshes this may run as high as 65 per cent of the population. The typical "black" of eastern Virginia has a uniformly glossy black dorsum, but the sides and belly have hairs which are banded with yellow. Dozier (1948), has shown that colors may vary from light buff and black to complete albinism. Animals of this latter type are apparently rare throughout the range of the race. Color ratios were obtained from several sections of eastern Virginia and North Carolina and are presented in Table 11.

Table 11. Color ratios in the Virginia muskrat (Ondatra zibethica macrodon) from several areas in Virginia and North Carolina

Area	No. muskrats examined	No. blacks	No. browns	Percentage ratio Blacks: Browns
James City County	446	203	243	46:54
Richmond County	623	296	327	48:52
Norfolk County	33	22	11	67:33
Nansemond County	9	5	4	56:44
Southampton County	297	75	222	29:71
Princess Ann County	51	31	20	61:39
Currituck County, North Carolina	31	19	12	61:39

It would appear from these data that the color ratio favors the "browns" as one approaches the southwestern range limits of the race. This has been the general observation of the writer.

In Montgomery County, two distinct color phases have been noted for the common muskrat (Ondatra zibethica zibethica). The first of these phases is the common "brown" which closely resembles the "browns" of the eastern race. The second of these phases is a so-called "black" which is rather rare, and is known locally as a "bastard" muskrat. This color phase differs from the "blacks" of the eastern race in that the guard hairs of the dorsum are not truly black, but are banded with yellow as are those hairs of the other body regions. Out of several hundred pelts examined from Montgomery and Floyd Counties during 1949-1950 and 1950-1951, only 14 of this color phase showed up. Eight of this number were from Montgomery County, and six from Floyd County. With the exception of two pelts from Stroubles Creek, all of the other "bastard" muskrats were apparently trapped on Little River. There was no obvious reason why this condition should exist.

In past years, the "blacks" of eastern Virginia brought $0.10 to $0.25 more per pelt on the market. In recent years, however, "blacks" and "browns" have brought an equal price when put up for sale. The "blacks" of Montgomery County brought $0.15 to $0.25 more per skin during 1949-1950 and 1950-1951 than did the regular "browns." There is not enough difference in the price of one color phase over another to make this condition economically important, either on the eastern Virginia study areas, or in Montgomery County.

Intraspecific Strife

Muskrats are often relatively pugnacious in their behavior toward one another. The incisors of the muskrat are very sharp, and capable of inflicting painful, if not mortal, wounds on other muskrats. Errington (1937), found that mortality of young resulting from attacks of adults was of frequent occurrence. Such strife undoubtedly results in the death of large numbers of young. In areas of high populations, Errington (1941) believes that serious intraspecific competition may often lead to cannibalism.

Intraspecific strife exhibited itself most frequently both in Montgomery County and in eastern Virginia as slashed and damaged pelts. The economic aspects of this damage will be considered more fully under the section on pelt studies. It is likely that pelt damage from intraspecific fights is not of particularly serious economic importance. It was found that pelts with one or two small slashes brought about the same price on the markets as did undamaged ones.

In Montgomery County, pelt damage resulting from intraspecific fights was most common on Stroubles and Meadow Creeks. This may undoubtedly be attributed to the high wintering population on these two areas. Intraspecific competition was apparently of little consequence on any of the other streams of the county.

Accidents

Muskrat losses from accidents appear to be relatively insignificant from the standpoint of the total population. Observations indicate

a number of muskrats are killed annually on the highways of the state. A total of fifteen animals was found dead on U. S. 360 and U. S. 33 during this investigation. Local residents were of the opinion that the number of animals killed in this way was usually very small. It was noticed that the number of animals killed on highways was greatest during the fall when dispersal movements were under way.

If one considers death from the loss of legs in traps as accidents, it is obvious that some mortality results from this cause. As previously mentioned under the section on disease, however, death from the loss of a leg is usually a result of secondary disease complications, and is usually of little economic importance.

In general, evidence is not sufficient to warrant placing accidents as a major cause of mortality in either Montgomery County or eastern Virginia.

Drowning and Freezing

Errington (1937), states that, "It is well known that muskrats may be drowned by high waters, especially in lowland stream habitats or in places subject to pronounced flooding." He further indicates that muskrats may be killed by beating rain and wave action, suddenly increased water levels, and by young being dragged from houses and ignored by females.

One adult animal whose death was attributed to drowning was found during this investigation. This animal was found just below the dam at the junction of Little and New Rivers where excessively heavy waters might easily flood a den and drown its occupants.

There have been reports by trappers in the state of animals freezing during the winter. The writer could find no evidence to substantiate this report. In Montgomery County, the muskrats appeared to winter comfortably, despite adverse weather conditions. Whereas a few animals are killed, it would not appear that mortality from drowning and freezing is of consequential economic importance.

Sex Ratios

Considerable data have been gathered on the sex ratios occurring among muskrat populations. Unfortunately, a large majority of this work was based only on a small series of animals, and the observed ratios thus may or may not reflect the true ratio which exists in the entire population of an area. With the possible exception of the work done by Smith (1938), in Maryland on pen reared muskrats, all sex ratios have been obtained from wild animals trapped during the legal open season. Dozier (1942), was probably the first worker to make a sex ratio study based on an extremely large series of animals. His data, recorded from 9304 muskrats, probably represent the most comprehensive work done to date.

Table 12 briefly summarizes muskrat sex ratios as recorded in the literature. These data were compiled through 1941 largely by Dozier (1942), and were brought up to date by the author. These ratios ranged between 47 and 64 per cent males. The only instances recorded in which there was a preponderance of females are from the works of Dozier (1944), Marshall (1937), and Svihla (1931).

Table 12. Muskrat sex ratios (Based principally on data recorded in the literature)

State	Authority	No. of males	No. of females	Sex Ratio (Males:Females)	Season
Maryland	Dozier (1944)	3749*	2635	143:100	1942-1943
Maryland	Dozier (1944)	114**	124	92:100	1942-1943
Maryland	Dozier (1942)	5210	4094	124:100	1941-1942
Louisiana	Svihla (1931)	282	318	88:100	1925-1926
Louisiana	Svihla (1931)	173	90	168:100	1926-1927
Utah	Marshall (1937)	808	748	108:100	1936-1937
Delaware	Stearns and Goodwin (1941)	1683	1095	142:100	1938-1939
Maryland (Dorchester County)	Smith (1938)	178	80	160:100	1933 1936-1938
Maryland (Worcester County)	Smith (1938)	887	697	124:100	1926-1932
Minnesota	Hatfield (1939)	281	110	128:100	1938
Wisconsin	Buss (1941)	1578	709	176:100	1939-1940
Iowa (young)	Errington (1939)	478	400	118:100	1934-1936
Iowa (fall trapped)	Errington (1939)	321	263	120:100	1936-1938
Illinois	Frison, et al. (1941)	294	206	126:100	1940
Vermont	Seamans (1941)	846	448	162:100	1940
Pennsylvania	Grimm (1941)	197	138	126:100	1938-1940
Pennsylvania	Grimm (1941)	391	284	124:100	1940
England	Warwick (1940)	396	279	128:100	1933 and 1934
Virginia (Montgomery County)	This study	211	165	124:100	1949-1950
"	" "	350	208	168:100	1950-1951
(Powhatan Marsh)	" "	323	260	124:100	1950-1951

* Adults only included in sample
** Kits only included in sample

In interpreting these data, it is imperative that several factors and conditions be given some consideration. Trapping techniques, season of the year, and weather conditions may all play some part in influencing a differential trapping success among the sexes in muskrats. It would appear that a sex ratio approaching 50:50 would most likely appear when a large series of animals was sexed from the same area. This was not the case, however, as the largest samples yielded results which were nearest the extremes, with nearly all of the ratios indicating 50-64 per cent males in those muskrats harvested between the fall and spring seasons.

The general consensus of opinion among trappers in many of the states is that proportionately more female animals are harvested as the trapping season progresses. This was found to be a common belief among Virginia muskrat trappers, and many of them altered their trapping methods so as to take the largest number of animals during the early part of the trapping season, when they reputedly would harvest a greater number of males. If this were true, and there was a point during the trapping season at which females began to make up a majority of the catch, it could be advantageously used in the management of the species, and in the manipulation of the trapping season for that species. In an effort to test the validity of this belief, trapping season sex ratios were recorded weekly during the course of this investigation. These data were kept for both Montgomery County streams and one of the Eastern Virginia marsh study areas, and are considered in detail later.

The work of several other investigators in different sections of the country would seem to indicate that a preponderance of males was

harvested throughout the entire legal trapping season. Dozier (1948), in summarizing the sex ratios for a five-year period from Maryland states that there was a significant preponderance of males over females. This excess of males over females was consistently maintained during each of the trapping seasons involved. Local trappers were of the opinion that the greater wandering tendencies of the males might lead to some selectivity in trapping. Marshall's (1937), work in Utah, mentioned previously, was one of the few instances in which there was an excess of females over males. The data from Utah revealed that intensive trapping in the fall resulted in a sex ratio of 48 males to 52 females and that intensive trapping in the spring, on the same areas, resulted in a sex ratio of 60.6 males to 39.5 females. Errington (1939), found the sex ratio of 878 young less than two weeks old to be 54.4 per cent males, compared with the late fall and early winter ratio of 54.9 per cent males for 584 young of the year. McCann (1944), found that a fall sex ratio among mature animals showed more females, and the spring sex ratio more males. This would seem to indicate that some mortality factor was operating disproportionately against the male muskrats between spring and fall. If this condition were true, there was evidently a preponderance of males in young of the year to compensate for the loss. Other workers have indicated that there was a greater percentage of males at birth, but that the males reacted more drastically to adversity than did the females.

Lay (1945), indicates that when traps are first set out in an area they usually catch males. The trapper on the Powhatan Hunt Club Marsh

in James City County agrees with this statement. He also maintains that his catch of females may be greatly increased at any time by walking into the marsh to set his traps, rather than confining his operations to the creek banks and edges of the marsh. Marshall (1937), quotes his trapper as saying that by conducting a series of light trapping operations on an area, he can achieve a high proportion of males in the catch. Apparently there is an inverse relationship between trapping intensity and the proportion of males in the catch. Under present state trapping regulations, average trapping intensity results in sex ratios of 50 to 60 per cent males, and where trapping intensity is increased, a proportionately greater number of females are caught.

An examination of the ratios found by Marshall (1937), in Utah would reveal that this theory does not hold true. Not only did intensive fall trapping produce a greater percentage of females, but females actually constituted a greater part of the total harvest. Spring trapping revealed an increase in the sex ratio in favor of the males. Petrides (1950), advances the possibility that Marshall's fall ratios might be true ratios resulting from practical extermination of the population, and that the increased proportion of males in the spring might be the result of ingress of wandering individuals. A thorough analysis of trapping season sex ratios would probably indicate that they are not the sensitive indicators of trapping pressure which trappers attribute them to be.

During the course of this investigation, sex ratios were obtained from specimens in Montgomery County during the 1949-1950 trapping season, and from Montgomery County and James City County during the 1950-1951 trapping seasons.

Several sexing techniques were employed, depending upon the material at hand. It was found that the easiest method of sex determination was the system proposed by Baumgartner and Bellrose (1943). This consists principally of noting whether the penis is present or absent in the urethral papilla. The penis may be easily exposed by pressing at the base of the urethral papilla. The vaginal orifice is posterior to the urethral papilla, and if closed, can be reopened by pulling the papilla forward and pulling posteriorly on the skin just anterior to the anus. This system was found to be applicable in sexing both dead and live animals. Figures 16 and 17 illustrate the method of sexing muskrats by an examination of the external genitalia. In those specimens in which the dead carcass was available, the sex was rechecked by an examination of the internal sex organs as proposed by Errington (1939). It was often necessary to sex many animals by an examination of the pelt, as all animals in widely scattered areas could not be examined before the animals were skinned. This technique involved the location on the dried skins of teats, in the case of females, and remains of the penal sheath in the case of males. It was found that this system of sexing was reasonably accurate, although there were some few pelts which could not be positively sexed.

During the 1949-1950 trapping season, a total of 376 specimens was sexed. Of these 376 specimens, 27 were sexed using all three of the techniques described above. It was found that in using all three techniques of sexing that there was no discrepancy in the established sex of any of the 27 specimens. The remaining 350 animals were sexed

Figure 16. The penis of the male may be easily exposed by pressing with the fingers at the base of the urethral papilla

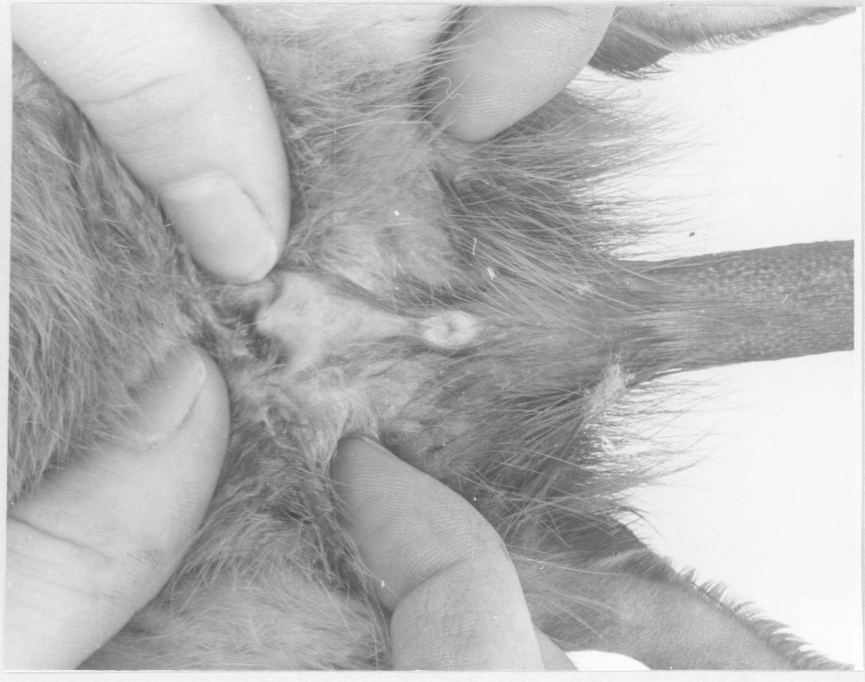


Figure 17. Females are easily distinguished by noting the complete absence of hair immediately posterior to the urethral papilla

in local buyers' fur houses by pelt examination. There were 10 pelts which were not considered because of inadequate evidence for accurate sex determination. It may be seen in Table 12 that of the 376 specimens examined, 211 (56%) were males and 165 (44%) were females. This gives a male:female sex ratio of 112:88 which is comparable to that observed by other workers.

As previously mentioned, sex ratios were recorded weekly during the trapping season on two of the study areas. These data are presented below in Table 13.

Table 13. Weekly muskrat sex ratios from Montgomery County and the Powhatan Hunt Club Marsh, James City County, Virginia, 1950-1951.

Period	Area					
	Montgomery County		Sex Ratio	Powhatan Marsh		Sex Ratio
	Males	Females	Males:Female	Males	Females	Males:Females
Jan 1-7	43	35	122:100	78	70	109:100
Jan 8-14	31	27	114:100	50	40	125:100
Jan 15-21	24	22	110:100	52	38	135:100
Jan 22-29	12	9	132:100	42	36	118:100
Jan 30-Feb 5	6	5	120:100	31	22	140:100
Feb 6-Feb 12	9	9	100:100	18	9	200:100
Feb 13-Feb 19	12	8	150:100	14	6	234:100
Feb 20-Feb 26	10	9	110:100	15	14	107:100
Feb 27-Mar 4	16	15	107:100	13	14	92:100
Mar 5-Mar 11	10	8	125:100	10	11	90:100
Totals	173	147		323	260	

It should be emphasized here that sex ratios were not obtained for every muskrat from both areas. Further, it was often very difficult to

ascertain just when the pelts examined were trapped. It is believed that a majority of the pelts sexed during January 1 - January 15 were trapped prior to the open season of January 1. In examining these data, this should be taken into consideration. The figures which were obtained should be sufficiently accurate to be indicative of the trend of the ratios throughout the trapping season. It may be seen in Table 13 that there was a preponderance of males throughout the trapping season in Montgomery County. There were local exceptions, however, on some of the streams, as the overall sex ratio of the animals trapped from Stroubles Creek favored the females.

On the Powhatan Hunt Club Marsh, there was a preponderance of males in the catch through the latter part of February. After this date, the rather small catch was composed of a greater number of females than males. This might tend to confirm the opinion of trappers that more females are caught during the latter part of the trapping season and toward the early part of the breeding season. The data are too limited to draw any definite conclusions on this point.

As previously mentioned, sex ratios were obtained for 376 muskrats from Montgomery County during the 1949-1950 trapping season. Of these 376 specimens, 349 could be definitely traced to the stream from which they were trapped. These sex ratio data are presented below in Table 14.

Table 14. Sex ratios of 349 muskrats from several streams in Montgomery County, Virginia, 1949-1950 trapping season

Stream	No. of males	No. of Females	Ratio Males:females
Stroubles Creek	40	30	134:100
Tom's Creek	45	44	102:100
Meadow Creek	20	12	167:100
Little River	30	26	115:100
Smith Creek	5	7	71:100
Big Branch	10	8	125:100
North Fork of the Roanoke Riv.	23	15	153:100
South Fork of the Roanoke Riv.	6	6	100:100
Whitehouse Branch	4	2	200:100
Elliott Creek	9	7	130:100
Totals	192	157	

It may be seen here that there was also a preponderance of males trapped on every stream in the county with the exception of Smith Creek. It is possible that this is a case of insufficient data, as records were secured for only 13 animals. Comparable data from other streams, however, still revealed a preponderance of males in the catch.

Because of the large number of skins handled by local dealers, it was impossible to establish the specific creek from which muskrats were trapped during 1950-1951. A total of 558 muskrats from Montgomery County were sexed by pelt examination during 1950-1951. It was impossible to find out the exact dates that some of these animals were trapped, and for that reason, data are presented for only 320 pelts in Table 13. Sex ratios for 558 Montgomery County and 337 Floyd County muskrats are presented in Table 15.

Table 15. Sex ratios of 895 muskrats from Montgomery and Floyd Counties, Virginia, 1950-1951 trapping season

Area	No. of males	No. of females	Sex ratio, Males:females
Montgomery County	350	208	168:100
Floyd County	185	152	122:100
Totals	535	360	

Again, there were more males than females in that portion of the muskrat harvest examined. It would appear that the ratio for Montgomery County is rather high, and is possibly due to poor sampling methods.

The application of sex ratio data to other problems of wildlife management has been greatly enhanced by the recent work of Petrides, (1949). Several important population conditions, including rearing success, juvenile mortality, peaks of breeding, population sizes, and mortality rates may be determined by a knowledge of sex ratios in combination with age ratios. A collection, analysis, and application of sex ratio data was not primarily a part of this investigation and all sex ratio data which were collected were obtained incidental to the main project. It is believed, however, that collection of such data would reveal facts which could advantageously be used in the management of the species, and which might, in the long run, be of considerable practical importance.

Age Ratios

The application of age ratios in determining various population phenomena has made the collection of such data very desirable. Age ratios in muskrats have been recorded by proportionately fewer investigators than have sex ratios. Petrides (1950), has largely compiled the available age ratios from the literature. Data from this investigation were added to the compiled list, and are presented in Table 16.

Errington (1940), in speaking of Iowa, states that "lower breeding densities have given somewhat higher rates of increase in all types of environment from which we have data, except when breeding animals were presumably too few to find mates as needed. Clearly, optimum breeding densities are at moderate, rather than at extreme, levels--low enough to avoid the disadvantages of overcrowding, yet not so low that seasonal recovery is handicapped."

If these premises are true, then trapping season age ratios may be used as readily available indices for determining whether the breeding population was low the preceding spring and summer. All of the muskrat pelts from Montgomery County are trapped on small creeks, rivers, and ditches. Errington (1940), points out that the population turnover in such habitat usually exceeds the turnover in marsh areas.

Several methods have been devised for separating young of the year from adult muskrats. These methods are particularly applicable during the legal, open, state trapping seasons. It is extremely unlikely that any of these methods is infallible. Errington (1939), distinguished young of the year from adults by macroscopic examination of the testes

Table 16. Trapping season juvenile: adult ratios of muskrats (Primarily computed from previous published data)

State and authority	Date	Method of age determination	No. of animals	Young per adult	Young per ad.female
Iowa (Errington 1944)	1936	Internal sex organs	181	2.77	5.54*
Iowa (")	1937	Internal sex organs	208	3.73	7.46*
Iowa (")	1938	Internal sex organs	206	4.28	8.56*
Iowa (")	1939	Internal sex organs	201	5.39	10.78*
Iowa (")	1943	Internal sex organs	831	7.31	14.62*
Illinois (Baumgartner and Bellrose) (1943)	1940-41	External genitalia	1147	2.46	4.92
Michigan (")	1940-41	External genitalia	7511	1.84	3.68
Minnesota (McCann 1944)	1941	Internal sex organs	567	2.65	4.84
California (Sooter, 1946)	1943-44	External genitalia	1530	3.09	6.18
South Dakota (Aldous, 1947)	1944-45	Tagged animals	85	1.07	2.09
Michigan (Applegate Predmore 1947)	1946	External genitalia	64	3.92	8.50
Missouri (Shanks, 1948)	1946	Several methods	455	2.18 to 3.74	4.39 to 7.48
Ohio (Petrides, 1950)	1947-48	External genitalia	202	5.73	13.23
Ohio (Petrides, 1950)	1947-48	Primeness method	1466	5.37	12.36
Virginia (Montgomery County)	1949-50	External genitalia	28	1.81	6.00
Virginia (Montgomery County)	1950-51	Primeness method	349	3.65	7.41
Virginia (Montgomery County)	1950-51	Primeness method	558	3.24	8.82
Virginia (Floyd County)	1950-51	Primeness method	337	4.52	9.52

* Assuming a male:female ratio of 50:50.

and uteri. The testes of adult animals were wrinkled and flaccid, showing evidence of having shrunk from previous enlargement whereas the testes of young muskrats did not show this condition. Females were distinguished on the basis of the presence or absence of placental scars. Baumgartner and Bellrose (1943), described a system of age determination which was applicable to live animals. This system distinguishes adult females from subadult females by noting the condition of the vaginal orifice. The orifice is apparently closed from birth to just before the first breeding season in subadult animals. In adults, the orifice appears to be open during most of the year and if a membrane is present, it is so thin as to break readily. In subadult females, the vaginal membrane is relatively thick, and considerably harder to break than that of an adult animal. Adult and subadult males were differentiated according to the size of the penis and the ease with which it can be pressed through the urethral papilla. The shape of the penis of an adult muskrat is different from that of a subadult, being blunt and more or less rounded at the tip, whereas that of a subadult is knob shaped. Applegate and Predmore (1947), classified a group of muskrats as subadults (one year old) and adults (two years and older) according to the method of age determination of Baumgartner and Bellrose (1943). They were then able to separate the subadult animals from the adults on the characteristics of their patterns of primeness. Shanks (1948), also recognized the significance of the apparent age differences in muskrat pelts which were noticed, but apparently passed over by Lavrov (in Shanks, 1948). They found that the primeness pattern on adult muskrats

exists as very irregular spotted areas, while the primeness pattern on juvenile pelts is typically bilaterally symmetrical. Figure 18 illustrates the typical primeness pattern of juvenile pelts.

The primeness pattern is a very valuable method of age determination, particularly when only the pelts are available for examination. Shanks (1948), points out that the method is not without complications, however. During the course of his investigation, he examined 16 females whose pelts were of a juvenile type, and which yet possessed placental scars. Of these 16 females, 3 had more than 7 placental scars which indicates that some adult pelts may possess juvenile-type primeness patterns.

Shanks (1948), attempted to analyze the accuracy of the primeness pattern method of aging as compared to Errington's (1939), internal sex organ method and Baumgartner and Bellrose's (1943), external genitalia method. He states that the results are comparable, and almost equally valid. Petrides (1950), analyzed these data but found the differences in results between the three methods were significant, and decided that Shank's conclusion apparently had no justification. Petrides (1950), accentuates the differences derived by Shanks by appending age ratios to his percentage data.

Since the different methods gave different results, it is rather difficult to ascertain whether one method is superior to another. Applegate and Predmore (1947), tested the primeness method in 69 pelts of known age and misidentified three adults as young, and two juveniles as adults. It may be seen that these errors tended to compensate for each

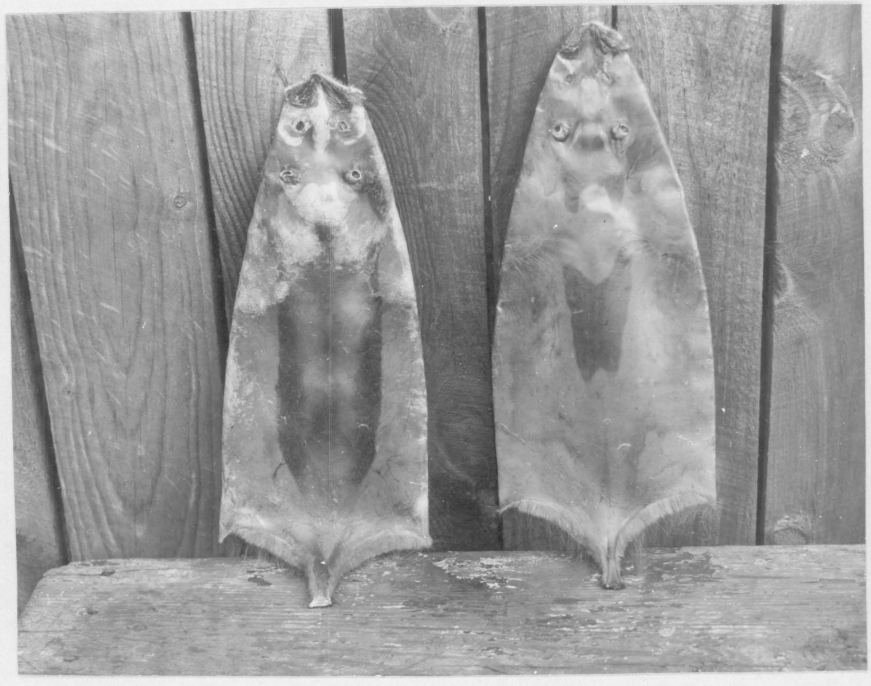


Figure 13. Typical bilaterally symmetrical primeness patterns of subadult muskrat pelts

other. It is quite possible that the errors in each method are more or less constant, and comparisons of age ratios derived annually by a single method might indicate changes in the proportions of young produced each year.

Shanks' (1948), data indicate that the two systems of determining age by examining sex organs are in closer agreement with each other than they are with the primeness pattern method. It would appear that examination of the external sex organs was the most accurate method of age determination.

During the course of this investigation, approximately three hundred muskrats were aged by an examination of the external sex organs. No difficulty was experienced in separating subadult males from adult males. It was found that there was often some difficulty in distinguishing subadult females from adult females. In several January subadult, female muskrats, there was no vaginal membrane present. The age of these animals was further verified by an examination of the pelt primeness pattern. Apparently this absence of the vaginal membrane in subadult females exists only in an occasional animal, and there is no specific period during which the frequency of occurrence increases. Petrides (1950), found that the vaginal membranes of a small number of juvenile Ohio muskrats showed indications of breaking in mid-December, and that the number of females displaying this condition increased during early January. It was found that this system of aging could not be applied to muskrats in Eastern Virginia after February 10. After this date, a large majority of the animals examined had open and enlarged vaginal orifices, indicat-

ing that they had already entered a breeding condition. This proved to be true in 12 female muskrats examined in Currituck County, North Carolina on February 11, 1949. The condition also existed in muskrats examined during late February on the Powhatan Hunt Club Marsh, James City County, and the Island Farm Marsh, Richmond County.

Petrides (1950), did some work on aging muskrats by means of bacula, or examination of the bone of the penis.
He states that "from these it was evident that the bacula of adult males were heavier and longer than those of juveniles. Their trident-like terminal elements were also less cartilaginous. Because of their small size, muskrat bacula probably will not prove suitable for widespread collection, but they may occasionally serve as checks against other criteria probably up to about January 1."

It was possible during the 1949-1950 and 1950-1951 trapping seasons to age 256 muskrats in Montgomery County by the use of all three systems described above. These data are presented in Table 17 in a form similar to Shanks' data as modified by Petrides (1950).

Table 17. Comparison of age ratios of 256 muskrats from Montgomery County, Virginia, by three methods

Method	No. of juv:ad.	Percentages juv:adults	No. of young/ adult	No. of young/ adult female
Primeness pattern	184:72(29)	72:28	2.56	6.34
External genitalia	171:85(35)	67.33	2.01	5.26
Internal sex organs	177:79(39)	69.31	2.08	4.54

Statistical tests reveal that the results here obtained are not of equal validity. This would agree with Petrides' (1950), analysis of Shanks' data. It is believed that the results obtained above by examination of the external genitalia are the most nearly correct.

During the 1949-1950 trapping season, age ratios were collected from 349 muskrats according to the streams from which they were trapped in Montgomery County. These data were made available by one of the local fur dealers who very kindly kept his muskrat pelts in lots as they were brought in from the different streams. It was, of course, impossible to collect age ratios from all of the muskrats harvested in the county. All of these age ratios were necessarily derived from an examination of the primeness pattern on the pelts. It is possible that these incomplete data may not be truly indicative of the true ratios prevailing on the streams. The age ratios obtained from Montgomery County during the 1949-1950 season are presented in Table 18.

Table 18. Age ratios of Montgomery County, Virginia, muskrats, 1949-1950 trapping season

Stream	No. of juv: adults	Percentage juv:adults	No. of young/ adult	No. of young/ adult female
Stroubles Creek	58:12(6)	83:17	4.83	9.67
Tom's Creek	78:11(6)	88:12	7.09	13.00
Meadow Creek	25:7 (4)	78:22	3.57	6.25
Little River	40:16(7)	71:29	2.50	5.71
Smith Creek	9:3 (2)	75:25	3.00	4.50
Big Branch	13:5 (2)	72:28	2.60	6.50
North Fork R.R.	29:9 (5)	77:23	3.22	5.80
South Fork R.R.	7:5 (2)	58:42	1.40	3.50
Whitehouse Branch	4:2 (1)	66:34	2.00	4.00
Elliott Creek	11:5 (2)	70:30	2.20	5.50

These data, assuming that they are close to true age ratios, follow closely Errington's premise that a low breeding population is followed by a heavy increase in the breeding potential. Trapping was very intensive on Stroubles and Tom's Creeks during the 1948-1949 trapping season. The high ratio of young per adult female would seem to indicate that the breeding population was low and was followed by a high production of young. Moderate to light trapping on the other streams resulted in a relatively high breeding population which produced a moderate number of young per adult female.

For reasons mentioned previously, it was impossible during the 1950-1951 trapping season to determine from which streams specific muskrats were trapped. All muskrats examined during the season were aged at local dealers' fur sheds by examination of the pelt primeness pattern. Data are presented below in Table 19 for 558 muskrats from Montgomery County and 337 from Floyd County.

Table 19. Age ratios of 895 muskrats from Montgomery and Floyd Counties, Virginia, 1950-1951 trapping season

Area	Ratio of juv:ad.	Per cent of juv:ad.	No. young/ adult	No. young/ ad. female
Montgomery County	450:108(51)	81:19	3.24	8.82
Floyd County	276:61 (28)	82:18	4.52	9.52

Assuming that these data also represent true ratios, it would appear that trapping was fairly heavy in the two counties during 1949-1950, leaving a moderate breeding population in the spring of 1950. This, in turn, was followed by a relatively high production of young per adult female.

Age ratios, as well as sex ratios, may be put to good use in determining various factors about the population in question. Widespread collection of such data in Virginia may solve management problems which could greatly increase the annual muskrat harvest. Answers to such problems may prove to be a real boon to the muskrat industry from the economic point of view, by permitting a maximum muskrat harvest without over utilization of this fur resource.

Weights

Weights have frequently been suggested as a possible criterion in aging muskrats. Several workers have kept very accurate records over a period of years in an effort to test the validity of weight as an age indicator.

During this investigation, weights were obtained for 706 muskrats, 158 of which were from Montgomery County; 249 from the Powhatan Hunt Club Marsh, James City County; and 299 from the Island Farm Marsh, Richmond County. It should be emphasized here that the weights obtained from the marsh areas are by no means representative of the trapping season as a whole, as all of them were obtained on several days during the first and latter parts of the trapping season.

All weighing was done on a Chatillon spring hand scale, reading in pounds and tenths. As muskrats were weighed only when completely dry, water had no effect on the weights. Weights by one tenth pound groups are presented for the three areas in Table 20.

Table 20. Weights of muskrats from three Virginia areas

Weight group pounds	Area					
	Montgomery County		Island Farm		Powhatan Marsh	
	Adults	Subadults	Adults	Subadults	Adults	Subadults
.6				1		
.7						
.8				2		4
.9		1		3		3
1.0		3		7		5
1.1				5		
1.2				4		3
1.3		1				
1.4						4
1.5		5		9		3
1.6				8		7
1.7						4
1.8		10		12		9
1.9		6	5	15	4	19
2.0		17	4	21		20
2.1	4	7	4	38		22
2.2	3	26		26	6	30
2.3	3	8		20	5	20
2.4	5	4	5	11	3	3
2.5		5		9		
2.6	8	2	7	4	12	5
2.7	3	3				7
2.8	9		15	3	5	
2.9	12		29		20	
3.0	2				3	
3.1	2		7			
3.2	2				4	
3.3	1		4			
3.4			6		5	
3.5					2	
3.6						
3.7				2		
3.8			1			
Totals	60	98	101	198	81	168

It may be seen in Table 15 that subadults most frequently weighed 2.0 to 2.3 pounds on all three of the areas. Adults weighed 2.8 to

3.0 pounds more frequently than any other weight on all three areas. Average weights for each area are presented below in Table 21.

Table 21. Average weights of subadult and adult muskrats from three Virginia areas

Age group	Area		
	Montgomery County	Island Farm	Powhatan Marsh
No. of subadults	98	198	168
No. of adults	60	101	81
Avg. weight in pounds (Subadults)	2.06	1.98	2.00
Avg. weight in pounds (Adults)	2.66	2.76	2.70
Avg. weight in pounds (Subadult Males)	2.12	2.09	2.11
Avg. weight in pounds (Subadult Females)	1.91	1.87	1.91
Avg. weight in pounds (Adult Males)	2.72	2.79	2.74
Avg. weight in pounds (Adult Females)	2.61	2.66	2.62

It may be seen from Table 21 that there was an amazing correlation between average weights on the three areas. There was a mean average difference in weight of males over females. This was found to be the case on all three areas. In order that the overlap in weights of subadults and adults might be more clearly seen, weight frequencies for each area were graphed in Figures 19, 20, 21, and 22 respectively. Figure 22 represents the composite weight frequencies of the muskrats from all

three areas. It would appear from Figure 19 that there is a somewhat sharper line of demarcation between the weights of subadult and adult muskrats in Montgomery County than is found on the other two areas. It may be seen, however, in Figures 19, 20, 21, and 22 that there is probably too much overlap in the weights of adults and subadults to use weight alone as an age criterion.

Weights, as such, apparently have no definite influence on the price of muskrat pelts. No correlation was derived between fat, heavy muskrats and the primeness and condition of their pelts. When weights may be correlated with vegetative conditions or other factors, however, they may be of some significance in the management of the species.

Population Estimations

The number of animals on any given area is constantly fluctuating, and for that reason it is often difficult to make accurate population estimates. The habits of species vary so greatly that it is usually necessary to set up a separate census method for each different animal. Some knowledge of the population of a given species on an area is essential for intelligent management of that species.

Survival of the muskrat depends largely upon the animal's ability to conceal itself. In Montgomery County, muskrats spend most of their existence in complicated underground burrow systems, and their presence is detected primarily by the amount of "sign" which they leave. This "sign" usually takes the form of droppings, scratch marks, tracks, slides, and cut vegetation. Observation of muskrat activity is frequently the

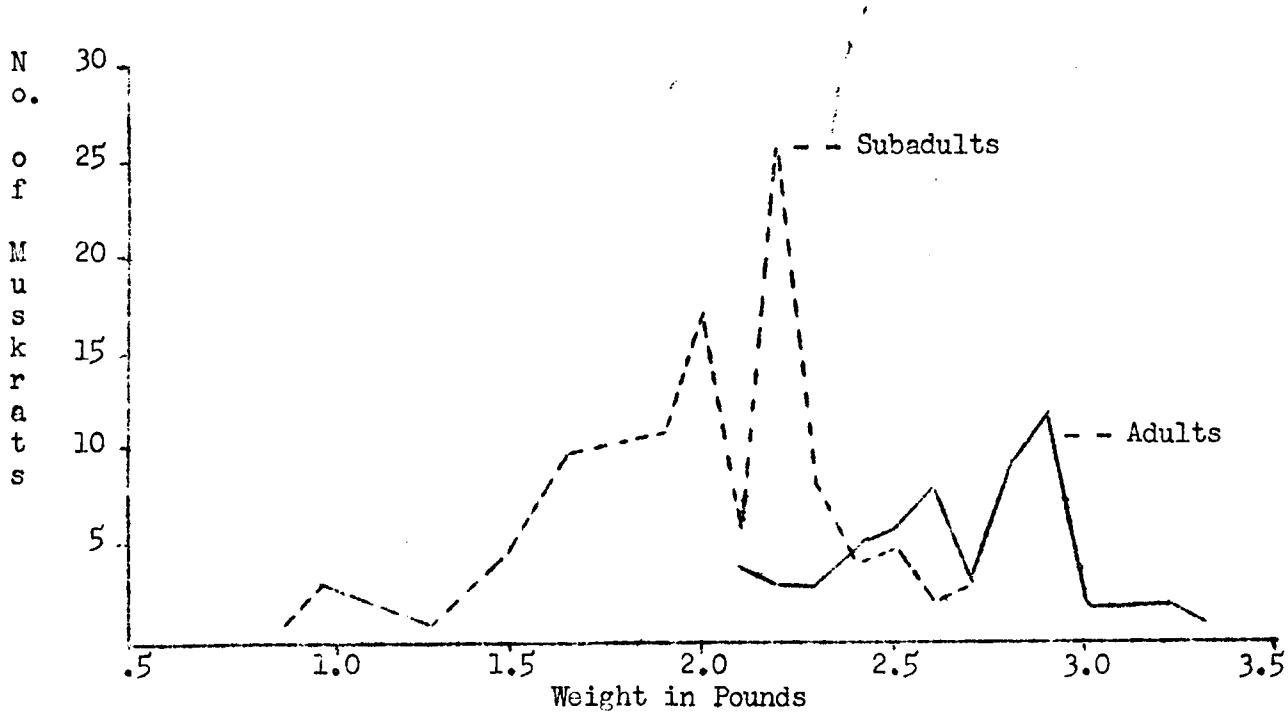


Figure 19. Weight frequencies of 98 subadult and 60 adult muskrats - Montgomery County, Virginia.

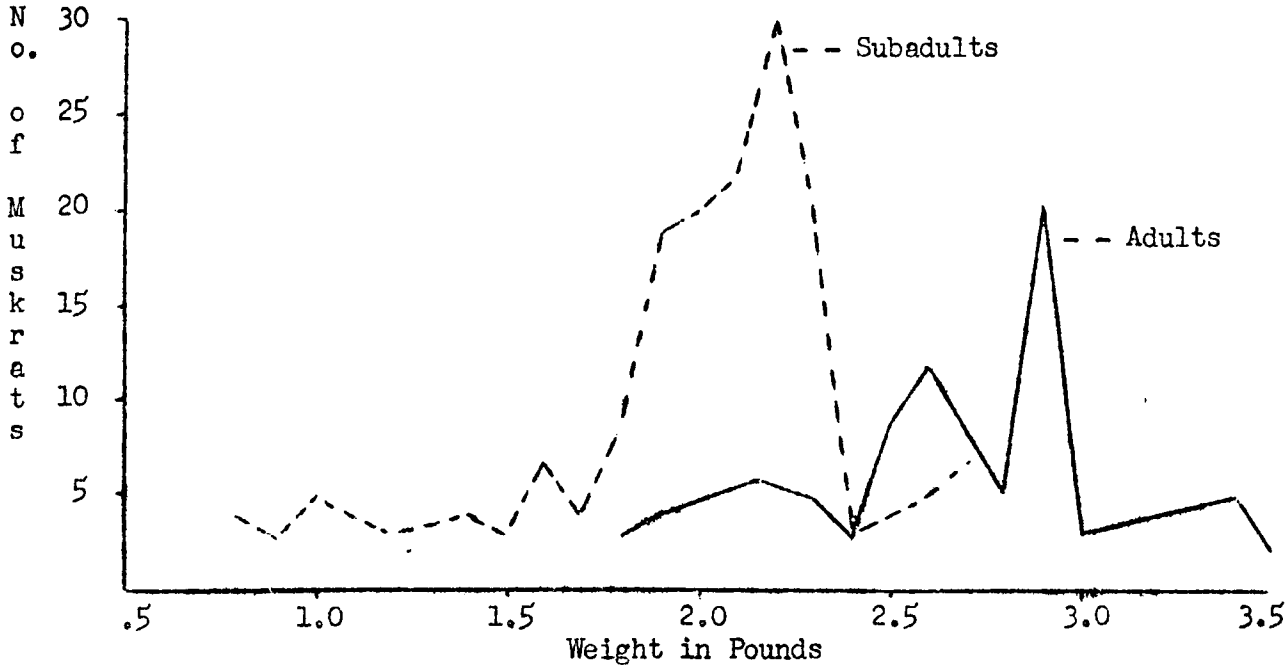


Figure 20. Weight frequencies of 168 subadult and 81 adult muskrats - Powhatan Hunt Club Marsh, James City County - Virginia.

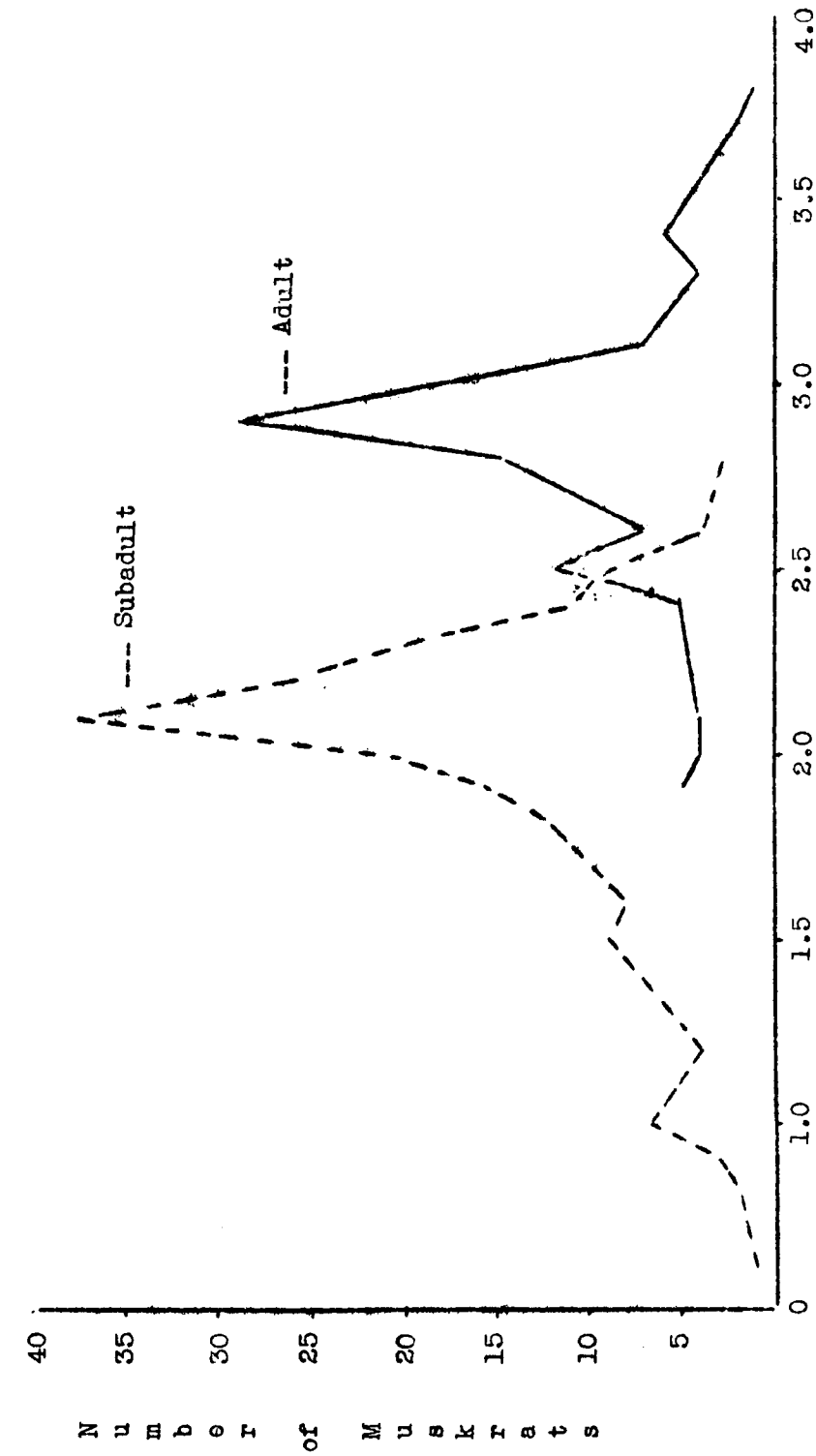


Figure 21. Weight frequencies of 101 adult and 198 subadult muskrats Island Farm Marsh, Richmond County, Virginia.

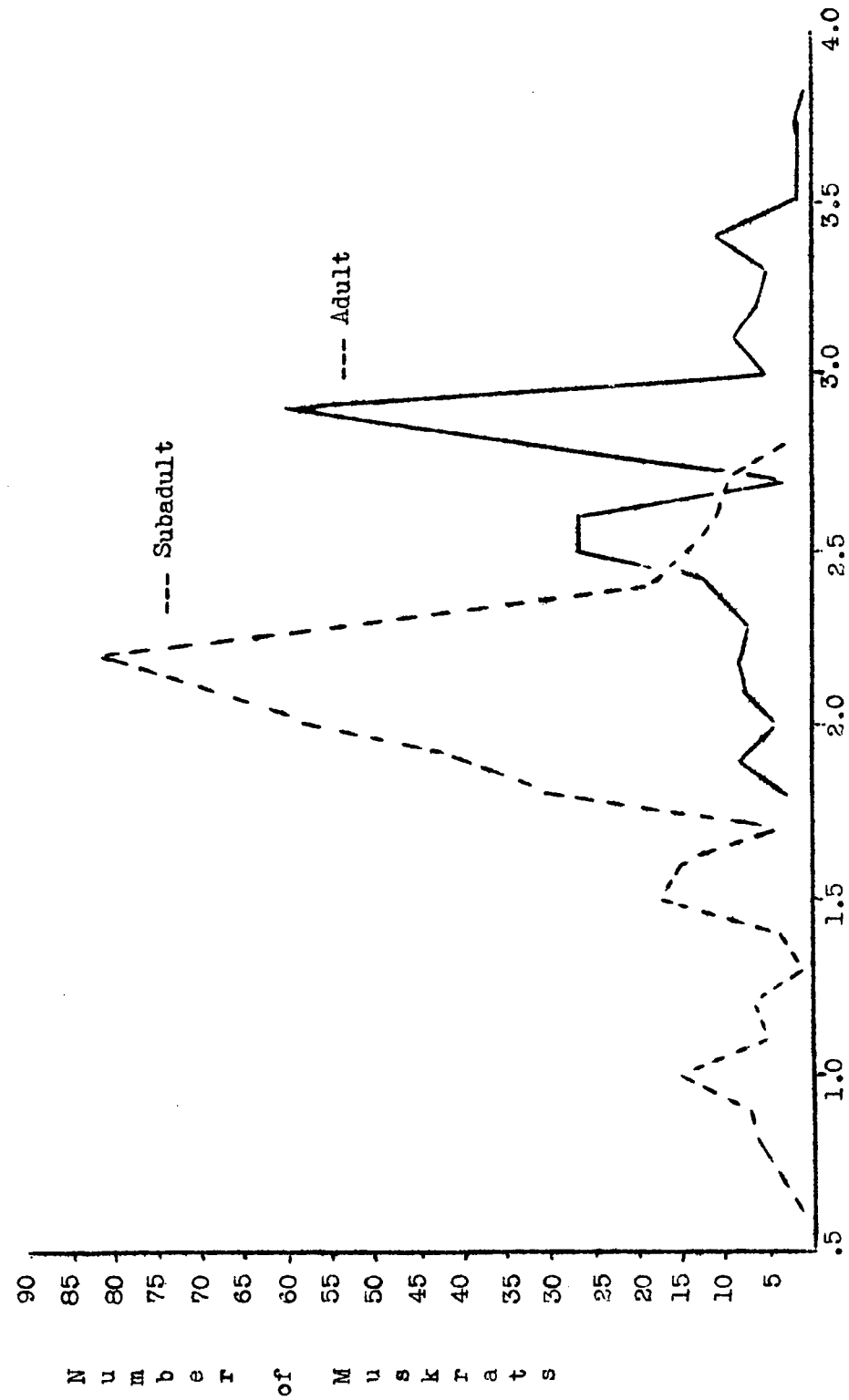


Figure 22. Weight frequencies of 464 subadult and 242 adult muskrats from three Virginia areas.

only method of studying these animals.

On the Island Farm Marsh, almost all of the muskrats live in large dome-shaped "lodges," or houses. Trappers often use the term, "live" house, to designate those structures which are inhabited by muskrats. Houses from which the occupants have disappeared through trapping or other reasons are referred to as "dead" houses. Many people often mistakenly term as "lodges" the smaller feeding platforms. These structures are usually smaller and closer to the water than are the true "lodges."

On the Powhatan Hunt Club Marsh, most of the muskrats live in bank dens. There are a few "lodges" present, but this type of den is definitely in the minority.

The use of house counts as a means of population estimation has received considerable attention and discussion. Dozier (1948), gives a very complete discussion of the application of this system to management problems. The accuracy of the final estimate depends on a number of factors, chief among which are: the season of the year at which counts are made; conditions existing on the marsh at the time of the count; the ability of the observer to differentiate between "live" or "dead" houses and feeding platforms. It should be emphasized here that all counts are more effective if taken in the fall months, preferably in November.

To be of maximum value, a system of censusing muskrats must be both simple and effective. The primary objective in making a muskrat census is to determine the relative abundance of the animals on an area. It should, theoretically, show the population trend, rather than the speci-

fic number of animals present. There are four methods of counting muskrat houses currently in use. These are as follows: use of transects; counts from roadside; ground strip counts; and aerial counts.

Transects are not entirely satisfactory for censusing an area. On most marshes, the vegetation is non-homogenous, and consequently, transects do not give a clear picture of the entire area. Areas on which the vegetation is relatively homogenous may frequently be sampled to good advantage by the use of transects. Such transects, when used, are most effective if permanently marked, in order that yearly comparisons of the same area can be made.

Several workers have tried counting houses from the roadside, but such a system is usually inadequate because of the inability of the observer to spot and distinguish all of the houses. It also frequently involves an excessive amount of driving.

The ground strip count method is unquestionably the most accurate of the four systems. Its principal drawback lies in the fact that considerable personnel and time are usually necessary to carry out the work. Dozier (1948), explains this technique in some detail. The system basically requires that observers run parallel strips, 50 feet wide, through the marsh. All observers are responsible for counting the houses between themselves and the man on their inside (inside refers here to that section of the marsh on which houses have already been counted). The counter on the outside is always responsible for marking the limits of the area which has just been counted. When the marsh is broken up by numerous small ponds and guts, it is necessary to vary the technique somewhat.

The need soon arose for a quicker and more economical census method. The use of the airplane for such work may prove to be the answer to the problem. Lay (1945), indicated that the airplane might be practical in censusing muskrat houses on the Texas coastal marshes, but that the technique would have to be varied to meet changing conditions on the marsh. The advantage of quick coverage may be more than offset by limitations which are not obvious at first. The cost of such a census is often prohibitive, and houses are sometimes difficult to distinguish from the air.

In order that the relative abundance of muskrats on the Powhatan Hunt Club and Island Farm Marshes might be determined, it was necessary to have some system of population estimation to be used on these areas. In view of the short amount of time which could be allotted to this work, it was essential that the method used be as simple and practical as possible.

The ground strip count method as previously described was the first system tried. It was quickly realized that this system was too time-consuming and laborious for one man to operate. This method would undoubtedly be very accurate if sufficient time and labor were available.

In an effort to find a technique which was more rapid, house counts from an airplane were tried. Because of the short amount of time the plane was available, and the inability of the writer to distinguish accurately the houses from the air, this method was discarded as being impractical.

After cover mapping the Island Farm Marsh, it was seen that the vegetation on the area was far from homogenous, and that the muskrats

definitely preferred certain vegetative types over other types. This posed the problem of counting the houses so as to get a sample which was representative of the area as a whole.

It was decided that the most practical method of getting the counts would be to take a series of one-acre random sample plots throughout the various cover types on the marsh. These sample plots were set up, using the percentage of the total area made up of each cover type as a basis for the number of plots to be taken. The system of locating plots consisted of using a base map of the area on a clip board, the corner of the marsh lying most nearly adjacent to each cover type being approached on the ground by the observer. After orienting the map, the writer offset 100 yards east or west as the case might be, using a box compass and pacing the distance. A north-south line was then run until the particular cover type in question had been penetrated to a distance of 200 feet. Lines were then run in an east-west direction, taking a one-acre plot every 400 feet. At these points, each plot was considered as encompassing 104 feet on every side of the observer. After every 10 plots, the writer offset in a north-south direction for a distance of 200 feet. Another line was then started in an east-west direction and plots taken as before. This actually gave a series of plots on parallel, staggered lines throughout a homogenous cover type. If a house fell half-way in a plot, it was considered as being in the plot in consideration. The house count data are presented in Table 22, and an explanation of the various cover types as used on the base map is found on page 50. A conversion factor of 4 muskrats per

house is a conservative figure for the Virginia muskrat (Ondatra zibethica macrodon). It should be emphasized here that the population figures in Table 22 should be increased by two or three hundred to compensate for bank dwelling muskrats. It is realized that this method cannot be considered as giving an absolute population count. If similar counts are made over a period of several years, however, they should give some indication of population trends. It is obvious even to the casual local observer who is familiar with this marsh that there is considerable annual variation in the number of houses present.

On the Powhatan Hunt Club Marsh, the writer was greatly surprised to notice the winter condition of the marsh, having seen it first during the summer and early fall. As previously mentioned, the marsh was covered by dense growths of wild rice (Zizania aquatica), millet Echinochloa walteri.), and pickerel weed (Pontederia cordata). Heavy usage of the area by ducks during the late fall and early winter practically eliminated these luxuriant growths of vegetation. The only muskrat houses observed on the entire 1000 acres were found in small sections of cordgrass (Spartina cynosuroides). Only 20 lodges were observed on the marsh, the remainder of the animals apparently living in bank dens. These conditions made a population estimate very difficult. On the basis, however, of personal observations, and observations of the marsh caretaker, it was estimated that approximately 1100 muskrats were on the marsh.

Table 22. Muskrat house counts by cover types and the estimated muskrat population on the Island Farm Marsh, Richmond County, Virginia, December, 1950

Cover Type	Percentage of total area	No. of acres in cover type	No. of one acre plots taken	Avg. no. of houses per acre	Estimated no. of houses in cover type	Population
CC	Not included	**	**	**	**	**
PP	12	130	14	0	0	0
RR	10	110	14	.4	44	180
DD	1	10	1	0	0	0
TT	14	150	16	.5	75	300
SS	63	695	65	.9	630	2520
Totals	100	1095	110		749	3000

As previously mentioned, all of the muskrats in Montgomery County live in bank burrows, a condition which presented some complications when population estimates were made. Apparently, the only logical procedure for getting around this situation was to base the estimate on the number of active dens and the amount of muskrat "sign" on each of the streams under consideration. During the fall months, 12 of the streams in the county were kept under close observation to determine the approximate number of animals on these areas.

It is obvious that such a method of population estimation has its limitations, and that it also is subject to many inaccuracies. It is also obvious that in the habitat types found in Montgomery County there

must be considerable ingress and egress of individuals on each of the streams. Field observations indicated that these movements did occur, and they were taken into consideration when the population estimates were made. It was essential, however, that such an estimate be available in order that some relationship might be established between the productivity, and subsequent degree of utilization of muskrats on the streams in question. It is believed that the estimates were reasonably accurate, and further work was based on this assumption.

Table 23 presents the estimated fall population of muskrats on 12 Montgomery County streams as of October 15, 1950. It may be seen that none of the streams are at present supporting a particularly high population of muskrats. This is probably due to certain environmental conditions which are discussed in another section of this report.

Population Movements

Muskrat populations constantly undergo local movements, and in some instances, exhibit widespread migratory tendencies. It is fairly well known that there are definite dispersal movements during the spring and fall.

Establishment of new territories is one of the principal reasons for the fall movement, with the spring dispersal being induced by breeding pairs setting up "home ranges". It has often been stated that young animals never leave home of their own accord, but rather, are forced out because of increased competition. It is obvious that in the fall following a successful breeding season, that there must be

Table 23. Estimated fall population of muskrats on twelve Montgomery County streams, 1950

Stream	Habitat classification	Length in miles	Area in Acres	Total Population	Rats/mile or acre
1/ Stroubles Creek	1	10	--	225	22.5
2/ Tom's Creek	1	12	--	300	25.0
3/ Crab Creek	1	9	--	50	5.6
4/ Plum Creek	1	4.75	--	25	5.3
5/ Meadow Creek	1	6	--	100	16.7
6/ Mill Creek	4	4.75	--	5	1.1
7/ Big Branch	1	3	--	75	25.0
8/ Brush Creek	4	5.50	--	50	9.1
9/ Don Creek	4	2.50	--	10	4.0
10/ Whitehouse Branch	1	3.50	--	30	8.6
11/ Wilson Creek	4	4	--	20	5.0
12/ V. P. I. ponds	3	--	7.23	15	2.1
Totals		65	7.23	905	Average 13.9 rats mile or 2.1/ acre

some movement to alleviate this competition.

Very few data were gathered on movements during this investigation. Some observations were made in Montgomery County, however. Errington (1940), advances the premise that sexually advanced animals may initiate the spring dispersal by driving sexually quiescent animals out of their wintering quarters. No definite evidence was obtained to substantiate this in Montgomery County, but the spring movements appeared to be tied up with breeding activity. In an effort to obtain more definite knowledge relative to muskrat movements, live trapping operations were instigated. Results of this undertaking are discussed in the section of this report dealing with live trapping. For reasons which will be discussed later, the live trapping failed to furnish the evidence necessary to determine definitely the dispersal movements.

Observations indicated that local movements took place on nearly every muskrat-populated stream in the county. It was interesting to note that spring movements served to repopulate several streams, and that fall movements often had exactly the reverse effect. Den Creek and Indian Run are particularly conspicuous from this standpoint. Neither of these two streams supports a muskrat population throughout the year. During the spring breeding season, however, several breeding pairs moved into these areas from the North Fork of the Roanoke River. These animals remained on the streams until the first stream "freeze ups" in the fall. Fall movements apparently are often induced by cold weather which freezes over the smaller streams but fall movements were at no time as pronounced as were the spring movements.

Stroubles Creek was kept under close observation during the spring months in order to detect any movements of the population which occurred. During mid-March, there was a dispersal of the population into the small tributaries and marshes adjacent to the main stream. In one of the small marsh areas, comprising about one acre, there were estimated to be six pairs of breeding animals. Prior to the spring movement, this area was devoid of any muskrat population at all. At this same time, a rather unusual phenomenon occurred on the main creek in that the muskrats abandoned it completely and concentrated on another short section of approximately one half a mile. There was an estimated spring breeding population of ten pairs of animals on this latter area, with there being a large gap of approximately one and one half miles of good habitat in which there were no muskrats at all. There was no obvious reason why the population should tend to concentrate, subjecting itself to serious intraspecific competition, as the area on which the concentration occurred was in no way better than the habitat which was deserted. From the standpoint of available food, the deserted habitat was superior. There may have been a difference in the intensities of grazing by cattle on the two sections, but if this condition existed, it was very slight.

The importance of fall movements in repopulating unstocked areas was not definitely determined. Errington (1940), states that "the role of movements other than local adjustments during the late summer period of social latitude does not, despite exceptions, seem of more than limited consequence in repopulating Iowa habitats." It would appear that this also holds true in Montgomery County.

During the fall, the population on Stroubles and Tom's Creeks remained relatively stable, with a few individuals moving into Stroubles Creek from the smaller tributaries during late November and early December. Such movements were probably induced by the extremely cold weather which caused the smaller streams to freeze over.

The fall population on Crab and Plum Creeks remained relatively constant, but there was some ingress of muskrats at the mouths of the streams. These animals moved in during a period in which New River was at flood level. Most of these animals moved back to their former homes when the river waters subsided.

Severe floods on Big Branch during early December apparently did not hurt the muskrat population to any extent. There may have been a slight influx of animals from Little River during a period of high water in early December.

During late October and early November, there was a pronounced movement of muskrats into the Virginia Polytechnic Institute ponds. These animals undoubtedly moved into the ponds from Stroubles Creek. There is no logical explanation for this movement, as the pond area does not have an adequate supply of food to support many muskrats throughout the winter. It might be that intensive studies of fall and spring movements would disclose the main reasons for the observed population "shuffles". In Montgomery County, at least, it would appear from the available data that population movements are only of local significance. Economically, such movements apparently have no direct effect on the utilization of the muskrat crop.

HARVESTING THE MUSKRAT CROP

Methods of Harvesting the Crop

Muskrats were harvested only by trapping in steel traps on the three Virginia study areas. The techniques involved naturally varied with each area and with the experience and preferences of the trapper.

With the exception of one or two small marsh areas, all of the muskrats in Montgomery County were trapped from small streams. In this type of habitat, muskrat sets are usually made in five general locations. These are: (1) trail sets; (2) slide sets; (3) feeding platform sets; (4) defecating post sets; and (5) den sets.

Trail sets are made where the animals have formed a beaten path in traveling from one place to another. Traps are more advantageously placed at the points at which such trails enter the water.

Muskrats frequently make muddy slides on the bank where they continuously enter and leave the water. Such slides are easily located since they are usually very slick, often being marked with the animals' tracks. Often a single trap in such locations may account for several muskrats during the course of a trapping season.

Feeding platforms are usually small, isolated spots to which muskrats bring food. Such areas are usually up under the banks and are thus protected from enemies above. Traps placed on feeding platforms are often very successful, but frequently tend to frighten animals away which would later use the site.

Defecating posts are usually small mounds of mud on the edges or in the middle of the smaller streams. Muskrats, when passing these mounds, will almost invariably climb upon them. This appears to be especially true during moderate weather. Many trappers find this set one of their most productive on the smaller streams in the county. The writer found that artificial creation of these mounds increased his catch of muskrats considerably. It should be emphasized that such a practice becomes illegal when the trap is set upon a surface which is floating.

Den sets are exactly what the name implies. Traps are frequently set in the entrances to active dens, and usually prove to be quite successful. In general, it is the opinion of the writer that den trapping is a rather undesirable practice. Evidence would seem to indicate that consistent den trapping will frequently cause muskrats to abandon an area completely.

When possible, traps should be staked out in deep water in order that the animals will drown when caught. Without question one of the greatest problems of amateur trappers is to prevent the trapped muskrat from twisting or gnawing off its leg, leaving a leg in the trap. Such losses are called "wring-offs". It has been the general observation of trappers that many of the animals which lose their legs in traps die, usually as a result of secondary complications.

In the Powhatan Hunt Club and Island Farm Marshes, sets were of the same general types. Both of these areas were trapped by experienced trappers who were in the business largely for a living. These men varied their trapping techniques to meet the conditions on their marshes.

On the Powhatan Marsh, the trapper begins his trapping operation at one side of the marsh and works that area until his catch begins to drop off appreciably. The traps are then moved in rotation until the entire marsh has been covered. On the Island Farm Marsh, the technique is basically the same. Both trappers mark their trap locations by means of stakes stuck in the ground. An ample supply of these stakes is usually cut in the period immediately preceding the trapping season.

An analysis of 3118 muskrat trap sites from three Virginia areas revealed that 99.2 per cent were natural sites and 0.8 per cent were man made. These data are presented below in Table 24.

Table 24. Analysis of 3118 muskrat trap sites from three Virginia areas, 1949-1950, and 1950-1951.

Type of site	Area			Percentage
	Montgomery County Number of Traps Set	Island Farm Number of Traps Set	Powhatan Club Number of Traps Set	
Den sites	462	115	380	31
Trail sites	96	705	601	45
Slide sites	105	10	8	3.2
Feeding platform sites	41	92	320	15
Defecating post sites (Natural)	129	13	10	5
Defecating post sites (Man made)	26	--	--	0.8
Totals	859	940	1319	
Percentage of total	28	30	42	

It may be seen from Table 24 that trail sets were the most important type, comprising 45 per cent of the total. This was true primarily because two of the study areas are large marshes. In Montgomery County, den sets were apparently the most commonly used trap site.

One of the first questions which normally presents itself when the muskrat crop is utilized is the intensiveness of trapping which should be carried on. Unfortunately, in Montgomery County, the common philosophy has become, "if I don't catch them, someone else will." This condition has, in some instances, resulted in far too many animals being trapped. On the two marsh areas, trapping is more closely regulated by the trappers.

On the Powhatan Hunt Club Marsh, the trapper has had considerable marsh experience, and is capable of regulating his harvest so that it is in adjustment with the available crop. On the Island Farm Marsh, a definite quota is established for each trapping season. This quota is set on the basis of preseason observations by both the trapper and the marsh owner. Should the trapper realize that his catch is beginning to exceed the trappable crop, then trapping operations are usually stopped immediately. It would appear that trapping on the two marsh areas tends to be conservative, rather than excessive.

In an effort to determine what type of habitat was trapped for muskrats in Virginia, information was gathered from one hundred and thirty five muskrat trappers. These people were either interviewed personally, or through a reliable person. All trappers were asked to indicate the type of habitat in which they trapped muskrats. No standard interview form was used, as it was not intended that systematic data be gathered

from these people. Some of those trappers who were interviewed by the writer also furnished other data on color ratios, economics, and age ratios. Part of these data were considered to be reliable, and are presented in other sections of this report. The one hundred and thirty five cooperators represented 29 counties, 15 of which are in the Coastal Plains Region, 4 in the Piedmont Region, and 10 in the Mountain Region. Data from these interviews are presented below in Table 25. As would normally be expected, a majority of the trappers in the Piedmont and mountains trapped only on streams. It was interesting to note, however, that a number of trappers in the Coastal Plains also trapped on small streams. This is largely due to the fact that many of the large marshes are trapped regularly by the same trapper. With the exception of the men on the Island Farm and Powhatan Hunt Club Marshes, no trappers of this type were interviewed. Figure 23 shows the location of the trapper cooperators by counties.

Types and Numbers of Traps Used

It was found that a wide variety of traps was used in trapping muskrats in Montgomery County. It is only logical that trappers should prefer certain types of traps over other types. A majority of the trappers in the county preferred and used the Number 1 Oneida Victor Single spring trap. This is, of course, a very good trap, but has the disadvantage of allowing the animals to wring legs off quite frequently. Among the more experienced trappers, the Number 1 Oneida Victor Stop Loss trap proved to be the most used. This trap practically eliminates

Table 25. Types of muskrat trapping reported by 135 trappers in Virginia, seasons of 1949-1950, and 1950-1951

County	No. of trappers questioned	Type of trapping reported					
		Marsh		Stream		Both	
		No.	Per cent	No.	Per cent	No.	Per cent
Accomac	2	2	100				
Bedford	2			2	100		
Brunswick	3			3	100		
Craig	4			4	100		
Giles	3			3	100		
Floyd	9	1	11	8	89		
Gloucester	2			2	100		
Essex	4	3	75	1	25		
Greensville	2			2	100		
Highland	4			4	100		
Isle of Wight	5	3	60	1	20	1	20
James City	5	3	60	1	20	1	20
Mecklenburg	1			1	100		
Montgomery	40	2	5	36	90	2	5
Nansemond	6	3	50	2	33	1	17
Norfolk	3	3	100				
Northampton	2	2	100				
Pittsylvania	3			3	100		
Princess Anne	3	1	33	1	33	1	33
Richmond	5	4	80			1	20
New Kent	2			2	100		
Rockbridge				2	100		
Scott	2			2	100		
Southampton	10	3	30	5	50	2	20
Surry	4	2	50	1	25	1	25
Sussex	2	1	50	1	50		
Washington	2	1	50	1	50		
Wythe	2			2	100		
York	1	1	100				
Totals	135	34	25	90	67	10	8

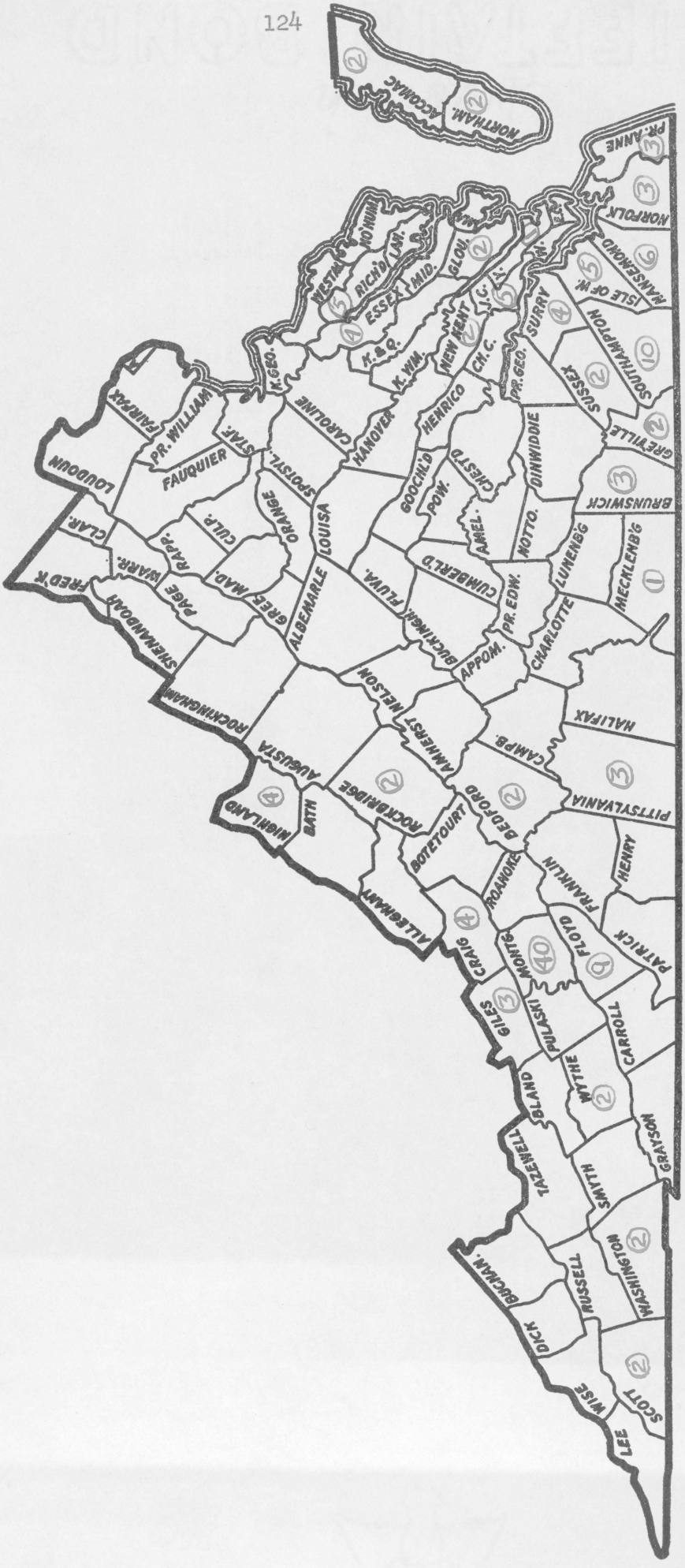


Figure 23. Map of Virginia showing the location by counties of 135 trapper cooperators on this project

"wring offs", a feature which more than offsets the small additional cost of the trap.

It was found that the two trigger trap was being used by some few trappers. The chief advantage of this trap lies in the fact that the outer jaw holds the body firmly, and in many instances kills the animal.

Some few trappers used the No. 2 Oneida Victor Double Spring trap. This trap is definitely too powerful for muskrats, and usually almost severes the animal's leg when it shuts. In one instance, a young boy of eleven was found to be using two Number 4 Gibbs traps for muskrats.

The Number 1 Jump trap was one of the traps most favored by the less experienced trappers. The Number 1 Jump is an excellent trap and is particularly valuable for setting on sites at which space is a premium such as in burrow entrances.

On the Island Farm Marsh, the trapper operates with eight dozen traps, all of which are of the Number 1 Victor Stop Loss type. The trapper on the Powhatan Hunt Club Marsh annually operates five dozen traps of the same type. It is unquestionable that this type of trap gives better results in general muskrat trapping than does any other type.

In Montgomery County, trappers used from six to thirty two traps. These data are presented later in the section on trapping success.

Trapper Data

It was found that it was very difficult to locate definitely every trapper in Montgomery County. This was true despite the limited number of people who engaged in muskrat trapping in the county. It would appear

that the simplest method of locating trappers would be by examining the license sales records. This would certainly be the case if all of the trappers in the county purchased licenses. It should be emphasized that landowners trapping on their own land and persons under sixteen years of age are not required by law to purchase a license. In 1949-1950, only 11 out of 40, or 28 per cent, of the trappers in the county purchased licenses. In 1950-1951, twelve out of 48, or 25 per cent, of the trappers purchased licenses.

In 1949-1950, all licensed trappers in the county were sent questionnaires and letters requesting information relative to their muskrat trapping for the year. Unfortunately, these questionnaires were not sent to the trappers until well after the trapping season was over. It was found that people usually had some difficulty in remembering information accurately if they were questioned long after the trapping season had closed. A return of 90 per cent was realized from this set of questionnaires. In order to double check the information derived from these questions, each licensed trapper was also personally interviewed. All unlicensed trappers were also personally interviewed, and were located largely through local fur dealers and through licensed trappers. Figure 24 shows a sample form of the questionnaire used in this survey. It may be seen that the form was made both simple and brief to facilitate returns.

In 1950-1951, all trappers in the county were personally interviewed, both during and after the trapping season. Data were gathered from them as to their trapping activities for the past season. It is believed that the data received in this way was more complete than that received for the 1949-1950 trapping season.

Virginia Cooperative Wildlife Research Unit

Trapper Data Sheet:

1. None_____
2. Occupation_____
3. Did you trap muskrats during 1949 - 1950?_____
4. If so, on what stream did you trap?_____
5. How many muskrats did you catch?_____
6. How much did you receive for the skins?_____
7. Where did you sell the skins?_____
8. Approximately how many traps did you use in trapping muskrats?_____
9. Can you make a reasonable estimate of the number of hours that you spent in trapping muskrats? If so, how many?_____
10. What furbearers did you trap besides muskrats?_____
11. How many did you trap?_____
12. Do you plan to trap muskrats during 1950 - 1951?_____
13. If so, may we contact you?_____

Figure 24. Sample questionnaire of the type sent to Montgomery County, Virginia, trappers, 1949-1950 trapping season.

All of the trappers in Montgomery County may be classified as part time trappers, as there is no known individual in the county who derives all of his income from trapping alone. A majority of the trappers were farmers who trap during their spare time and on their own land. Schoolboys make up a large percentage of the trappers, and often receive substantial profit for their efforts. In order that other data might be more easily presented, the trappers in Montgomery County were classified by five-year age groups.

As previously mentioned, the trapper on the Powhatan Hunt Club Marsh should be considered a professional. His primary duty is, of course, caretaker on all of the land of the club. He has had many years experience in trapping muskrats, and devotes almost all of his time to this occupation during the open season.

The principal trapper on the Island Farm Marsh should also be considered a professional in that he has trapped muskrats for a living for many years. There are usually three or four smaller trappers on the marsh who have had varying degrees of experience, and who trap only on small sections of the area.

Utilization of the Muskrat Crop

The extent to which the muskrat crop is utilized in Montgomery County is difficult to ascertain. Some streams are certainly trapped excessively hard, whereas others are trapped only moderately. It was impossible to examine and accurately determine from which specific stream all muskrats were trapped during 1950-1951. It was, however,

possible to determine with some accuracy the number of muskrats which were trapped from several of the streams. This information was secured directly from the trappers. On the basis of the population estimations made for twelve Montgomery County streams in the fall of 1950, it was possible to determine the approximate percentage of the estimated crop which was utilized. It is assumed here that natural losses were insignificant between the time of population estimation and the time of harvest.

Table 26. Percentage of estimated muskrat population which was utilized on twelve streams in Montgomery County, Virginia, 1950-1951

Stream	Estimated population	No. of muskrats harvested	Percentage of crop trapped
Stroubles Creek	225	119	52
Tom's Creek	300	205	68
Crab Creek	50	30	60
Plum Creek	25	5	20
Meadow Creek	100	75	75
Mill Creek	5	--	--
Big Branch	75	50	67
Brush Creek	50	28	56
Den Creek	10	4	40
Whitehouse Branch	30	18	60
Wilson Creek	20	14	70
V.P.I. ponds*	15	15	100
Total	905	563	62

* - There was considerable ingress of animals after this population estimation was made and before the harvest was begun

Assuming that these population figures are reasonably accurate, it would appear that trapping is fairly intensive on most of these streams. It will be noted that some 62 per cent of the estimated population on

these twelve areas was harvested by trapping. Trapping which removes sixty per cent of the population from small streams may be considered heavy, and when such trapping removes seventy-five or eighty per cent of the population it is becoming excessive. The above figures represent only a portion of the muskrat harvest from the county.

On New and Little Rivers, muskrat trapping is limited largely by extreme fluctuations in the water level. Some muskrats are trapped from these areas, however. Other streams not considered above also contribute a part toward the muskrat harvest. In general, trapping is often too heavy locally on some of the streams in Montgomery County. If the streams as a whole are considered, trapping is usually not too severe. The breeding stock which is left on some areas may probably be accounted for by the fact that there is a certain portion of the population which will not be caught despite intensive trapping. Also, ingress of new individuals tends to repopulate areas which may have been overtrapped.

On the Island Farm Marsh, 1900 animals out of an estimated 3000 were trapped during 1950-1951. This represented sixty three per cent of the estimated population, and was probably not too severe for a marsh of this type.

On the Powhatan Hunt Club Marsh, 583 of an estimated 1100 muskrats were trapped during 1950-1951. This harvest comprised 53 per cent of the estimated population of the area, and was in keeping with the marsh trapper's policy of leaving a large breeding population on the area. It will take further study to determine to what extent this condition creates intraspecific strife.

Trapping Success

The success of different trappers naturally varies a good deal. Any number of factors such as weather, water fluctuations, number of muskrats, and the experience of the trapper may all influence trapping success. Some data were obtained during this investigation on the catch per trapper; these data were obtained by the interview method previously described. This information is presented below in Tables 27 and 28.

Table 27. Trapping success by age groups of Montgomery County, Virginia, trappers, 1949-1950

Age Group (Years)	No. of trappers in age group	No. of traps used	Avg. per trapper	No. muskrats trapped	Avg. no. of muskrats per trapper
10-15	10	60	6	180	18
15-20	12	150	13	316	26
20-25	5	80	16	260	52
25-30	3	35	12	36	12
30-35	2	30	15	48	24
35-40	1	32	32	9	9
40-45	2	36	18	17	8.5
45-50	1	12	12	26	12
50-55	2	18	9	74	37
55-60	1	12	12	38	38
60-65	1	15	15	25	25
Total Averages	40	480	12	1029	26

Table 28. Trapping success by age groups of Montgomery County, Virginia, trappers, 1950-1951

Age Group (Years)	No. of trappers in age group	No. of traps used	Avg. per trapper	No. muskrats trapped	Avg. no. of muskrats per trapper
10-15	14	70	5	84	6
15-20	13	156	12	364	28
20-25	3	66	22	90	30
25-30	4	56	14	84	21
30-35	3	54	18	87	29
35-40	2	38	19	38	19
40-45	2	42	21	42	21
45-50	2	26	13	50	25
50-55	2	24	12	44	22
55-60	2	30	15	32	16
60-65	1	19	19	39	39
Totals	48	581		954	
Averages			12		20

It may be seen from Table 27 that a relatively high trapping success was not confined to any age group. The high success in the 20-25 age group may probably be explained on the basis that these trappers were more consistent in their work than were some of the others. Those trappers in the 50-55 and 55-60 age groups were more successful because they had previously had considerable experience and were trapping on some of the best streams in the county. It may also be seen that each trapper in the county averaged catching 26 muskrats during the 1949-1950 trapping season. This is considered a very good catch in view of the type of habitat which is present in the county.

From Table 28 it may be seen that the average catch was more evenly distributed as to age groups in 1950-1951. The average catch

of no age group was as high during this season as was the average catch for the 20-25 group in 1949-1950. It was interesting to note that in both years, the trappers used the same average number of traps, and the annual muskrat harvest was approximately the same.

As would normally be expected, trapping success was considerably higher on the Island Farm and Powhatan Hunt Club Marshes than it was in Montgomery County. Table 29 presents the annual muskrat harvest from the Island Farm Marsh for the period, 1934-1950, and shows the trapping success for the area. It may be seen that there was a progressive decline in trapping success from 1934-1944, and that since that period there has been a progressive increase. The catch of muskrats per trapper is not here indicative of a decline, since the number of trappers has not remained constant. The catch of muskrats per acre, however, does reflect this fluctuation. There was no obvious explanation for this apparent cycle in the muskrat population, but future work on the marsh might give a clearer picture of this phenomenon.

Since only one trapper operates on the Powhatan Hunt Club Marsh, his trapping success is represented by the entire catch for the area. The muskrat harvest from this marsh for the period, 1946-1951, is presented in Table 30.

During this investigation it was possible to get some data on the relationship between the number of traps set and the muskrats caught. These data are presented in Tables 31 and 32 for Montgomery County and the Powhatan Hunt Club Marsh respectively.

Table 29. Annual muskrat harvest from the Island Farm Marsh, Richmond County, Virginia, for the period, 1934-1950, showing trapping success for the area

Year	No. of muskrats trapped	No. of trappers	Ave. catch per trapper	Ave. catch per acre
1934	2600	5	520	2.4
1935	2300	4	575	2.1
1936	1800	4	450	1.6
1937	1800	4	450	1.6
1938	1600	5	320	1.5
1939	1500	3	500	1.4
1940	1500	4	375	1.4
1941	1200	5	240	1.1
1942	1200	5	240	1.1
1943	1100	3	367	1.0
1944	1100	5	220	1.0
1945	1200	5	240	1.1
1946	1300	6	217	1.2
1947	1400	4	350	1.4
1948	1600	4	400	1.5
1949	2200	4	550	2.0
1951	1900	3	633	1.7
Average	1606		391	1.45

Table 30. Annual muskrat harvest from the Powhatan Hunt Club Marsh, James City County, Virginia, for the period 1946-1951

Year	1946	1947	1948	1949	1950	1951
Adults	635	701	586	470	392	569
Kits	---	11	28	---	44	14
Total	635	712	614	470	436	583

Table 31. Daily trapping success of six Montgomery County, Virginia, trappers, 1951

Date	No. of traps set	No. muskrats caught	Percentage of success
January 5	42	12	30
January 6	42	14	33
January 7	42	2	5
January 8	35	4	11
January 9	35	2	6
January 10	35	1	3
January 11	35	0	0
January 12	31	15	50
January 13	31	5	16
January 14	31	4	13
January 15	31	2	6
January 16	31	3	10
January 17	31	5	16
January 18	35	9	26
January 19	35	2	6
January 20	42	12	30
January 21	42	4	10
January 22	42	2	5
January 23	30	2	7
January 24	30	6	20
January 25	30	0	0
January 26	30	0	0
January 27	30	2	7
January 28	38	2	5
January 29	38	3	8
January 30	38	3	8
January 31	38	4	11
Totals	950	120	
Average			13

Table 32. Daily trapping success of the trapper on the Powhatan Hunt Club Marsh, James City County, 1951

Date	No. of traps set	No. of muskrats caught	Percentage of success
January 9	36	14	40
January 10	36	20	56
January 11	36	18	50
January 12	36	18	50
January 13	36	20	56
January 14	48	—	—
January 15	48	15	31
January 16	48	12	25
January 17	48	17	31
January 18	48	19	40
January 19	48	15	21
January 20	48	12	25
January 21	48	—	—
January 22	60	12	20
January 23	60	9	15
January 24	60	16	27
January 25	60	14	23
January 26	60	14	23
January 27	60	6	10
January 28	60	5	8
January 29	60	2	3
January 30	60	5	8
February 1	36	6	17
February 2	36	9	25
February 3	36	10	28
February 4	36	11	30
February 5	24	12	50
February 6	24	5	21
February 7	24	3	13
February 8	24	3	13
February 9	24	6	25
Totals	1320	328	
Average			25

Trapping success on both of the areas above fluctuated considerably. It was found that the number of muskrats caught was not necessarily pro-

portional to the number of traps which were set. A few traps during periods of good weather may frequently catch a large percentage of the population.

On all three areas, temperature was found to be one of the most important factors influencing trapping success. Temperature records were kept through January and February, 1951, in order to see whether trapping success could be correlated with temperature.

These data revealed that a greater number of muskrats were caught when the temperature ranged between 32° F. and 45° F. When temperatures dropped below freezing, the catch usually declined sharply. It would appear from the data that since muskrats are more active on warm nights, the catch would thus be higher. This did not prove to be the case, as few muskrats were caught when the temperature was higher than 45° F. In general, excessively cold temperatures were a greater limitation to trapping success than were unseasonably warm temperatures.

Handling of Traps

Certain rules of caring for equipment might advantageously be applied in handling traps. Unfortunately, most small-time trappers consider their traps as useless equipment at the end of the trapping season, and usually treat them as such.

Proper treatment of traps will unquestionably increase the length of time which they remain in good working order. At the end of the trapping season, traps should be cleaned, oiled, and hung up under some shelter. Before trapping is begun the next year, traps should be inspected before the opening of the season in order that any non-functioning traps might be re-

paired or replaced. Traps should then be boiled for several hours in a container filled with oak chips, walnut hulls, or a similar material. Such boiling produces a blue "slick" on the surface of the traps, making them less susceptible to rusting.

With the exception of the writer, no trappers in Montgomery County boiled their traps just prior to the trapping season. About ten per cent of the trappers boiled their traps before storage. The remainder simply hung their traps up at the end of the trapping season.

None of the trappers on the two marsh areas boiled their traps. On both areas, however, the trappers did thoroughly clean and oil their traps before hanging them in storage. The trappers' experience would seem to indicate that traps used in marsh trapping of the type above have a longevity of four years. Trappers in Montgomery County indicate that their traps have an average life of six years. This is, of course, assuming that no losses to thieves occur. No data were obtained by which a comparison could be made between the longevity of boiled and unboiled traps. The writer's personal experience would indicate that traps so treated might be expected to have a two-to-three-year longer life than untreated traps.

Commercial Lures

Commercial lures containing ingredients which appeal to the mating instincts of muskrats have been on the market for some time. These scents are thick, pasty liquids, and may be purchased at any trapper's supply house for one dollar per ounce. The writer on different occasions has experimented with a lure of this type. Apparently so far as could be

determined, the use of such a lure had no apparent effect on increasing the catch of muskrats in steel traps. Williams (1951), reported that he got almost twice as good results in live-trapping muskrats when he used a commercial lure in his traps.

Only one trapper, a fifteen-year old boy, was found to use a commercial lure in trapping muskrats in Montgomery County. He was of the opinion that it increased his trapping success. Since he caught a total of only nine muskrats, it would be difficult to draw any conclusions on this point. None of the marsh trappers used, or ever had used, any commercial scents in their trapping operations. In general, it would appear from the limited evidence that commercial lures are used very little on the small streams of southwest Virginia, and are of little importance from an economic standpoint.

Ratio of Muskrats Trapped to Other Furbearers

Trappers ordinarily place their traps where "sign" indicates that the animal to be trapped is using. It is inevitable that traps which are so located will sometimes catch animals other than the ones for which they were intended.

This condition is especially prevalent when the legal trapping season is earlier for one furbearer than for others. In 1951, the Virginia open trapping season on muskrat ran from January 1 - March 15, whereas the open mink trapping season ran from December 15, 1950 - January 31, 1951. It is obvious that some muskrats would be trapped during the first fifteen days of the mink season. This situation, in combination with intentional preseason muskrat trapping, often results in the harvest of large numbers

of muskrats before the legal trapping season. Such overlapping in trapping seasons probably is of some economic importance if one considers the state as a whole. In an area as localized as Montgomery County, preseason trapping only, may sometimes reach serious economic proportions. On the two marsh areas, the muskrat is the only furbearer which is trapped, and therefore this problem does not exist.

The entire fur harvest for Montgomery County was compiled for 1949-1950 and 1950-1951. This information was obtained by interviewing trappers and fur dealers. It is realized that these figures are subject to inaccuracies. It is likely that the figures for the skunk and the opossum are too low, and that the figures obtained for muskrat and mink are probably more accurate, since they were easier to check. These data, showing the ratio of muskrats to each furbearer in the total harvest, are presented below in Tables 33 and 34. A total of 1029 muskrats was harvested during 1949-1950 and 954 during 1951.

Table 33. Total fur harvest for Montgomery County, Virginia, 1949-1950, showing the ratio of muskrats trapped to each furbearer in the harvest

Species	Number Harvested	Ratio to Muskrats Trapped Per Listed Furbearer
Mink	63	16:1
Skunk	175	6:1
Opossum	257	4:1
Weasel	12	86:1
Red fox	21	50:1
Gray fox	19	54:1
Total	1576*	

*Includes the muskrat harvest also

Table 34. Total fur harvest for Montgomery County, Virginia, 1950-1951, showing the ratio of muskrats trapped to each furbearer in the harvest

Species	Number Harvested	Ratio of Species to Number of Muskrats Harvested
Mink	94	10:1
Skunk	510	2:1
Opossum	354	3:1
Weasel	10	95:1
Red fox	36	27:1
Gray fox	27	35:1
Total	1985**	

** Includes the muskrat harvest also

It may be seen from Tables 33 and 34 that muskrats made up a larger percentage of the annual fur harvest than did any other single animal. As will be discussed later, muskrats also accounted for a larger percentage of the total value of the harvest than did any other single furbearer. The decided increase in the number of skunks harvested in 1950-1951 may be attributed to a jump in the price of certain long hair furs.

Disposal of Furs

Trapping is usually a strictly business proposition, not a sporting one, and should be considered as such. Trappers are free to dispose of legally-caught muskrats to any licensed dealer whom they wish. Of course, it is to the trapper's advantage to dispose of his furs to the dealer who will pay him the highest price.

There are two general classes of dealers to whom most small-time trappers may sell their skins--the small local dealers and the large,

centrally located fur houses. Some trappers naturally feel that they receive a better bargain by selling direct to the large dealers. In doing this, they believe that they cut out the profit of the middleman between the small local dealer and his buyer. This may possibly be the case in some instances, but the general rule of most fur houses is to grade all of their skins rather closely. In so doing, they pay very high prices for the top skins, but grade some of the poorer ones very low. On the basis of this, they sometimes pay an average price which is below that paid by local dealers.

The general practice of reputable local dealers is to pay an average price for all skins, based on their market quotations. It was found during this study that the average price paid by these dealers was higher than the average price paid by the large fur houses. This will be discussed more completely in another section of this report.

In Montgomery County, data were obtained from the trappers as to the method by which they disposed of their skins. These data are presented below in Table 35. It may be seen that a majority of the trappers in the county preferred to sell their skins to local dealers, with only a very small percentage of the trappers selling their skins to the large fur houses.

The trapper on the Powhaten Hunt Club Marsh annually sells his muskrat skins in two lots to the same local dealer from Newport News, Virginia. The trappers on the Island Farm Marsh sell their skins twice during the season at local auction. There are several dealers represented at this sale, but the pelts usually go to one or more local dealers from Eastern Virginia.

Table 35. Types of dealers to whom Montgomery County, Virginia, muskrat pelts were sold during the 1949-1950 and 1950-1951 trapping seasons

Year	Number of muskrats sold		Percentage of skins sold	
	Local dealers	Large fur houses	Local dealers	Large fur houses
1949 - 1950	734	295	71	29
1950 - 1951	804	150	84	16
Totals	1538	445		
Averages			78	22

ECONOMIC CONSIDERATIONS AND PELT STUDIES

(ECONOMIC STUDIES)

Average Price of Virginia Muskrats

It would appear that the prices paid for pelts would be indicative of pelt values, but this is usually not the case. Pelt prices are governed largely by fluctuations in the market, and therefore high prices do not necessarily denote pelts of high quality.

A majority of the fur dealers do not care to discuss their business, and for that reason it is often difficult to obtain pelt prices. Several dealers in different parts of the state were interviewed, however, and the average prices paid by them for muskrats for the past three years were obtained. In order that a comparison might be easily made, the average pelt prices from Montgomery County are presented separately in Table 36.

Table 36. Average prices of Virginia muskrat pelts for 1948-1949, 1949-1950, and 1951

Year	Montgomery County		Virginia (Exclusive of Montgomery County	
	No. of muskrats	Average price	No. of muskrats	Average price
1948 - 1949	485	$2.10	2100	$1.95
1949 - 1950	1029	1.70	2600	1.65
1951	954	2.75	2400	2.70

From Table 36 it may be seen that Montgomery County muskrats brought a slightly higher price on the market during 1948 - 1949 and 1951 than

did pelts from different sections of the state. This difference might easily be a result of interviewing dealers who did not pay representative prices. It would appear, however, that muskrat pelts from Montgomery County brought prices which were equivalent to, or possibly greater than those received in the state as a whole. It was found that muskrats which had been illegally caught between December 1 and January 1 brought the same price from local dealers as did muskrats which were caught between January 1 and March 15. If there was a difference in price it could usually be accounted for by fluctuations in the market, rather than differences in the pelts.

Fluctuations in Prices

As previously mentioned, the prices of muskrat pelts vary considerably from year to year in accordance with the market demand for the fur. The average price of muskrat skins in Virginia has usually been on a level with skins from other areas. In past years, Virginia muskrats have brought slightly less on the market than have Maine muskrats, and slightly more than have North Carolina and Louisiana muskrats. This did not hold completely true in 1951, as northern muskrats brought a much higher price than did Virginia muskrats. This was undoubtedly due to a high market demand for skins of the northern type. In general, it may be said that Virginia muskrats will usually be in demand, and will bring a price on the market comparable to prices received in other states.

Value of the Fur Harvest on the Virginia Study Areas

The value of the fur harvest in Montgomery County was compiled from data furnished by local fur dealers and county trappers. These data are tabulated below in Tables 37 and 38. It may be seen that in 1949-1950, muskrats made up 60 per cent of the value of the entire fur harvest. This figure dropped slightly to 53 per cent of the harvest in 1950-1951. This may be explained by the increase in value of some of the long-haired furs, notably skunk. It would appear from these data that muskrats are the most important furbearers in the county, both from the standpoint of numbers harvested, and value of the skins.

Table 37. Value of the annual fur harvest in Montgomery County, Virginia, 1949-1950

Species	Total number of skins	Total value of skins	Percentage of total value
Muskrat	1029	$1,749.00	60
Mink	63	976.50	34
Skunk	175	87.50	3
Opossum	257	50.00	2
Weasel	12	18.00	0.5
Red fox	21	10.50	0.3
Gray fox	19	4.75	0.2
Totals	1576	$2,896.50	100.00

Table 38. Value of the annual fur harvest in Montgomery County, Virginia, 1950-1951

Species	Total number of skins	Total value of skins	Percentage of total value
Muskrat	954	$2,623.50	53
Mink	94	1,410.00	28.5
Skunk	510	739.50	15
Opossum	354	123.90	2.5
Weasel	10	15.00	0.3
Red fox	36	27.00	0.5
Gray fox	27	8.10	0.2
Totals	1985	$4,947.00	100.0

Data on the value of the fur harvest from the Powhatan Hunt Club Marsh and the Island Farm Marsh are tabulated below in Table 39. Since muskrats only are trapped on these two marshes, the entire value of the fur harvest is made up of this species. In 1951 alone, the value of the muskrat harvest on the Island Farm Marsh was greater than the entire fur harvest from Montgomery County. It may be expected that the value of the furs in Montgomery County will be considerably greater in years when the price of fox and skunk is high.

Table 39. Value of the annual muskrat harvest on the Island Farm and Powhatan Hunt Club Marshes, 1948-1949, 1949-1950, and 1951

Year	Powhatan Hunt Club Marsh		Island Farm Marsh	
	No. of muskrats	Value	No. of muskrats	Value
1948-1949	470	$ 920.00	1600	$3,120.00
1949-1950	436	699.00	2200	3,630.00
1951	583	1,574.00	1900	5,113.00
Totals	1489	$3,193.00	5700	$11,863.00

Amount of Time Spent on the Trapping Operation

Each trapper in Montgomery County kept reasonably accurate records of his trapping time. Trapping time here includes all time spent in caring for and setting traps, skinning muskrats, and preparing pelts for the market. On the basis of this information, Table 40, showing a breakdown of the income derived from muskrat trapping in 1949-1950 was compiled. Similar data were compiled in 1951, and are presented in Table 41. It may be seen in Table 40 that the income derived per unit of effort was greater for some age groups than for others. This might be attributed to several factors, but was undoubtedly due, in most cases, to the experience of the trapper, and the conditions on the stream which he was trapping. Trappers in Montgomery County received an average of $0.75 per hour and $1.70 per pelt during the 1949-1950 trapping season.

Table 40. Income derived from muskrat trapping by Montgomery County, Virginia, trappers, 1949-1950

Age Group (Years)	No. of hours spent on the trapping operation	Income derived from sale of muskrat pelts	Avg. income per hour of work	Avg. price received per pelt
10 - 15	538	$ 295	$0.55	$1.64
15 - 20	730	530	.73	1.67
20 - 25	470	440	.94	1.69
25 - 30	59	50	.85	1.40
30 - 35	111	80	.72	1.70
35 - 40	25	15	.60	1.67
40 - 45	35	26	.74	1.53
45 - 50	48	36	.75	1.40
50 - 55	195	190	.97	2.41
55 - 60	76	55	.72	1.45
60 - 65	45	32	.71	1.28
Totals	2332	$1,749		
Averages			$0.75	$1.70

Table 41. Income derived from muskrat trapping by Montgomery County, Virginia, trappers, 1951

Age Group (Years)	No. of hours spent on the trapping operation	Income derived from the sale of muskrat pelts	Avg. income per hour of work	Avg. price received per pelt
10 - 15	300	218.50	$0.73	$2.60
15 - 20	700	981.00	1.40	2.70
20 - 25	180	261.00	1.45	2.90
25 - 30	170	235.00	1.38	2.80
30 - 35	190	235.00	1.23	2.70
35 - 40	78	104.00	1.33	2.75
40 - 45	87	121.00	1.40	2.90
45 - 50	106	143.00	1.35	2.85
50 - 55	91	121.00	1.33	2.75
55 - 60	75	90.00	1.20	2.80
60 - 65	80	114.00	1.42	2.95
Totals	2057	$2,623.50		
Averages			$1.28	$2.75

In 1951, trappers made an average of $1.28 per hour of work, and received an average of $2.75 per pelt. It was interesting to note that trappers in the different age groups averaged approximately the same amount per hour for their efforts. This was somewhat in contrast to the figures compiled for 1949-1950, in which some of the more experienced trappers were decidedly more successful.

On the Powhatan Hunt Club and Island Farm Marshes, similar data were collected during the 1951 trapping season. Since these trappers make a full-time job of trapping, the number of hours which they work at this occupation daily is much greater than the number of hours put in by part-time trappers in Montgomery County. Data from these two areas for the 1951 trapping season are tabulated below in Table 42.

It should be emphasized here that the trappers on these two marsh areas do not receive the entire income from the sale of muskrats trapped annually. There are any number of agreements currently in use between trappers and marsh owners. On the Island Farm Marsh, the trapper receives fifty per cent of the gross income, and the marsh owner received fifty per cent. Under this system, the trapper is responsible for furnishing everything that he needs in the way of equipment.

The trapper on the Powhatan Hunt Club Marsh traps muskrats on the marsh each year as part of his regular job as marsh caretaker. In addition, he receives a commission of $0.50 on each muskrat trapped and sold from the marsh. Since it would be difficult to figure his salary into the income derived from trapping, only the commission is considered in Table 42. It should be realized that the figures thus obtained do not truly represent the income which could be derived from trapping on a marsh of this type.

Table 42. Income derived from muskrat trapping on the Island Farm and Powhatan Hunt Club Marshes, 1951

Area	No. of hours spent on the trapping operation	Total income from trapping muskrats	Owner's share	Trapper's share	Trapper income per hour of work
Island Farm Marsh	1022	$5,113	$2,556.50	$2,556.50	$2.56
Powhatan Hunt Club Marsh	365	1,574	1,282.50	291.50	.80

It may be seen from Table 42 that the trapper on the Island Farm Marsh made the very good income of $2.56 per hour in 1951. This is ap-

proximately twice the amount received by Montgomery County trappers for their spare time trapping. Results obtained in this study suggest that small stream trapping in mountainous Montgomery County furnishes an income per hour which is, considering the size of the operation, comparable to the income received on large Eastern Virginia marshes. In view of the trapping agreement, it is difficult to make a comparison of Montgomery County trapping success with trapping success from the Powhatan Hunt Club Marsh. If this trapper had operated on a fifty-fifty basis, he would have received $1.76 per hour which is more nearly comparable to the income derived per hour from trapping on the other two study areas. There are, of course, trapping expenses which will be considered in another section of this report.

Trapping Expenses

In the preceding discussion of trapping income, no consideration was given to possible expenses. It is obvious that some expense will be incurred for traps, transportation, and other items. Unfortunately, none of the trappers on either of the three study areas kept any accurate records on their expenses. It was possible, however, to figure some costs on the basis of information furnished by trappers.

A majority of the trappers in Montgomery County do their trapping on small streams which pass through their own property. As a result, transportation usually involved very little expense. The major expense of any of these small time trappers is traps. Oneida Victor Number 1 Jump traps currently cost $0.35 each on the retail market. As previously discussed, traps used in small stream trapping usually last an average of

six years. On the basis of this, and assuming no losses, each trap costs the trapper in Montgomery County $0.06 per year. The total trap expense may be figured on the basis of the number of traps used by the trappers during 1949-1950 and 1951.

Trap expenses on the Island Farm and Powhatan Hunt Club Marshes are similar with the exception that traps only have an average life of four years. Each trap thus costs the trapper $0.09 per year. At this rate, the sixty traps used by the trapper on the Powhatan Hunt Club Marsh cost him $5.40 per year. Other expenses incurred on this marsh include gasoline, and depreciation on an outboard motor. The trapper on this area, as well as the one on the Island Farm Marsh, use a number of wire stretchers for drying their pelts. These stretchers may be purchased for $2.15 per dozen from trapper's supply houses. There was no way of determining just how long these stretchers might be expected to last. Trappers who use them claim that they will last for many years, with their being no parts to wear out or be replaced.

Trap expenses on the Island Farm Marsh amounted to $8.64 per year. There were no other outstanding expenses on this area except the trapper's transportation to and from the marsh.

It is realized that these data are insufficient and inadequate if the trapping picture is to be economically complete. Accurate data should be kept on trapping expenses for these three areas. If the three areas as a whole are considered, it would appear that actual trapping expenses do not appreciably affect the annual income from trapping muskrats.

(PELT STUDIES)

Primeness

Primeness is a term which is rather generally applied in the fur business. Gunn (1932) made a very complete scientific study of primeness in furbearing animals. Primeness is primarily a phenomenon of hair pigmentation and not of skin condition as is commonly supposed. In the summer and early fall, each individual hair on the muskrat's body has many granules of a dark pigment, melanin, in its roots, giving the skin side of the unprime animal a dark appearance. As the season progresses toward winter, the granules move from the base of the hair toward its tip. The skin side of the prime pelt will thus have a pinkish - white color, rather than the dark areas which are characteristic of unprime pelts. As previously mentioned in the section on age ratios, adult and subadult muskrats exhibit a primeness pattern which is typical for each age group. Unprime areas exhibit themselves in subadult animals in a bilaterally symmetrical pattern, a condition which may be correlated with the number of molts which the animal has passed through. The unprime areas on an adult muskrat usually take the form of an irregular spotted pattern.

Some fur dealers grade their furs largely on the basis of the percentage of the skin which is black. It was found during this investigation that local dealers in Montgomery County graded muskrat skins more on the basis of fur condition, rather than skin color. The percentage of primeness of muskrat skins was collected from Montgomery County throughout the trapping season in 1951. The percentage of primeness was determined entire-

ly by ocular appraisal of each pelt. This method appears to be reasonably accurate and rapid for recording this information. In determing the two-week period during which pelts were taken, as reported by local trappers and fur dealers, there may have been errors of a few days in some cases, a situation which probably does not affect the results appreciably. No distinction was made between the primeness on the backs and bellys of the pelts used here. Percentage of primeness includes the average primeness on the backs and bellys when taken together. No pelt primeness data were recorded from the two marsh areas. Results of the Montgomery County primeness study are given in the following table:

Table 43. Primeness of muskrat pelts by periods in per cent (Montgomery County, Virginia, 1951)

Period	Number of muskrats examined	Avg. percentage of primeness
December 1 - December 15	84	65
December 16 - December 31	56	70
January 1 - January 15	150	80
January 16 - January 31	124	90
February 1 - February 15	80	95
February 16 - February 28	70	95
March 1 - March 15	34	55
Totals	598	

It may be seen that there was a progressive increase in the average percentage of primeness from December 1 through February 28. Pelts caught between December 1 and December 31 were, of course, caught by pre-season trappers. After March 1, muskrat pelts began to become "springy".

Muskrats which had been almost 100 per cent prime began to have large, black, unprime areas appearing on the skin. Local fur dealers were of the opinion that this was somewhat early for this condition to appear, and might have been induced by the unseasonably warm weather which occurred during the first part of March.

It would appear from limited data collected during this study that primeness, as such, has no great effect on the price of muskrat pelts in Montgomery County. It is possible that there is a wide discrepancy in the time at which pelts become prime in the different physiographic provinces of the state. This condition might have some influence on pelt prices and should be given some study.

On the basis of information furnished by several local dealers, Figure 25 was compiled. This chart shows the approximate time at which the important fur animals in Montgomery County are partly prime, prime, and past prime. The chart represents the prime period of muskrat only for that time at which they are at maximum primeness. Dealers and trappers alike in Montgomery County are of the opinion that the primeness of all the furbearers are about the same between December 1 and January 31. An open season on all furbearers between these dates would do much toward reducing illegal trapping. With the possible exception of mink during late January, there apparently would not be enough difference in pelts to be of economic importance. It is believed that this point should be given some consideration in an effort to standardize trapping regulations to some extent.

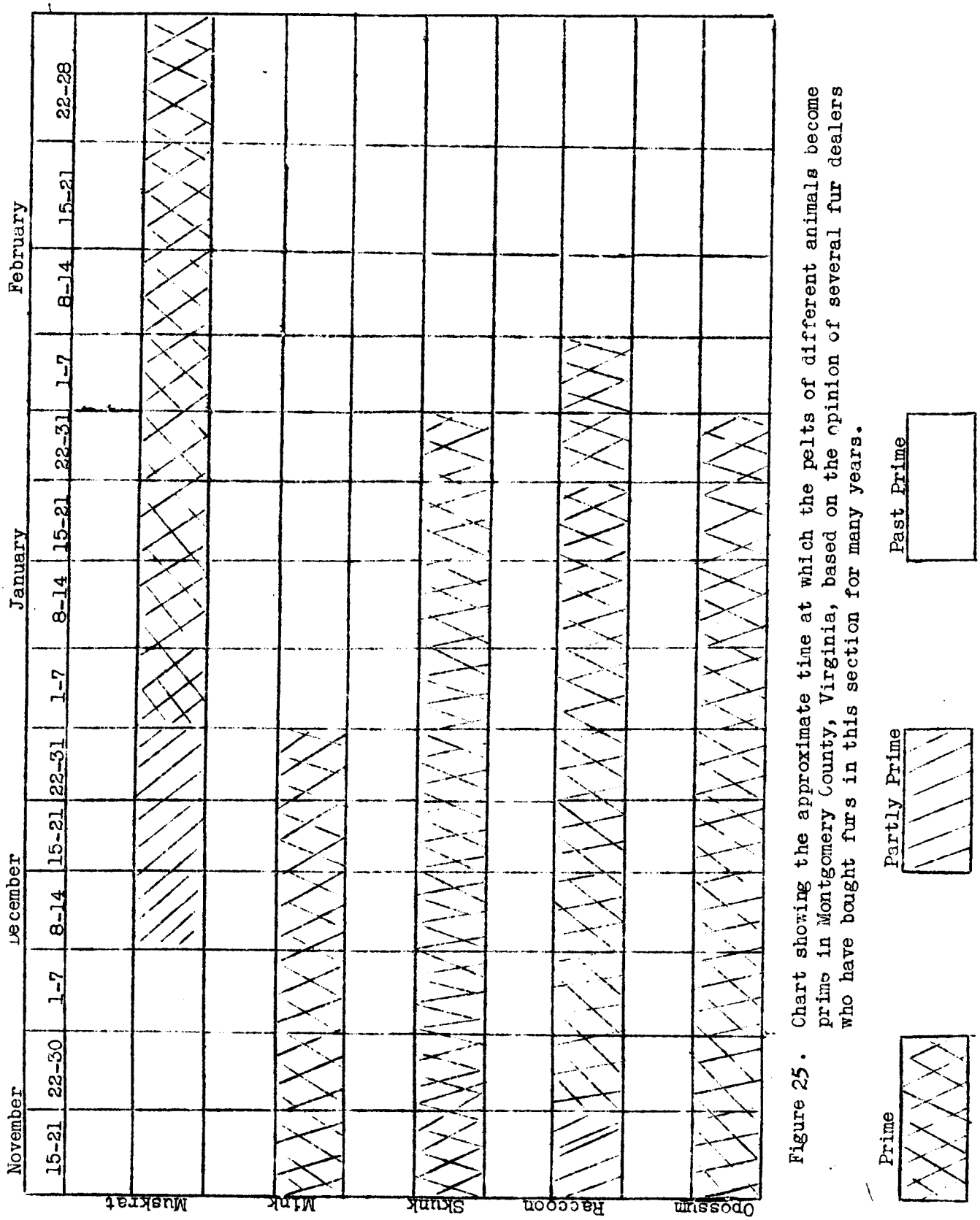


Figure 25. Chart showing the approximate time at which the pelts of different animals become prime in Montgomery County, Virginia, based on the opinion of several fur dealers who have bought furs in this section for many years.

Pelt Measurements

Kellogg (1947), has made quite an extensive study of muskrat pelt measurement and grades. His system involves measuring from the posterior edge of the eyeholes to a cross line connecting the extreme posterior sides of the pelt. Lay (1945), describes a T-frame which can rapidly be used in making these measurements. During this study, measurements were taken with a ruler graduated in millimeters. Many variations commonly occur in stretching pelts, particularly the nose, and for this reason, total length is not always an accurate measurement.

Pelt measurements were obtained for 365 muskrats from Montgomery County in 1951. Unfortunately, all measurements were obtained from one lot of skins at a local buyer's fur house. Gashwiler (1948), found that there was a decrease in size of muskrat pelts from November to January, and attributed this discrepancy to the small number of January pelts in the sample, and the fact that there were few adults present. He is of the opinion that a larger sample would have shown considerable growth throughout the trapping season.

It is possible that pelt measurements in Montgomery County, if taken throughout the trapping season, might show an increase in size and a significant difference in size between subadult and adult animals. The pelt measurement data from Montgomery County are presented in Figure 26. There was not enough difference between the size of subadult and adult animals to be of economic importance. It may be seen that there was also considerable overlap in the measurements of adults and subadults.

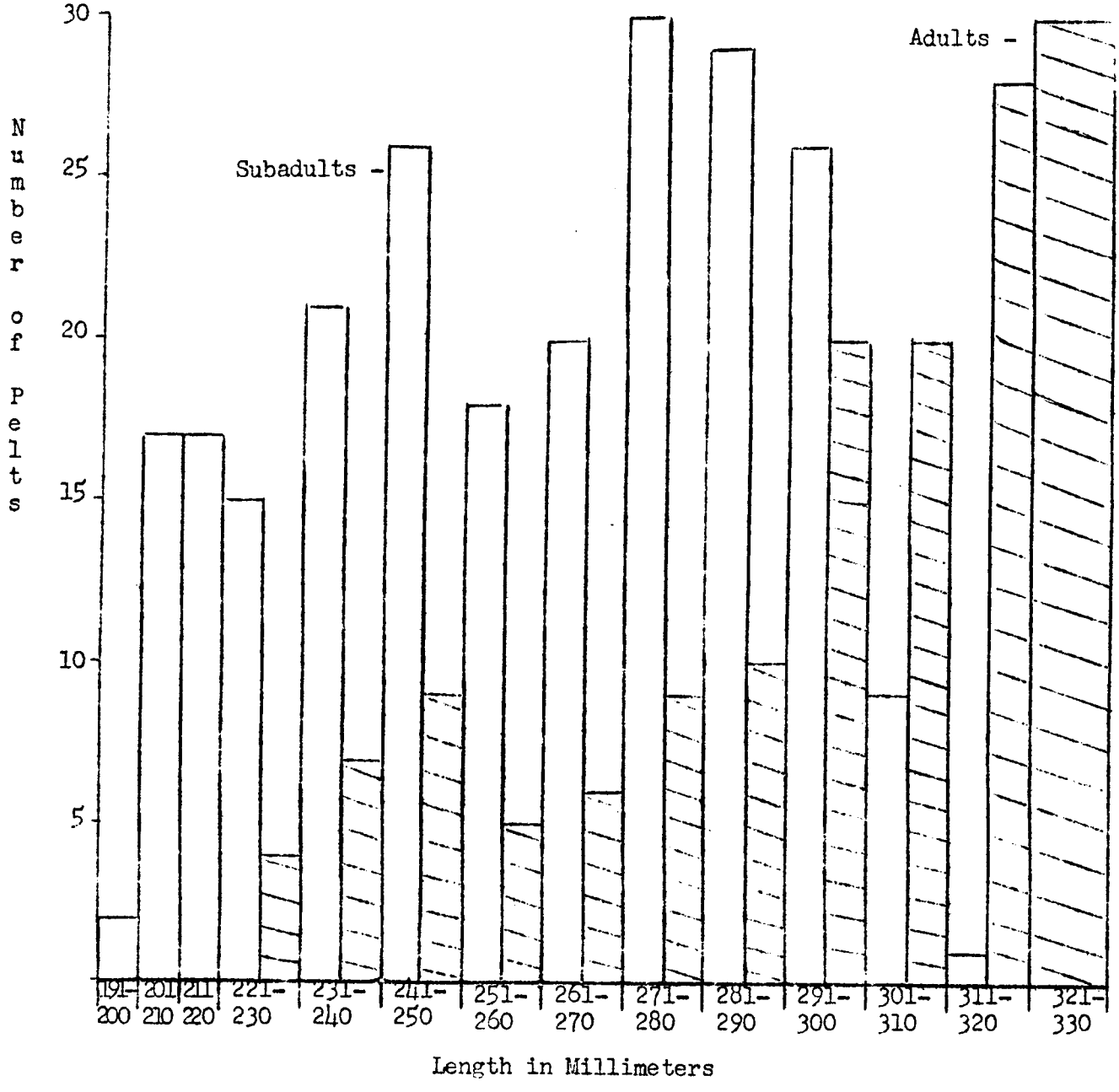


Figure 26. Pelt length in millimeters of 365 muskrats from Montgomery County, Virginia.

No measurements were taken on the two marsh areas. It is probable that there would have been a greater size difference in the pelts from these two areas, since a relatively large number of very young animals are trapped. Pelt sales from the area indicated, however, that with the exception of kits, all undamaged skins brought the same average market price. If the three areas are considered as a whole, pelt size differences are not of great economic importance insofar as the fur buyers are concerned.

Pelt Damage

The value of a pelt, or of a series of pelts, may be seriously affected by the amount of damage such as slits, holes, and cuts, which occurs. Kellogg (1947), reported a steady increase in the amount of pelt damage from December until the end of March. Aldous (1947), in South Dakota found pelt damage starting in December and increasing gradually to a peak during the first half of April. It would appear from these investigations that pelt damage might be worthy of consideration when establishing muskrat seasons.

Gashwiler (1948), made a study in Maine in which he kept monthly records of pelt damage, including the percentage of the backs and bellys which were injured. During 1951, 594 muskrat pelts were examined in Montgomery County for damage. These were classified approximately on the basis of the month in which they were trapped. The number of damaged skins only was recorded, with no data being gathered on the extent to which skins were injured. Results of this study are presented below in Table 44.

Table 44. Percentage of damaged pelts by months in Montgomery County, Virginia, 1951

Month	Number of pelts examined	Number damaged	Percentage damaged
January (Includes December skins)	414	83	20
February	150	48	32
March	30	17	57
Totals Average	594	148	36

It may be seen that there apparently was a progressive increase in the amount of pelt damage as the trapping season advanced. The March sample was very small, but observations indicated that intraspecific fights became very common during this period, and caused considerable pelt damage. With the exception of several skins damaged by mink, all of the damage in Montgomery County was apparently the result of intraspecific fights. Pelt damage appeared to be of considerable economic importance in that skins with more than two large holes were always reduced in price.

Some pelt damage was found on both the Island Farm and Powhatan Hunt Club Marshes. No specific data were kept on pelt damage on these areas, however. On the Island Farm Marsh, intraspecific strife resulted in more damage than any other cause. On the Powhatan Hunt Club Marsh, eagles and raccoons caused a majority of the damage after the muskrat was caught in the trap. On both of the two areas, pelt damage resulted in an appreciable economic loss to the trapper.

LIMITING FACTORS FOR MUSKRATS

Topography

As previously discussed, most of Montgomery County is rough and mountainous. Almost all of the streams are rocky and support little vegetation of a type desirable for muskrats. As a result, only those streams which pass through the cultivated bottoms support a good muskrat population. In the higher sections of the county, topography is undoubtedly one of the most important limiting factors for muskrats.

Stream Gradient

In considering topography, it is only natural that stream gradient be taken up at the same time. The gradient of most streams, may, of course, be correlated almost directly with the topography of the surrounding country.

On those streams in the county which have a very steep gradient, such as those in habitat classification 5, there are very few, if any, muskrats. Those streams in habitat classification 1 have a relatively level gradient and support the heaviest muskrat populations in the county. A steep gradient does not necessarily imply that a stream cannot support a muskrat population. Many steep, swift streams which have suitable environmental conditions do support such a population. When the condition of rough topography exists in combination with a steep stream gradient as is the case in much of Montgomery County, then a limiting factor for muskrats introduces itself. Both stream gradient and topography, being

natural conditions, cannot be controlled or altered. Fortunately, there are more important limiting factors which can be controlled to some extent.

Intensive Grazing

It is the opinion of the writer that grazing by cattle on the better muskrat stream banks is the most important single factor in the county limiting muskrats. Such grazing frequently causes animals which are already present on the stream to move out.

That grazing is one of the limiting factors on Stroubles Creek, is well illustrated in two of the small marsh areas. One of these areas was first subjected to grazing in the winter of 1950. Six muskrats were harvested from this area during the winter of 1949-1950, immediately preceding the grazing. Since that time there has been no sign of muskrat activity on the marsh.

On a small marshy area approximately one-half mile from the above marsh, there was no grazing during the winter of 1949-1950, at which time 4 muskrats were harvested. There was no grazing during the spring of 1950. Observations at this time indicated that the area had a breeding population of six pair. During mid-June, this area was opened to grazing. As a result of trampling by cattle, two active dens were broken in. It is believed that all of the occupants left the marsh area completely. In view of the poor food quality of the plants present, it is very doubtful that the grazing value of this marsh area was equal to its potential value as a muskrat producer.

All through the summer of 1950, it was constantly noted that cattle had caused cave-ins of active dens. In many instances, plants desirable for muskrats had been rather closely utilized by cattle. These conditions were frequently responsible for shifts in the population on certain streams Heavy grazing on the stream banks is a condition which is subject to some control, and will be discussed later under management recommendations.

Intensive Trapping

As discussed earlier in this report, trapping is rather heavy on some of the streams of the county. Trapping pressure, however, is not the important limiting factor it was believed to be at the beginning of this project. As will be discussed later, a more systematic trapping program would probably increase the number of muskrats which could be trapped annually from some of the streams of the county. In view of the fact that a certain percentage of the population usually remains untrappable, it would appear that a sufficient number of animals remain to keep over trapping from becoming too serious a problem. It was found that most trappers became discouraged when their catch dropped off considerably, and thus ceased their trapping operations before the danger point was reached.

Edaphic Factors

It has been shown in many studies that animal distribution may often be correlated with soil type. It has been found in several instances that muskrats definitely prefer a loamy or clayey soil to a

sandy soil. This would naturally be expected in view of the animal's burrowing habits. No specific correlations were made between soil types and muskrat populations during this investigation. It was noticed, however, that as the soil changed on the same stream, muskrat abundance fluctuated. Usually there is, of course, a complex vegetative change associated with any of the major soil changes. All of these conditions should be considered together when the edaphic factor is taken up. In Montgomery County, muskrat distribution and abundance appeared to be affected by changes in the soil type, and it is believed that further studies might prove that the edaphic factors are important limiting agents.

Preseason Trapping

Preseason trapping undoubtedly accounts for the harvest of a large number of muskrats annually. It should be pointed out, however, that it makes no difference whether a muskrat was trapped in November or January, unless the muskrat is considerably more susceptible to trapping in November. It has been the general observation of the writer that the animals are more easily trapped during the fall season. Until further data are gathered on this point, it is deemed inadvisable to consider preseason trapping as an important limiting factor.

Early Mink Trapping and Hunting Seasons

As previously discussed, some muskrats are taken by mink trappers during the early open mink season. No data were gathered as to the extent to which this condition exists in Montgomery County. Systematic

collection of ratios of muskrats trapped to mink might reveal that it was a very important factor. In view of the fact that the muskrat is subjected to the stress of the equivalent of two trapping seasons, this fact probably should be considered as a very undesirable condition.

Fluctuating Water Levels

Violent and sudden changes in water levels of streams have been shown to be very detrimental to muskrat populations. In most cases, the animals soon leave streams which exhibit these sudden fluctuations. In Montgomery County, nearly all of the streams may have sudden increases in water level of one or two feet following a heavy rain. On the best streams in habitat classification 1, this condition is not important, as the stream banks are sufficiently steep for the animals' dens to remain above the water.

On New and Little Rivers, there are much more frequent and severe water level fluctuations. On both of these streams are hydro-electric dams, through which water is released at intervals throughout the day. When this water is released, the rivers may very suddenly rise as much as two feet. These changes in water level, occurring several times a day, have constituted the principal factor limiting muskrat production on these two streams. Very little trapping is done on New River, as the trappers find their traps under water a large part of the time. This condition is not as pronounced on Little River, and as a result, a much larger harvest of muskrats is trapped annually from this stream.

Winter Food Supply

It was found during this investigation that muskrats in Montgomery County ate almost any vegetation which was succulent. Because of this feeding characteristic, an adequate winter food supply seldom becomes a problem.

As previously described, however, there is never a luxuriant plant growth on the ponds in habitat classification three. This is especially true during the winter, and the over-wintering muskrats on these areas frequently have to move to the feeder streams for an adequate supply of food. In at least two instances, it was observed that muskrats had resorted to tree barking. Population movements constantly take place on these areas as the available food becomes more or less abundant. It would appear that in the pond type of habitat, adequate food throughout the winter is the most important factor affecting the resident muskrat population.

MANAGEMENT RECOMMENDATIONS

Habitat Development

There are many areas, such as the small marshes previously mentioned, in the county which could be developed for muskrats. These areas are usually located adjacent to a stream or in a low place in a pasture which lies next to a stream. Almost without fail, these areas are drained by means of a small ditch.

It is believed the natural areas such as this could be profitably converted into marshes with a much deeper water level. Wooden dikes have been constructed across the openings to similar marshes in North Carolina and were successful in raising the water level as much as two feet. Muskrat production on these areas was increased as much as four times. The dikes were constructed of double thickness in order that the second layer of boards would overlap the cracks in the first layer.

It has been the general observation of the writer that these small marshes usually support plants which are desired by muskrats. Such areas apparently are not used by muskrats because they rarely have an adequate amount of water in them.

On the basis of the above observations, it is recommended that landowners having small marshy areas adjacent to muskrat populated streams, construct wooden dikes across the mouths of these marshes in an attempt to raise the water level on these areas. It is unlikely that cattle would enter the marsh to any extent once the water depth was materially in-

creased. Should it be found that cattle continue to use the marsh, then it would be necessary to fence the area. The initial cost of the dike would be only a few dollars, with the fencing, should it be necessary, being the most expensive part of the job. It is believed that the increased number of muskrats which can be trapped from these areas will soon pay back the expense of the initial investment.

Control of Grazing

As previously mentioned, intensive grazing frequently causes part of the muskrat population on a stream to make local movements. When such grazing becomes very severe, complete abandonment of the habitat may take place. This condition should be corrected by fencing the pasture off from the stream banks for a distance of about three feet. Small, local, watering holes could be left unfenced, so that the cattle would have an adequate supply of drinking water. This should be done only on those streams in habitat classification 1, which already have the environmental conditions necessary to support a good muskrat population. Fencing stream banks is a recommended farm management practice to reduce bank erosion.

Systematic Harvest of the Muskrat Crop

A systematic harvest of the muskrat crop can be achieved only by the landowners themselves. Every landowner who does not trap the streams himself should have a definite working agreement with the trapper who does. Each trapper should be allotted a predetermined section of stream

for his trapping operation. Within certain limits, a quota should be established for each trapper, with the landowner having the final word in every case. The trespass law which is currently in effect in Virginia has done much toward achieving a more regulated muskrat harvest on many small farm streams.

Trapping Season

The trapping season is probably the most important single factor in the management of the muskrat. For obvious reasons, the season is also the factor most susceptible to immediate action.

There is a wide variation in the length and time of the muskrat seasons in the states along the Atlantic Tidewater. As may be seen in Table 45 there have been numerous changes in the muskrat trapping regulations in Virginia. Knowledge of the Virginia muskrat is inadequate at the present time, and it is difficult to make any definite conclusions on a statewide basis. With relation to the trapping season, however, some tentative management practices have suggested themselves.

It is difficult to advocate a split trapping season in the state, one for East of the Blue Ridge, and one for West of the Blue Ridge. As may be seen from Table 45, such a season previously existed, and according to several fur dealers' reports was very satisfactory. As mentioned in the discussion on primeness, all of the furs, excluding mink, in southwest Virginia, are prime at about the same period, December 1 - January 31. Muskrats, of course, are not at their maximum primeness during early December. After early December, however, muskrat pelts do

Table 45. Major changes which have taken place in the muskrat trapping regulations in Virginia during the past twenty five years, 1924-1925 through 1950-1951

Year	Open Season	Remarks
1924-25	December 1 - March 31	This was a blanket law covering all furbearers
1926-27	December 1 - March 31	This was also an overall law, but had certain provisions to protect the muskrat
1928-29	November 15 - March 1	This was a statewide law with local exceptions
1930-31	December 15 - March 31	This was a statewide law with local exceptions
1932-33	December 15 - March 31	----------
1933-34	December 15 - March 31	This was a statewide law with local exceptions
1934-35	December 15 - March 31	This was also a statewide law, with no limit being imposed on the trapper's catch
1936-37	December 15 - March 31	This law and preceding laws stipulated that land owners may trap crop damaging muskrats out of season upon written permission of the game warden
1937-38	January 1 - March 15	Preceding law was amended as to open season
1938-39	January 1 - March 15	This was then a statewide law with local exceptions
1939-40	January 1 - March 15	Law still stipulated that landowners might trap crop damaging muskrats out of season
1940-41	January 1 - March 15	----------
1942-43	East of Blue Ridge- January 1 - March 15 West of Blue Ridge- December 1 - Feb. 28	Amendment made of the law of 1940
1943-44	East of the Blue Ridge- January 1 - March 15 West of Blue Ridge - December 1 - Feb. 28	----------
1944-45	East of Blue Ridge- January 1 - March 15 West of Blue Ridge- December 1 - Feb. 28	There are local exceptions in both sections
1948-49	December 15 - Feb.28	Law still stipulates that landowner may trap crop damaging muskrats on his own property under written consent of the game warden
1950-51	January 1 - March 15	Only change in regulations was in the dates of the open trapping season

not increase in quality to an extent which would result in any great increase in price. Mink, on the other hand, are beginning to become unprime toward the latter part of January. Despite these conditions, it is believed that a general open trapping season of December 1 - January 31 on muskrat, mink, skunk, fox, opossum, and weasel should be advocated for the southwestern Virginia counties. The economic loss from decreased primeness of skins would be more than offset by a reduction in preseason trapping, especially of the muskrat. The law enforcement problem would certainly be simplified by a standardization of the season. It is suggested, because of inadequate data, that all trapping seasons in Eastern Virginia remain as they are at the present time.

CONCLUSIONS AND SUMMARY

1. There are 216.5 miles of stream in Montgomery County, Virginia, all of which may be classified into 5 general groups on the basis of their suitability as muskrat habitat.

2. Vegetative studies indicate that the muskrat in Montgomery County eats anything which is succulent. Water cress (Nasturtium officinale) is the most favored food throughout the four seasons of the year.

3. Predators, parasites, and disease, while killing some animals on each of the three Virginia study areas, do not appear to be of serious economic importance. A 31 per cent infestation of muskrats by Taenia taeniaformis on Stroubles Creek indicated that a predatory carnivorous host species for this parasite might be of considerable importance.

4. Sex and age ratios may advantageously be collected and utilized in determining population phenomena. Daily trapping season sex ratios indicate that an inverse relationship between trapping intensity and the proportion of males in the catch. Age ratios may be used as indicators of trapping intensity, as a high juvenile:adult ratio denotes over trapping the preceding year. Age ratios indicated that trapping in Montgomery County ranged from moderate to intensive on the twelve streams which were kept under close observation. Application of sex and age ratios are of considerable practical importance.

5. Sex and age are most easily determined by an examination of the external genitalia of the animals. Should the animals not be available, ages may fairly accurately be determined by an examination of the prime-

ness pattern on the pelts. Sex may also be determined from the pelts by noting whether mammary glands are present or absent.

6. Weights alone cannot be used as a criterion for determining the age of a muskrat on either of the three Virginia study areas. There was too much overlap between the weights of heavy subadults and light adults to make this possible. There apparently was no correlation between muskrat weights and the size and quality of their pelts.

7. On the Island Farm Marsh, the most practical method of population estimation proved to be by house counts. These counts were obtained by taking a series of one-acre sample plots in each of the cover types on the marsh. These counts indicated that there were approximately 3000 animals on the marsh. Population estimations were made for the Powhatan Hunt Club Marsh on the basis of observations by both the writer and the marsh trapper. These observations indicated a population of approximately 1100 animals for the area.

8. Population estimations for twelve Montgomery County streams were based on periodic observations of the number of active dens. Such estimates are naturally subject to a great many limitations, but indicated that none of the streams under consideration supported a very high population.

9. Muskrats were trapped on the three study areas only in steel traps. The Number 1 Victor Stop Loss trap was the most satisfactory for general trapping. In Montgomery County, trappers used from six to thirty two traps.

10. Trapping data were obtained from the trappers by both questionnaires and personal interviews, with the latter being the better of the two systems.

11. On the twelve streams in Montgomery County which were kept under close observation, twenty to one hundred per cent of the estimated population was harvested. On small streams, trapping which removes sixty per cent of the population may be considered heavy, and when such trapping removes seventy five or eight per cent of the population, it is becoming excessive. The average proportion of the population harvested on 12 Montgomery County streams was 62 per cent. Each trapper in Montgomery County caught an average of 26 muskrats in 1949-1950, and 20 in 1950-1951. Trapping success naturally varied somewhat with the age and experience of the trapper. The average success of 6 Montgomery County trappers in 1951 was 13 per cent. The trapper on the Powhatan Hunt Club Marsh had a trapping success of 25 per cent.

12. Temperature was found to be the most important factor influencing trapping success. The greatest number of muskrats were caught when the temperature ranged between 32 degrees Farenheit and 45 degrees Farenheit. In general, below freezing temperatures were a greater limitation to trapping success than were temperatures above 45 degrees.

13. The greatest percentage of Montgomery County trappers preferred to sell their skins to local dealers. It was found that such dealers paid a slightly higher average price for muskrat pelts.

14. Each trapper in Montgomery County received an average of $0.75 per hour for his trapping activities in 1949-1950. The average price received per pelt was $1.70 during this season. In 1950-1951, each trapper in the county made an average of $1.28 per hour and received an average of $2.75 per pelt.

15. Comparable data from the Island Farm and Powhatan Hunt Club Marshes respectively show that the trappers on these areas made an average of $2.56 and $1.76 per hour. If the size of the trapping operation is considered, trapping on small streams in mountainous Montgomery County furnishes an income per hour which is comparable to the income received from large Eastern Virginia marshes.

16. There was a progressive increase in the average percentage of primeness from December 1 through February 28 in Montgomery County. After March 1, muskrat pelts become "springy". Primeness, as such, has no great effect on the price of muskrat pelts in Montgomery County.

17. Pelt measurements of 365 muskrats from Montgomery County showed that there was no significant difference in the size of pelts of subadult and adult animals. There was considerable overlap in the measurements of adult and subadult pelts.

18. In Montgomery County, there was a progressive increase in the amount of pelt damage as the trapping season advanced. It appears that pelt damage in March is greatly increased as a result of intraspecific strife.

19. Limiting factors for muskrats in Montgomery County are: (1) topography (2) stream gradient (3) intensive grazing (4) intensive trapping (5) soil conditions (6) preseason trapping (7) early mink trapping and hunting seasons (8) fluctuating water levels and (9) winter food supply. Of these factors, intensive grazing appears to be the most important.

20. Several management practices appeared to be feasible for increasing muskrats in Montgomery County. The first of these practices is the creation of new habitat by raising water levels in small marshes

adjacent to the streams. This may best be accomplished by constructing wooden dikes across the mouths of these marshes, a job which is relatively inexpensive.

Grazing should be controlled by fencing the pasture off from the stream banks for a distance of about three feet. Small, local watering holes should be left unfenced, so that the cattle would have an adequate supply of drinking water.

A systematic harvest of the muskrat crop should be made by having a working agreement between the landowner and the trapper. Within certain limits, a quota of muskrats to be trapped should be set up for each trapper.

The trapping season is probably the most important single factor in the management of the muskrat. On the basis of data obtained during this investigation, it is advocated that there be a standard open trapping season of December 1 - January 31 on muskrat, mink, skunk, fox, opossum, and weasel in the counties West of the Blue Ridge Mountains. It is suggested, because of inadequate data, that all trapping seasons in Eastern Virginia remain as they are at the present time.

APPENDIX

Skull Measurements

Stress has often been laid upon the importance of cranial characters in the discrimination of species and subspecies in groups of closely allied forms. Gould and Kreeger (1948) made an extensive study of the adult skull of the Louisiana muskrat in an effort to demonstrate sexual and geographic variations. Their data were kept separately for the two sexes. It was anticipated that an extensive collection of skulls of the two subspecies of muskrat in Virginia would be made. Several factors made such a collection impractical. It is possible that extensive skull measurements would have indicated cranial differences between the two subspecies.

Skull measurements were made on 41 specimens of Ondatra zibethica zibethica from Montgomery County, Virginia. There was no attempt made to keep measurements separate for males and females. As would be expected, the mean measurement was greater in adults than in subadults in every case except post zygomatic width, interorbital width, and alveolar length. These data are presented below in Appendix Tables 1 and 2.

Appendix Table 1. Skull dimensions in millimeters of 28 adult muskrats (Ondatra zibethica zibethica) (Includes both males and females)

Dimension	Number	Mean Measurement
Total skull length	28	65.8
Post zygomatic width	28	21.5
Zygomatic width	28	40.5
Interorbital width	28	6.5
Cranial (Brain case) length	28	29.3
Condylo-postalveolar length	28	24.0
Condylo-alveolar length	28	38.5
Alveolar length	28	14.8
Diastema length	28	23.5

Appendix Table 2. Skull dimensions in millimeters of 13 subadult muskrats (Ondatra zibethica zibethica) (Includes both males and females)

Dimension	Number	Mean Measurement
Total skull length	13	62.0
Post zygomatic width	13	23.0
Zygomatic width	13	37.0
Interorbital width	13	7.0
Cranial (Brain case) length	13	28.0
Condylo-postalveolar length	13	23.0
Condylo-alveolar length	13	37.0
Alveolar length	13	15.0
Diastema length	13	22.0

An explanation of the measurements as made above is as follows:

Total skull length - Most anterior point of the premaxillae (or anterior surface of incisors if more prominent) to condylions.

Post zygomatic width - Least distance between outer surfaces of the small bars of the squamosal behind the zygomatic arch. This measurement does not give the full width of the brain case, but there is no definitely located point from which the full width can be taken.

Zygomatic width - Greatest width between the outer surfaces of the zygomatic arches.

Interorbital width - Least distance between the orbits, taken with the fine points of the calipers.

Cranial (Brain case) length - From anterior surface of most prominent point of postorbital process to posterior surface of corresponding occipital below lamboidal ridge. This measurement approximates the length of the brain box.

Condylo - postalveolar length - Condylo - alveolar length minus alveolar length.

Condylo - alveolar length - Anterior margin of the molar alveolus to condylion.

Alveolar length - Anterior margin to posterior margin of upper molar alveolus; length of the molar tooth row.

Diastema length - henselion (posterior margin of alveolus of incisor) to anterior margin of molar alveolus.

Annotated Catalogue of Plant Species Observed to Have Been Utilized by Muskrats in Montgomery County During the Period, September, 1949-April, 1951

Family Typhaceae

Typha latifolia- Rootstock - Utilized in small marshes adjacent to both Stroubles and Tom's Creeks.

Typha angustifolia - Shoots and rootstock - Observed to have been utilized on Stroubles Creek, both as nesting material and as food.

Family Hydrochartiaceae

Elodea canadensis - Leaves - Used as food slightly during the fall season on the V. P. I. ponds.

Family Gramineae

Festuca ovina - Roots and leaves - On nearly all of the streams of the county. Roots appear to be important as food only during the critical winter season.

Festuca elatior - Roots - The vigorous variety of the plant known as Kentucky 31 is particularly desirable as a food. It is heavily utilized along Whitehouse Branch and Meadow Creek where it has been planted to pasture. A small island in one of the V. P. I. ponds was sown with Kentucky 31, and a vigorous growth resulted. Muskrats utilized this heavily during the fall season.

Poa pratensis - Roots - rhizomes - Important food principally because of its abundance in pastures along most of the streams in the county. This plant was utilized whenever it and muskrats occured on the same area, particularly along Stroubles, Tom's, Meadow, and Smith Creeks.

Poa compressa - Roots - rhizomes - Generally found in the same areas as Poa pratensis, and utilized for food in about the same quantities.

Zea mays - Fruit and culms - Eaten only on Meadow Creek and Whitehouse Branch. This plant would have received greater utilization had it been found close to more streams. Corn, when available, is apparently a much desired food.

Dactylis glomerata - Roots - Utilized greatly on Stroubles, Tom's and Meadow Creeks, as it is also an important grass in many pastures. Important principally in the fall when muskrats can easily dig for the roots.

Avena sativa - Roots and stem - Observed to have been eaten only on Whitehouse Branch. This plant would probably be eaten in greater amounts if found in close proximity to many streams.

Phleum pratense - Roots and stem - This plant is only occasionally used for food and does not appear to be desirable as such. Plant received some utilization during the summer and fall on Tom's, Stroubles, Meadow, Smith, and Plum Creeks, and on Big Branch.

Eleusine indica - Roots - Not widely distributed on stream banks, but was eaten slightly during the fall on Sidney Creek.

Setaria glauca - Roots - Not particularly common along streams but used slightly on Stroubles Creek.

Family Cyperaceae

Scirpus validus - Rootstock - eaten usually in the late fall where available, principally in the small marshes adjacent to Stroubles and Tom's Creeks.

Scirpus cyperinus - Entire plant - This plant is limited in the county to moist situations in which there is a very low muskrat population. The only record of utilization by muskrats occurred on Indian Run during the summer. The plants were probably used as den material.

Family Araceae

Peltandra virginica - Rootstock and stem - This plant is known to occur in the county only in the small marsh on the V. P. I. farm. It was utilized here rather heavily during the fall.

Acorus calamus - Rootstock - This plant is known to occur in the county only in small marshes on the V. P. I. farm, Tom's and Meadow Creeks. It is heavily utilized during all seasons of the year.

Family Lemnaceae

Lemna minor - Entire plant - This plant occurs in numerous wet marshy places in the county. On two occasions, muskrats were observed feeding on this plant.

Family Lilliaceae

Allium canadense - Bulb - This plant is probably not important as a muskrat food. It has been observed on Meadow and Plum Creeks that muskrats occasionally dig for the bulb of the plant.

Family Salicaceae

Salix nigra - Shoots - Muskrats frequently build dens under willow trees in the county. Young twigs appear to be very desirable as a food in the spring and are utilized fairly heavily on Stroubles, Tom's, Meadow, Elliott, and Smith Creeks.

Salix babylonica - Shoots - Muskrat utilization of this species has been observed only on the V. P. I. ponds during the early summer.

Family Moraceae

Morus rubra - Fruit - Heavy usage by muskrats of the area immediately beneath a tree of this species on Stroubles Creek would seem to indicate that the fruit of the tree was being eaten.

Family Polygonaceae

Rumex acetosella - Leaves - This plant was utilized, during the winter on most of the streams of the county, including Bradshaw Creek, Plum Creek, Big Branch, Stroubles Creek, Tom's Creek, and Den Creek. This was probably due to the fact that in the winter condition, this plant presents a green rosette form above the ground.

Polygonum hydro-piperoides - Roots and stem - This plant was observed to have been eaten only on Stroubles and Tom's Creeks. It is important chiefly as a summer food. On several occasions, muskrats were observed feeding on this plant.

Polygonum amphibium - Leaves, stem - This plant occurs in the county in only one isolated patch in Stroubles Creek. This patch was heavily eaten by muskrats in late summer, and in one instance a muskrat was seen feeding on the plant.

Family Caryophyllaceae

Saponaria officinalis - Stems - The only usage of this plant by muskrats was observed on the North and South Forks of the Roanoke River where the plant is fairly abundant and other food plants relatively scarce.

Family Ceratophyllaceae

Ceratophyllum demersum - Leaves and branches - Remnants of parts of these plants were found in the entrances to muskrat dens on the V. P. I. ponds. It was assumed that these specimens were carried there and partially consumed by the animals. One muskrat was observed swimming in the pond with a piece of vegetation, believed to be Ceratophyllum, in his mouth.

Family Nymphaeceae

Nymphae odorata - Stems - Two instances of muskrats cutting this plant were observed on the V. P. I. ponds.

Family Ranunculaceae

Ranunculus spp. - Leaves, stems, and roots - Plants of this genus were heavily utilized as a year round food on nearly all of the streams of the county. Ranunculus recurvatus occurred frequently on Stroubles Creek and was especially good as a fall food.

Caltha palustris - Stems - One plant of this species was cut by muskrats in the small marsh adjacent to Stroubles Creek on the V. P. I. farms.

Family Cruciferae

Brassica nigra - Thick root - The roots of this plant appear to be important as a winter food, and on Stroubles and Tom's Creeks are dug up during the winter months. Utilization of this species occurs on several other streams in the county, as the plant occurs very abundantly in waste places.

Brassica rapa - Thick roots and leaves - This plant occurs with Brassica nigra and is similarly utilized, with the leaves being eaten to a greater extent than with B. nigra.

Nasturtium officinale - Entire plant - With the exception of swift rocky streams, this species occurs in all of the streams of the county. It is heavily eaten throughout the year, and appears to be the most important muskrat food in the county. On numerous occasions, muskrats have been observed feeding on this plant.

Family Rosaceae

Fragaria virginiana - Leaves - This plant is not particularly abundant along the streams of the county, being more characteristic of woods and field borders. It was utilized for food during the summer and fall on Stroubles, Tom's, Meadow, Sidney, Plum, and Crab Creeks, and on Big Branch and Little River.

Potentilla canadensis - Leaves and roots - Observed some utilization during the summer on Stroubles Creek.

Family Leguminoseae

Trifolium pratense - Leaves - Eaten quite readily during the summer. Utilized heavily on Meadow, Tom's, Stroubles, and Den Creeks.

Trifolium repens - Leaves - Same as for Trifolium pratense.

Melilotus officinalis - Stem and leaves - Apparently a very desirable summer and early fall food. Utilized on all of the streams of the county which support a muskrat population.

Melilotus alba - Stem and leaves - Occurs with Melilotus officinalis and is utilized to about the same extent.

Medicago sativa - Leaves and stem - Utilized for food only on Whitehouse Branch where there is a large field planted to alfalfa immediately beside the stream.

Amphicarpa bracteata - Leaves - Used as a summer food on Den, Stroubles, Meadow, Tom's, and Sidney Creeks, and slightly on Little River.

Family Geraniaceae

Geranium maculatum - Leaves - Cut slightly on Bradshaw Creek, probably for nesting material.

Family Balsaminaceae

Impatiens capensis - Leaves and stem - Cut rather heavily during the summer on Stroubles and Tom's Creeks. It is likely that this plant was utilized as nesting material.

Family Onagraceae

Oenothera biennis - Stem and leaves - Cut slightly during the summer on Stroubles Creek. Rosette form utilized slightly during the winter on Stroubles Creek.

Gaura biennis - Stem and leaves - Cut slightly on Stroubles Creek during the summer, probably for nesting material.

Family Umbelliferae

Pastinaca sativa - Root - Thick, fleshy root heavily utilized during December and January on Stroubles and Tom's Creeks. Probably constitutes the most important winter food on these areas.

Family Asclepiadaceae

Asclepias syriaca - Stems and leaves - Cut on Stroubles Creek during the summer, probably as nesting material.

Family Verbenaceae

Verbena simplex - Leaves and stem - Cut slightly on Smith, Tom's, and Verbena urticifolia Stroubles Creeks during the summer; probably used as nesting material.

Family Labiatae

Satureja calamintha - Leaves - Utilized slightly as a summer food on Smith Creek.

Lycopus americanus - Leaves - Utilized slightly during the summer on Stroubles and Tom's Creeks.

Mentha spicata - Leaves and stem - Used during the summer, principally on Stroubles, Tom's, Smith, and Meadow Creeks.

Family Solanaceae

Solanum dulcamara - Leaves and stem - Utilized during the summer on Stroubles, Smith, and Tom's Creeks. There was no evidence of the utilization of the fleshy fruit of this plant.

Family Scrophulariaceae

Mimulus ringens - Leaves and stem - Cut slightly on Stroubles Creek during the summer.

Veronica angallis -aquatica - Stem - Used on Stroubles Creek.

Family Plantaginaceae

Plantago lanceolata - Leaves - Used slightly on the V. P. I. ponds, and on Stroubles and Tom's Creeks during the summer.

Plantago major - Leaves - Occurs with Plantago lanceolata and is utilized to about the same extent.

Family Campanulaceae

Specularia perfoliata - Leaves and stem - Cut slightly on Smith, Stroubles, and Tom's Creeks during the summer.

Family Compositae

Taraxacum officinale - Stems and leaves - Occurs on nearly all streams of the county, and is utilized by muskrats where ever found.

Food Habits

As previously discussed, vegetative studies were undertaken on each of the streams in the county to determine the most important seasonal foods of the muskrat. Sample plots were taken during each of the seasons, and the results of these studies are presented in the following four tables.

Appendix Table 3. Ten most important winter foods of the muskrat in Montgomery County, Virginia

Plant Species	Degree of Utilization	Portion of Plant Utilized
Nasturtium officinale	Heavy	Entire plant
Pastinaca sativa	Heavy	Roots
Brassica rapa	Heavy	Roots
Poa pratensis	Heavy - Moderate	Roots and rhizomes
Festuca elatior	Moderate	Roots
Scirpus validus	Moderate	Rootstock
Acorus calamus	Moderate	Rootstock
Ranunculus spp.	Moderate	Stems and roots
Lemna minor	Moderate	Entire plant
Dactylis glomerata	Moderate	Root

Appendix Table 4. Ten most important summer foods of the muskrat in Montgomery County, Virginia

Plant Species	Degree of Utilization	Portion of Plant Utilized
Nasturtium officinale	Heavy	Entire plant
Poa pratensis	Heavy	Roots and rhizomes
Dactylis glomerata	Heavy	Roots
Ranunculus spp.	Heavy	Leaves, stems and roots
Polygonum hydropiperoides	Moderate	Roots and stems
Trifolium pratense	Heavy	Leaves
Acorus calamus	Moderate - heavy	Rootstock
Melilotus officinalis	Heavy	Stem and leaves
Impatiens capensis	Heavy	Leaves and stem
Mentha spicata	Moderate	Stems and leaves

Appendix Table 5. Ten most important fall foods of the muskrat in Montgomery County, Virginia

Plant Species	Degree of Utilization	Portion of Plant Utilized
Nasturtium officinale	Heavy	Entire plant
Dactylis glomerata	Heavy	Roots
Scirpus validus	Moderate	Rootstock
Acorus calamus	Moderate to heavy	Rootstock
Ranunculus spp.	Heavy	Leaves, stems, and roots
Pastinaca sativa	Moderate	Roots
Brassica nigra	Moderate	Roots and leaves
Taraxacum officinalis	Moderate	Stems and leaves
Typha latifolia	Moderate	Rootstock
Lemna minor	Moderate	Entire plant

Appendix Table 6. Ten most important spring foods of the muskrat in Montgomery County, Virginia

Plant Species	Degree of Utilization	Portion of Plant Utilized
Nasturtium officinale	Heavy	Entire plant
Poa pratensis	Heavy	Roots and rhizomes
Acorus calamus	Heavy	Rootstock
Salix nigra	Moderate - heavy	Shoots
Polygonum hydropiperoides	Moderate	Roots and stems
Ranunculus spp.	Moderate	Leaves, stems, and roots
Impatiens capensis	Moderate	Stems and leaves
Solanum dulcamara	Moderate	Leaves and stems
Plantago major	Moderate	Leaves
Taraxacum officinale	Moderate	Stems and leaves

Descriptions of Several Important Streams in Montgomery County, Virginia

Stroubles Creek

Stroubles Creek was considered to be one of the more important study areas in the county. A large part of it passes through land which is owned or leased by the Virginia Polytechnic Institute. This creek originates at the town of Blacksburg and empties into New River, a distance of approximately 10 miles. A majority (70%) of the length of the stream passes through pasture, 20% through woodland, and 10% through overgrown meadows. There are numerous small tributaries leading into the creek, most of which contain a small amount of water throughout the year.

The banks of Stroubles Creek are relatively steep for its entire length, and are as high as four or five feet in some sections. There is only a moderate water flow on this creek except during periods of heavy rains. During these periods, water fluctuations as great as two feet may occur. The vegetation on approximately 50 per cent of the banks of this creek is subjected to grazing. Results of the vegetation study on the area are presented in Appendix Table 7.

Appendix Table 7. Principal plants in order of abundance on Stroubles Creek, showing their utilization by muskrats, based on twenty plots taken in June.

Plant Species	Degree of Utilization by Muskrats	Portion Utilized
Poa pratensis	Slight	Culms
Asclepias syriaca	None	-----
Ranunculus repens	None	-----
Brassica rapa	None	-----
Carex spp.	None	-----
Pastinaca sativa	None	-----
Trifolium repens	None	-----
Trifolium pratense	Slight	Leaves
Veronica angallis-aquatica	Slight	Stem
Phleum pratense	None	-----
Panicum capillare	None	-----
Plantago major	None	-----
Solanum dulcamara	None	-----
Nasturtium officinale	Heavy	Roots, stems, leaves
Plantago lanceolata	None	-----
Solanum carolinense	None	-----
Chrysanthemum leucanthemum	None	-----
Salix nigra	Slight	Shoots
Eupatorium perfoliata	None	-----
Polygonum hydropiperoides	Slight	Roots
Scirpus validus	None	-----
Cirsium lanceolatum	None	-----
Oxalis stricta	None	-----
Amphicarpa dioica	None	-----
Chicorium intybus	None	-----
Trifolin hybridum	None	-----
Sambucus canadensis	None	-----

It would appear from the above data that availability is not that factor which primarily determines which plants are most readily eaten on the area. Although blue grass (Poa pratensis) is the most prevalent plant on the creek, it is not utilized to any great extent. Water cress (Nasturtium officinale), when available, appears to be the most desirable early summer food on the creek. Red clover (Trifolium pratense), water

speedwell (Veronica angallis-aquatica), black willow (Salix nigra), and smartweed (Polygonum hydropiperoides) are all utilized to some extent.

There are two small marsh areas adjacent to Stroubles Creek on the Virginia Polytechnic Institute farm. These two areas comprise approximately three acres and have a decidedly different vegetation from the creek proper.

The most important species of plants on these two areas are cattail (Typha latifolia), sweet flag (Acorus calamus), bulrush (Scirpus validus), water speedwell (Veronica angallis-aquatica), sedges (Carex spp.), duckweed (Lemna minor), and water cress (Nasturtium officinale). With the exception of Carex spp., all of these species were eaten by muskrats. It will be noted that bulrush (Scirpus validus) which was not utilized on the creek, is utilized heavily on the small marshes immediately adjacent to the creek. This may be due to its greater availability, although this factor did not seem to be of any great importance on the creek. It was probably due to an excessively high breeding population of muskrats in these marsh areas, which would, in turn, necessitate a greater utilization of food.

Plum Creek

This creek was given a habitat classification of 1 in the preliminary rating. This rating was based only on a cursory examination of the area in the winter. Upon closer inspection it was obvious that this area should be given a permanent habitat classification of 4. Whereas this type of stream is valuable principally as a breeding area, Plum Creek is utilized little for this purpose.

The banks of this creek are rather shallow in most places, but do get up to several feet in places. The soil and shores are, in most instances, rather rocky. There is little chance for muskrats to establish good permanent den systems. It has been found that areas with a crumbly type of soil are utilized very little by muskrats as denning areas. The depth of the stream varies from a few inches to several feet. The gradient is relatively shallow, and in no place is the water very swift.

The creek is approximately four and three quarters miles long. It crosses Route U. S. 11 several times between Radford and Christiansburg. The stream originates in the hollows between the above mentioned towns and empties into New River about one mile east of Radford.

It is believed that an occasional muskrat may use this stream, but it definitely is not capable of producing any kind of muskrat harvest. The nature of the banks and the rocky, shallow, stream bed are probably the limiting factors in this case. There is an adequate supply of plants, several of which are readily taken by muskrats in other areas.

The principal plant species in order of their abundance on Plum Creek are as follows:

Verbescina occidentalis
Amphicarpa dioica
Arrenatherum elatius
Brassica rapa
Chicorium intybus
Asclepias syriaca
Phleum pratense
Dactylis glomerata
Bromus tectorum
Taraxacum officinale
Plantago major
Erigeron annuus
Salix nigra
Achillea millefolium
Trifolium pratense
Mentha sp.
Apocynum medium
Viola rotundifolia
Convolvulus purshianus
Rumex crispus
Daucus carota
Oxalis stricta
Platanus occidentalis

It may be seen from the above listing that there are several plants on the stream which are frequently utilized by the muskrat. The creek passes through two major land use types: pasture and meadow (overgrown) and woodland. Approximately 85% of the stream passes through pasture and 15% through woodland.

When considering all of the environmental factors, the stream is generally unsuitable at all seasons of the year for muskrats. For this reason, it is recommended that no intensive studies be made of this area, but rather that infrequent observations be made to determine if there is any usage of the area by muskrats.

Meadow Creek

Meadow Creek is one of the few creeks which has potentialities for development as a muskrat area. The creek originates northeast of Riner, Virginia, and empties into Little River, a distance of approximately 6 miles. A large part of the creek passes through agricultural land, including quite a large portion of grazing land. Almost all of the creek which passes through cultivated land is posted. There is no hunting, fishing, or trapping allowed on these areas. These areas are capable of supporting a good muskrat population and of providing a good annual harvest of muskrats. About 15 per cent of the creek passes through woodland or partially shaded land.

The banks are relatively steep in most sections, and in very few places is the stream bed rocky. Along several sections of the creek are small marshes similar to the ones along Stroubles Creek. The principal vegetation on these areas is Typha latifolia, Scirpus validus, Scirpus lineatus, and Acorus calamus. Also present in relatively abundance are Sedges (Carex, spp.), Water speedwell (Veronica angallis-aquatica), touch me not (Impatiens capensis), water cress (Nasturtium), and vervain (Verbena angustifolia). There appears to be little usage of these marsh areas by muskrats, possibly because they are rather closely grazed by cattle. Results of the vegetation survey on the creek proper are presented below.

It may be seen from the data below that there is a greater utilization of plant species by muskrats on this area than on any area covered in the survey. The area from all indications is capable of producing a

muskrat harvest equivalent to any other area in the county. There is little likelihood that there is much illegal trapping because of the large amount of posted land bordering the creek.

Appendix Table 8. Principal Plants in order of abundance on Meadow Creek, Montgomery County, Virginia, showing their utilization by muskrats, based on 15 plots.

Plant Species	Degree of Utilization by Muskrats	Portion Utilized
Chicorium ibtybus	None	-----
Asclepias incarnata	None	-----
Asclepias syriaca	None	-----
Amphicarpa dioica	None	-----
Phleum pratense	None	-----
Carex spp.	None	-----
Trifolium repens	None	-----
Saponaria officinalis	None	-----
Mentha arvensis	None	-----
Trifolium pratense	None	-----
Verbescina occidentalis	None	-----
Scirpus validus	Slight	Roots
Melilotus officinalis	None	-----
Veronica angallis aquatica	Slight	Stems and leaves
Dactylis glomerata	None	-----
Salix nigra	None	-----
Plantago major	None	-----
Nasturtium officinale	Slight	Roots, stems, leaves
Poa pratensis	Slight	Culms
Medicago sativa	Slight	Stems
Arrhenatherum elatius	None	-----
Chrysanthemum leucanthemum	None	-----
Nepeta hederacea	None	-----
Erigeron annus	None	-----
Impatiens capensis	Slight	Stem
Achillea millefolium	None	-----
Verbascum thapsus	None	-----
Medicago lupulina	None	-----
Solanum carolinense	None	-----
Cirsium lanceolatum	None	-----
Monarda fistulosa	None	-----
Rhus toxicodendron	None	-----
Rumex crispus	None	-----
Typha latifolia	Slight	Rootstocks
Oxalis stricta	None	-----

Smith Creek

Smith Creek is approximately four miles long, running from just west of Christiansburg to Rogers, Virginia, where it empties into Elliott Creek which in turn empties into the South Fork of the Roanoke River. This creek is relatively slow moving and in most sections has rather steep, heavily vegetated banks. In some sections, however, it becomes rather rocky and shallow.

About 85 per cent of this creek passes through open land and about 15 per cent through shaded and wooded land. In several sections the banks are grazed rather heavily by cattle. There is a great diversity of plants on the area and it potentially appears to be one of the best muskrat streams in the county. In July, however, there was little evidence of any muskrat population, with only one active den being located. On a preliminary survey made in the winter, this creek appeared to be supporting a fairly good muskrat population. There is only one good tributary leading off from this creek, but as it passes through good agricultural land, it is quite possible that the muskrats are using it for a breeding area. Signs of activity would not seem to indicate this condition. There is evidently some factor other than food, banks, and grazing limiting the number of muskrats which this area produces every year. Winter evidence would seem to indicate that this area was not trapped during the winter of 1949-1950. The few animals using this area during the summer of 1950 were not using that area which appeared to be the best habitat. Results of the vegetative survey are presented below:

It may be seen from the data below that there is an abundance of plants on the area, several of which are particularly desirable to muskrats. That these are not utilized more heavily is due to the rather low population on

the area. It should be remembered that this applies to the summer population and conditions may be entirely different in relation to the winter population.

Appendix Table 9. Principal plants in order of abundance on Smith Creek, showing their utilization by muskrats, based on 15 plots

Plant Species	Degree of Utilization by Muskrats	Portion Utilized
Solanum carolinense	None	-----
Scirpus validus	Slight	Roots
Carex spp.	None	-----
Chrysanthemum leucanthemum	None	-----
Eupatorium perfoliata	None	-----
Medicago lupulina	None	-----
Asclepias syriaca	None	-----
Asclepias incarnata	None	-----
Chicorium intybus	None	-----
Dactylis glomerata	None	-----
Prunella vulgaris	None	-----
Satureja vulgaris	None	-----
Satureja calamintha	None	-----
Impatiens capensis	Slight	Stems
Lepidium virginicum	None	-----
Veronica angallis-aquatica	None	-----
Potentilla recta	None	-----
Melilotus alba	None	-----
Melilotus officinalis	None	-----
Arrhenatherum elatius	None	-----
Salix nigra	None	-----
Amphicarpa dioica	None	-----
Trifolium repens	None	-----
Vinca minor	None	-----
Ranunculus recurvatus	None	-----
Nasturtium officinale	Slight	Roots, stems, leaves
Potentilla canadensis	None	-----
Verbascum thapsus	None	-----
Cirsium lanceolatum	None	-----
Specularia perfoliata	None	-----
Dianthus armeria	None	-----
Echium vulgare	None	-----
Rhus toxicodendron	None	-----
Phleum pratense	None	-----
Erigeron annuus	None	-----
Trifolium pratense	None	-----
Plantago major	None	-----
Polygonum hydropiperoides	None	-----
Rumex crispus	None	-----
Achillea millefolium	None	-----
Oxalis stricta	None	-----

Sidney Creek

Sidney Creek is a very shallow, rocky stream which originates just southwest of Riner, Virginia. It is approximately 3 miles long and is given a habitat classification of 4, based on the system used in this investigation. The stream actually lies somewhere between habitat classification 4 and 5, not being typical of either of these classifications. The stream empties into Little River, serving principally as a drainage for some of the farm land in this section.

Because of its many unfavorable environmental conditions, this creek apparently does not support a muskrat population. It is quite possible that during certain seasons of the year that this creek is occupied by muskrats. This condition is more likely to be true in the spring and summer breeding seasons than at any other time. During the hottest part of the summer, this creek very likely does not have an adequate supply of water to hold muskrats. Results of the vegetative study are indicated below. As far as could be ascertained, the area does not have any muskrats at the present time.

It may be seen from the data below that the availability of food and cover is not the limiting factor for muskrats on this area. During the summer, large parts of the stream dry up, completely, leaving no place for the muskrats to maintain themselves. Approximately 90 per cent of this stream passes through open land, pasture and cropped, the remaining 10 per cent going through woodland or at least partially shaded land. It is not believed that any part of this stream carries muskrats at any season of the year. The environmental conditions limiting them are too great.

Appendix Table 10. Principal plant species on Sidney Creek in early July, based on 15 plots. The species are listed below in order of their abundance on the area

Plant species present on the area as of July, 1950
Asclepias syriaca
Asclepias incarnata
Solanum carolinense
Erigeron annuus
Trifolium repens
Trifolium pratense
Acillea millefolium
Verbescina occidentalis
Plantago major
Plantago lanceolata
Arrhenatherum elatius
Mentha arvensis
Rhus toxicodendron
Poa pratensis
Dactylis glomerata
Saponaria officinalis
Taraxacum officinalis
Veronica officinalis
Impatiens capensis
Pastinaca sativa
Melilotus alba
Melilotus officinalis
Carex spp.
Chrysanthemum leucanthemum
Amphicarpa dioica
Potentilla recta
Salix nigra
Cirsium lanceolatum
Veronica angallis-aquatica
Lepidium virginicum
Verbascum thapsus
Oxalis stricta
Eupatorium perfoliata
Scirpus validus
Verbena urticifolia

Mill Creek

This creek is located in the southwestern section of the county. It originates at Riner, Virginia, and empties into Little River, a distance of approximately four and three quarters miles. There are numerous small tributaries leading off from the main creek.

The banks of this creek are, for the most part, shallow and rather rocky. In some sections, however, the banks are relatively steep, and are bordered by agricultural land. In most of these sections, however, grazing is rather heavy. Taken as a whole, this creek is poor for muskrats, but in some sections is capable of, and does support a light muskrat population. In general, the water flow on this area is rather slow. Local residents could give no information which would indicate that this area produces an annual harvest of muskrats. It does on the other hand, undoubtedly produce animals which could be economically harvested.

Vegetation studies on the area indicate that it has adequate food and cover in most sections, but that the nature of the stream itself probably limits the number of animals which are produced. In the agricultural sections, the cover is as dense as on any of the streams covered in this investigation. It is in these sections that the stream's muskrats are found. Results of the vegetative study are presented below.

It may be seen here that the plants which are utilized on the area by muskrats are very low. Water cress (Nasturtium officinale), despite its relative scarcity on the area appeared to be the most important food. Willow (Salix nigra) and Sweet clover (Melilotus officinalis) are also

utilized slightly. It is quite likely that the fields of corn (Zea mays) may be damaged somewhat by muskrats later on in the season because of their proximity to the banks of the creek.

Appendix Table 11. Principal plants in order of abundance on Mill Creek, showing their utilization by muskrats, based on 15 plots taken in July

Plant Species	Degree of Utilization by Muskrats	Portion Utilized
Verbescina occidentalis	None	-----
Dactylis glomerata	None	-----
Achillea millefolium	None	-----
Asclepias syriaca	None	-----
Asclepias incarnata	None	-----
Chrysanthemum leucanthemum	None	-----
Erigeron annus	None	-----
Melilotus officinalis	Slight	Stems and leaves
Melilotus alba	None	-----
Pastinaca sativa	None	-----
Mentha arvensis	None	-----
Poa pratensis	None	-----
Phleum pratense	None	-----
Plantago major	None	-----
Plantago lanceolata	None	-----
Monarda fistulosa	None	-----
Salix nigra	Slight	Shoots
Nasturtium officinale	Slight	Roots, stems and leaves
Veronica angallis-aquaticum	None	-----
Carex spp.	None	-----
Scirpus validus	None	-----
Medicago sativa	None	-----
Zea mays	None	-----
Sambucus canadensis	None	-----
Cirsium lanceolatum	None	-----
Specularia perfoliata	None	-----
Oxalis stricta	None	-----
Scutellaria serrata	None	-----
Dianthus armeria	None	-----
Oenothera biennis	None	-----

Brake Branch

Brake Branch was given a habitat classification of 4, based only on a cursory examination. Intensive observations would indicate that this stream does not actually belong directly in any of the habitat classification groups. In classifying this stream, it should probably be considered as lying somewhere between habitat classification 4 and 5. The stream is very rocky throughout its entire length. In no place is there any bank other than a shallow rock shore.

About 50 per cent of the stream passes through woodland and 50 per cent through cleared land. In several sections of the main branch there is no water. This lack of water occurs during a period in which most of the streams of the county are swollen from excessive rains. In view of the number of undesirable features present, there is no possibility for this area to support a muskrat population at any season of the year. On the basis of the one survey, this stream will be omitted from any further studies.

Vegetative studies were made on the area, with a total of 10 plots being taken. In view of the unsuitability of the area for muskrats, these data will not be included here.

Den Creek

Den Creek is located in the south-central part of the county. It empties into the South Fork of the Roanoke River. At its mouth, the creek is relatively wide and swift. The width at this point is approximately 10 to 15 feet. The creek is relatively rocky in some places,

but in other sections it is ideal muskrat territory.

The area was given a preliminary habitat classification of 4. Intensive examination of the area confirms this rating. The best possible estimate would indicate that there are not over 5 pair of breeding muskrats on the area. This would normally be expected as this type of stream serves only as a breeding area for muskrats. The animals which summer in this area undoubtedly move into the South Fork of the Roanoke River during the winter months.

The creek is approximately two and one half miles in length. At its upper end it is relatively shallow and rocky, gradually becoming deeper and less rocky at its mouth. There is one half mile of this stream which could adequately support a year round muskrat population provided that the water does not freeze to the bottom in the winter. It is believed that a wintering population of muskrats on this area is prohibited because of this factor. Much of the stream is too shallow to have a water flow during the extremely cold months.

The creek passes through two major land use types. About 90 per cent of the stream passes through cleared land in various stages of cultivation. The remaining 10 per cent passes through woodland. Among the agricultural crops which border this stream are wheat, rye, corn, and alfalfa. There are several fields of alfalfa, in one of which there was some utilization by muskrats. It is not believed that there is a muskrat population present of great enough density to do any great amount of damage to agricultural crops. It is possible that there might be some damage to the corn later in the season. Results of a vegetative survey made on the area show the following plants to be the most abundant.

Appendix Table 12. Principal plants in order of abundance on Den Creek, Montgomery County, Virginia, showing the degree of utilization by muskrats
(Based on 10 plots taken in early July)

Plant Species	Utilization by Muskrats	Portion Utilized
Erigeron annuus	None	-----
Pastinaca sativa	None	-----
Acillea millefolium	None	-----
Medicago sativa	Slight	Stems and leaves
Asclepias tuberosa	None	-----
Asclepias syriaca	None	-----
Salis nigra	Slight	-----
Saponaria officinalis	None	-----
Chenopodium album	None	-----
Melilotus officinalis	Slight	Stems
Polygonum hydropiperoides	None	-----
Arrhenatherum elatius	None	-----
Rumex crispus	None	-----
Campanula spp.	None	-----
Chicorium intybus	None	-----
Verbascum blattaria	None	-----
Verbascum blattaria var. albiflorum	None	-----
Trifolium pratense	None	-----
Lepidium virginicum	None	-----
Nepeta hederacea	None	-----
Fraxinus americana	None	-----
Oxalis stricta	None	-----

It may be seen that the only plants which were noticeably utilized on this stream by muskrats were alfalfa (Medicago sativa) and black willow (Salix nigra). There would necessarily be a slight utilization of most plants on the area since the muskrat population is low. The alfalfa was not eaten to an extent which would be inimical to man's interests. One of the chief disadvantages of the system being used in this investigation is the fact that those plants which receive only a slight amount of utiliza-

tion do not always show up in the plots taken. When the food plant list is compiled for the entire county, however, all of the species which are eaten will probably be recorded.

Trapping License Sales

The sale of trapping licenses varies annually in Virginia, but not to any great extent. The amount of revenue furnished the Commission of Game and Inland Fisheries is relatively small from these sales. In addition to the revenue furnished from the sale of trapping licenses in the state, the Commission also receives revenue from the sale of permits to dealers for the purchasing of furs. These licenses are renewable annually. Prior to 1935, the Annual Reports of the Commission of Game and Inland Fisheries did not give an itemized account of the numbers of trapping licenses sold in the State. The following table gives the annual sale of trapping licenses in the State after 1935.

Appendix Table 13. Sale of trapping licenses, both county and state, in Virginia, for the period, 1935-1945, showing the income derived from these sales (Taken from the Annual Reports of the Commission of Game and Inland Fish.)

Year	County Licenses		State Licenses	
	Number	Revenue	Number	Revenue
1935	1965	$1.50 @ $ 2947.50	15	$5.00 @ $ 75.00
1936	1763	2644.50	22	110.00
1937	2778	4167.00	154	770.00
1938	2181	3271.50	130	650.00
1939	1886	2829.00	111	555.00
1940	1885	2827.50	95	475.00
1941	1838	2757.00	122	610.00
1942	1923	2884.50	144	720.00
1943	1436	2154.00	103	515.00
1944	2063	3094.50	168	840.00
1945	1787	2680.50	194	970.00
Totals	21505	$32255.50	1258	$6290.00
		Grand total		$38,545.50

It may be seen from the above data that income from the sale of trapping licenses does not or could not adequately support any widespread fur resources work by the Commission of Game and Inland Fisheries. It should be remembered that the above figures include the amount which is deducted for clerk's commissions. There is no way of telling how many of these license holders are muskrat trappers. It is likely that a majority of them are since the muskrat is our most widespread and abundant furbearer. The breakdown of these sales by counties would naturally show a preponderance of sales for the Coastal counties of the State. The following table shows the annual sale of trapping licenses in Montgomery County subsequent to 1935.

Appendix Table 14. Sale of trapping licenses in Montgomery County for the period 1935-1945, showing the amount of income derived from these sales
(Taken from the Annual Report of the Commission of Game and Inland Fisheries)

Year	No. of licenses sold		Revenue	
	County	State	County	State
1935	12	0	$18.00	$00.00
1936	6	0	9.00	00.00
1937	17	0	25.50	00.00
1938	15	0	22.50	00.00
1939	8	0	12.00	00.00
1940	13	0	19.50	00.00
1941	6	1	9.00	5.00
1942	11	0	16.50	00.00
1943	14	0	6.00	00.00
1944	11	0	16.50	00.00
1945	10	0	15.00	00.00
Totals	113	1	$169.50	$ 5.00

The table above indicates that the sale of trapping licenses is consistently low in a mountain county such as Montgomery. The above figures do not reflect a true picture of the number of trappers, as many of the farmers trap muskrats on the streams which pass through their personal property. Under these conditions, a license is not required by the land owner. Many trappers, also, do not trouble to purchase trapping licenses. Several of the trappers interviewed in this investigation were not legal trappers in that they did not possess a license. It is the opinion of the writer that this is much more an educational problem than a law enforcement problem. Also, a relatively large amount of fur is caught in the county by boys between the ages of 12 and 14 years. These people are not required to purchase a license.

It is only logical to assume that the sale of trapping licenses will be greater in the coastal counties where there are numerous marshes producing the highest fur populations in the state. Even in these counties, however, the sale of licenses is not extremely high.

It may be seen from the table below that the sale of licenses is approximately twice that of a mountain county in a coastal county. The annual harvest of muskrats is 10-20 times greater, however, because of the much greater productivity of the habitat in Eastern Virginia.

These data are presented simply to indicate the trend of licensed trapping which has taken place in two of the counties under consideration in this study, and to indicate somewhat the place of this phase of the economic side of the trapping picture.

Appendix Table 15. Sale of trapping licenses in Richmond County for the period, 1935-1945, showing the amount of income derived from these sales (Taken from the Annual Report of the Commission of Game and Inland Fisheries)

Year	No. of licenses sold		Revenue	
	County	State	County	State
1935	24	0	$36.00	$ 00.00
1936	18	0	27.00	00.00
1937	17	0	25.50	00.00
1938	9	0	13.50	00.00
1939	28	0	42.00	00.00
1940	25	0	37.50	00.00
1941	22	0	33.00	00.00
1942	16	0	24.00	00.00
1943	18	0	27.00	00.00
1944	13	0	19.50	00.00
1945	12	2	18.00	10.00
Totals	202	2	$303.00	$ 10.00

Live Trapping and Tagging

Numerous investigators have worked on live-trapping techniques for the muskrat. Numerous conditions such as growth, population movements, and sex ratios may be determined by a successful live-trapping program.

The Errington (1937), banded large numbers of young muskrats which they removed from lodges. Cook (1941), in New York described a system of tagging muskrats in which the tag was placed among the Tendon of Achilles of the animal. This method apparently gave very good results.

In Maine, Takos (1943), tried both the Errington and Cook methods of tagging muskrats. When tagging all-age muskrats, best results were obtained by the use of the method described by Cook. Takos used a rectan-

gular trap made of 1/2 inch hardware cloth, the trap being operated by a door release tripped by the animal's efforts to secure bait placed in a chamber at the rear. Slices of carrots or apples were used for bait, the former proving to be the most effective.

Aldous (1946), reported using three types of live traps--the Gibbs, Hancock, and National. The National, which is basically the same as the trap used by Takos, proved to be the most satisfactory of the three types.

In an attempt to gather some information on spring and fall movements, live-trapping was tried during this investigation. These operations were conducted on Stroubles Creek for a period of twenty days in August. Six Bailey beaver traps were borrowed from the Virginia Commission of Game and Inland Fisheries, and were used in this work. The beaver traps had several features which made them undesirable, but were the only type of trap in which any muskrats were captured. One very great disadvantage of the trap is the difficulty involved in one man's setting them. Both wooden box traps and hardware cloth traps were previously tried with no success. The wooden traps had the disadvantage of swelling when wet, a condition which made them very difficult to spring.

Using green corn for bait, the beaver traps were set for a period of twenty days, with eight muskrats being caught. These eight captures represented six different animals and two recaptures. Unfortunately, because of high water, three animals were drowned in the traps. It would seem that the trapping results represented a very low trapping success, but it should be emphasized here that the traps were made non-functional on several occasions from excessively high water. Average trapping suc-

coss for the period was 10 per cent. All trapped animals were tagged in both ears, using Number 1 Monel tags. The sex, weight, and capture location were recorded for each muskrat. The tags were apparently satisfactory, as the external ear of the muskrat is amply large to take the tags. All muskrats were transferred from the Bailey trap into a small funnel before tagging. This funnel, constructed of hardware cloth, is illustrated in Appendix Figure 1. The funnel proved to be very satisfactory for holding the animals immobile during the tagging process. While in the funnel, all of the muskrats were weighed on a Chatillon hand scale.

The live-trapping operations were again tried in December, using only three traps in this case. These traps were set for a period of twelve days, but excessively heavy rains, in combination with ice in the streams, limited the functioning of these traps to six trap nights. There was no catch during the period, although two of the traps were sprung. Three more beaver traps of a different type were obtained from the Game Warden in Craig County. These traps had large openings in the wire which necessitated patching them with hardware cloth. In view of inclement weather, and the short length of time which remained before the open trapping season, these traps were never set, and those traps which were already set, were taken up. It is believed that traps of this type would be effective if consistently used during the spring, summer, and fall seasons. It is not believed, however, that a trap of this type is effective during the winter season when there is a period marked by high water and frozen streams. No returns have been received from any of these tags, and it is not likely that any conclusions could be drawn from such a limited number of tagged animals.

Appendix Figure 1. Attaching No. 1 Monel tag to the ear of a muskrat while in the hardware cloth holding funnel

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