INVESTIGATIONS ON THE EFFECTS OF CONTROLLED WATER LEVELS UPON MUSKRAT PRODUCTION

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Although North Carolina embraces numerous rivers, several large lakes, thousands of miles of ditches, several hundred thousand acres of swamps and at least 200,000 acres of marshland, the muskrat harvest according to fur dealers' reports since 1940, has never exceeded 147,000 pelts. Muskrats, it is true, do not exist along the coast below Pamlico Sound, nor are many found in the expansive swamps, but why the remaining habitat in the State, which is considerable, is not more productive remains an unsolved problem. Doubtlessly many limiting factors are involved; overtrapping, limited food supply, lack of water or too much water, or combinations of these, to mention a few. One might ask, what then is good muskrat habitat? What constitutes basic environmental requirements? The standard answer often is: Give the muskrat plenty of food and water and it will increase in large numbers. But is the answer really as simple as that? No! If it were, muskrat investigations would not be necessary. Right now thousands of farmers and owners of marshland over the State would welcome information they could economically employ to obtain bigger muskrat yields. Vast areas of marsh along the coast never produce a muskrat; in fact, except for occasional cattle range, are useless. Tidal marshland in northeastern North Carolina represents the largest and most productive block of muskrat habitat in the State, but the approximately 34,000 acres seldom yield more than one muskrat to the acre. This, too, presents a management problem. An increase of one muskrat per acre in any of these habitats would mean increased State wealth and a bigger dollar income for the people who need it most.

This paper covers only the beginning of a study, the major objective of which is to find out what combination of food, cover, water, and other environmental influences produces the largest trappable muskrat surpluses per given acre of habitat. Equally important investigations are being conducted in the control and eradication of undesirable herbaceous vegetation like needlegrass, *(Juncus roemerianus),* sawgrass *(Cladium jamaicense),* and cordgrass *(Spartina cynosuroides)* by mowing, burning, flooding, and the use of herbicides. A major project segment covered in this paper involves investigations on the effects of controlled water levels upon muskrat populations.

The acquisition of an 800-acre tract of marsh and woodland along the Northwest River two miles east of Moyock in Currituck County by the North Carolina Wildlife Resources Commission in 1948, resulted in the establishment of the Northwest River Marsh Refuge. Construction of the Fur Animal Field Station, the first in North Carolina history, and a boat house was completed last summer. One biologist with occasional student assistance from North Carolina State College and labor when needed comprises the project personnel.

The marsh acreage consisting of about 400 acres is typical of low productive muskrat habitat in Currituck Sound. Cattails, all four species *(Typha glauca, angustifolia, domingensis, latifolia),* three square grass *(Scirpus olneyi)* and other good food sources are present in large to medium quantities on about 300 acres. Principal vegetation on the remaining acreage is needlegrass, sawgrass, cordgrass, and royal fern *(Woodwardia virginica).* Water in the area is fresh to slightly brackish. When bought in 1948, the unit carried about 500 muskrats, numerous raccoons, some mink, marsh rabbits, deer, a few gray fox and otter, plenty of cottonmouth moccasins and on higher land bordering the Virginia State line, a few canebrake rattlesnakes.

MUSKRAT PRODUCTION

Muskrats inhabiting the northeastern North Carolina coast are known as the Virginia or coastal muskrat *(Ondatra zibethica macrodon).* Its range extends along the Middle Atlantic Coast Region from Delaware Bay to Pamlico Sound, North Carolina. Two color phases occur throughout its range, a black and brown. Examination of 6,668 muskrats in Currituck County fur sheds from 1947 to 1949 revealed 62 "browns" for every 38 "blacks." Higher prices are normally paid for black pelts, but to avoid confusion fur dealers usually pay a "flat" though higher rate. Proof that muskrats from North Carolina are considered good merchandise is found in the prices annually paid. The average pelt price paid in 1948 for 958 muskrat pelts trapped on a local marsh in Currituck County was $2.25, and with $125.10 for meat, an average of $2.38. The same year in Maine, 600 miles to the north, 475 spring pelts brought an average of $2.87(1). A difference of 62 cents per pelt between muskrats reared in the sunny south and the cold north woods of Maine. Prices paid to the same trappers for 617 muskrats during the 1948 - 1949 season averaged only $1.81 per pelt, but $158.76 received for 567 carcasses, (28¢ per animal), brought the average to $2.07. Fifty-four nice muskrats from the Northwest River Marsh, two of which weighed more than 4 pounds, averaged $2.03 per pelt. Yields in the bulk of Currituck Sound marshes range from almost nothing to two animals per acre, but in some areas of apparent optimum habitat catches up to 20 muskrats per acre and even more are made. Approximately 34,000 acres of marshland in the county normally yield an annual crop of muskrat pelts worth from $50,000 to $75,000.

LIMITING FACTORS

Overtrapping, disease, predation, limited food supplies; any of these could be the factor behind the poor yield returns from many local marshes, but what appears to be the perennial and principal limiting factor operating in Currituck Sound marshes is the year in and year out lack of consistently stable water levels. High water over the marsh one day, low water below marsh level the next, high water for weeks at a time, usually in the summer, low water for weeks and even months at a time, usually in the winter. Thousands of acres of marshland in the Northwest River section of the Sound contain immense quantities of the choicest three square grass and cattail muskrat foods, however, year after year many of these acres do not produce a muskrat and no large semgents in recent years have averaged even one muskrat per acre. Nevertheless, pockets or depressions in the

marsh that never go dry usually produce a substantial crop of muskrats. Trapping records from the Tice brothers' marshes, Tulls Bay, Currituck Sound, for the 1947 - 1948 season reveal that 103 muskrats trapped from 61 acres of marsh, 66 (64%) came from two pockets totaling 10 acres. The same year 120 acres of additional marsh yielded 237 muskrats, but 85 (36%) of them came from 14 acres or about 12 per cent of the marsh. This area also was a pocket with year round water. Additional examples could be sited, but they are not necessary. We all know that muskrats must have water. Just what the minimum requirements are is not known by the writer, but field observations seem to indicate that muskrats old enough to swim can tolerate marsh holding 20 inches of water much better than habitat with water levels 5 inches below the marsh. Experiments and studies in the use of wooden diking to control marsh water levels will, it is hoped, divulge this information.

Approximately 10,000 acres of almost worthless needlegrass, sawgrass, cordgrass vegetation represent another important limiting factor in muskrat production. Experiments and studies to eradicate and replace them with cattails, three square grass and other valuable foods are being conducted now.

INVESTIGATION PROGRAM

Most of the investigations reported upon here represent only the beginning. The big project lies ahead. Whether some of them are initiated, however, depends largely upon the outcome of the preliminary work.

Controlling Water Levels

Wooden diking has been successfully used for years in Currituck Sound to impound and maintain marsh pond water levels to attract waterfowl. Most diking has been constructed in sand at considerable expense. Diking established over peat marsh usually costs less, but unless dike wings are driven into the marsh on either side of the main impoundment, leaks from muskrat diggings usually occur. Wooden dikes built in 1928, on Bray's Island in upper Currituck Sound were found intact in 1949. Muskrat excavations flanked all the impoundments, none of which were holding back water, but the weathered pine boards though worn on the edges, were still sound enough to take a nail and hold water.

Methods — All dikes constructed have been made from heart pine lumber. No special equipment has been available and every dike built was put in by hand. Since most of the marsh in the Northwest River vicinity lies over 10 to 25 feet of peat, the job, in most cases, has not been difficult. All dikes were made of lumber one inch thick by 6 to 8 inches wide. Boards in most small dikes were 5 to 7 feet long, but dikes across guts more than 10 feet wide usually required material from 8 to 12 feet long. Dike construction consisted of driving down a double line of overlapping boards across the ditch or creek. Early attempts to drive down more than one board at a time failed. By sharpening boards and driving them singly with a maul, a snug water-tight job resulted. The two-inch thick dike was then nailed from water level up to the top with 10 penny galvanized nails. One 14-foot wide dike was reinforced with a buffer dike (a line of one-inch boards driven 2 feet behind the main dike) and braces (in front of dike) 4 feet apart. Every dike, except one, had dike wings. Constructed of one inch material, 3 - 6 feet long, they perform

two things; impound water and prevent the muskrat from digging holes which would drain the marsh. All of the larger dikes were equipped with spillways to facilitate draining and taking in water.

Dikes designed to impound three ranges of water levels have been established. The first — and most of these are across small guts and ditches 2 to 6 feet wide — allows high water in the marsh, but during periods of low tide holds it at marsh level. No spillway is used with this dike. The second type of dike in use also allows the entrance of high water, but impounds 5 to 7 inches. To impound this much water, dike wings 3 to 6 feet in the marsh and 8 inches up, extend several hundred feet on either side. A spillway affords drainage when desired. The third diked area, surrounded by roads and high land, keeps out creek water except during unusually high tides and the water levels in this impoundment have been kept fairly stable. This unit is equipped with a spillway also. Another dike of this type capable of keeping out all high water will be constructed when the performance of test dikes already established prove that wooden diking over deep layers of peat is practical and capable of impounding and holding water for long periods.

Results — From what we have learned, diking in tidal marshland of the Northwest River — Tulls Bay variety is comparatively simple, economical and to date all nine dikes that have been completed are holding water. Dike with the most impressive record embraces a 14 acre segment of marsh owned by the Tice brothers. Completed last October 9, 1948, it has consistently held an average of at least seven inches of water for more than a year. Three days in June, following two weeks of low tides and three weeks of no rain, water dropped three inches below marsh level, but excessive transportation and evaporation resulting from high winds, not leakage, caused this situation. The only other dike capable of backing up water on more than ten acres of marsh is located on the Northwest River Marsh. Mistakes in construction that caused this dike to leak have been rectified. From late June when repaired through July and August, high water has covered the area, but since early September this dike has had several severe tests and, except for some minor leaks, without the loss of water. The records of other, though similar, dikes have all been good.

Costs — When compared to impoundments made on higher land the cost of constructing a marsh dike is small. For example: One hundred board feet of lumber and nine hours labor were required to build a dike across a 6 foot wide canal, 60 board feet went into the dike and 40 board feet was used to build the dike wings. Cost of lumber, $8; labor, $9; with a total cost of $17. Another dike 16 feet wide with lumber for 12 feet of wings included took 240 board feet of lumber and 31 hours of labor to complete at a cost of $49. Total cost, expense of dike wings included, about $3 per lineal foot of dike.

Effects upon muskrat populations: Muskrat house counts and close scrutiny of the diked areas last fall and winter revealed what appeared to be heavier muskrat populations on most units but, if true, bigger yields should have resulted and, except for one segment of marsh, they did not. The rat harvest in many Currituck marshes was done last year, however, and in the Tice marshes production fell off 36%. A few months hence we will be better able to evaluate the effects of year-round diking on muskrat populations.

Very little is known about the plant ecology of Currituck Sound tidal marshes. Marginal zones between woodland and marsh are continuously changing and building up the forest area. The process is slow, but each year the marsh acreage shrinks. The direction of plant succession in Northwest River marshes appears to be from three square grass — cattail to pure stands of needlegrass — sawgrass. Absence of fires and the year after year accumulation of rank vegetation accelerate the trend toward woody vegetation.

Investigations into means of eradicating undesirable climax marsh vegetation have been in progress about 20 months. Most of the early work was done with burning, followed by experiments in mowing and herbicides.

Burning — Late winter-early spring burns in climax vegetation permit rapid growing three square-cattail vegetation to get a new grip in habitat they are gradually losing, but except for a thinner appearance and where late spring burns have precluded florescence, needlegrass-sawgrass-cordgrass vegetation have shown no ill effects. If this vegetation could be burned hard every year, it might be eradicated but attempts to do so have failed. Burning, however, cleans a marsh of "roughs" and accumulated organic matter, slows its building up, which doubtlessly retards the invasion of the climax plants. It is, therefore, a good management tool, but in forested areas should be used judiciously. Where diking facilities are available, burning followed by flooding appears to be the cheapest, easiest, and most effective way to rid a marsh of climax vegetation. Last spring, experiments conducted along these lines in sawgrass-needlegrass vegetation resulted in mortality ranging from 75 per cent to complete eradication. Next year all marsh in the big diked areas will be burned early and flooded.

Mowing — Mowing experiments conducted in climax vegetation on the Northwest River Marsh have not shown much lethal promise. Preclusion of inflorescence and thinner stands resulted in most strips but inventories made in June 1949, revealed increased growth and more plants in every mowing.

Mowed plots inundated by 6 to 20 inches of water produced a different story. A total of eight strips was established in the diked areas and ranged from 12 feet wide to 30 and 50 feet long. Five needlegrass plots mowed during June and July and flooded with 6 to 20 inches of water (only 2 - 4 inches of water over top stems most of this time, however) for 70 to 90 days showed mortality ranging from 90 to 100 per cent. Four plots contained good stands of water smartweed *(Polygonum punctatu)* and spike rush *(Eleocharis palustris)* some three square grass and a few cattails *(Typha domingensis).* The fifth plot showed almost no vegetation; one water lily *(Castalia odorata)* and one muskrat-cut stem of pickerel weed *(Pontederia cordata).* Two cordgrass strips supported numerous spike rush, a few cattails *(Typa domingensis)* and about 200 stems of narrow three square grass *(Scirpus ammericanus.)* Practically a 100 per cent kill was obtained. One sawgrass plot showed no surviving plants, but instead a dense stand of pickerel weed. A ninth mowed strip of needlegrass made during July in undiked marsh revealed 80 per cent mortality, numerous plants of sweet flag *(Acorus calamus),* a muskrat food, and spike rush. Four to 20 inches of water covered this cutting about 50 days.

Herbicides — During August and September 1948, 28 herbicide plots 10 feet square were laid out in needlegrass-sawgrass-cordgrass-reed *(Phragmites communis)*

vegetation. Half were mowed, half unmowed and each had a control plot. Sodium arsenite in liquid form was used at a ratio of 1:5 in water with Vel and soap wetting agents on a relatively dry marsh. Results tabulated in June 1949, showed heaviest plant mortality in unmowed plots and the following average kill percentages:

Needlegrass	mowed,	69%;	unmowed,	82%
Sawgrass	mowed,	34%;	unmowed,	75%
Cordgrass	mowed,	38%;	umowed,	79%
Reed	mowed,	46%;	unmowed,	37%

Reed was affected the least, needlegrass the most and unmowed plots gave best results in all the treated vegetation except reed.

Last spring and summer more sodium aresenite, King-O-Cide and A. M. C. C., two new formulas, were sprayed on 14 additional plots in needlegrass, sawgrass, and cordgrass vegetation. Next spring several more herbicides will be introduced and about three times as many plots established.

SUMMARY

The following summarizes the principal items of discussion:

1. Despite what appears to be extensive muskrat habitat over the State, greatest number of pelts trapped in recent years has been only 147,000.
2. The 34,000 acres of Currituck County tidal marshland annually produces between 30 and 40 thousand muskrat pelts worth between $50,000 and $75,000.
3. Principal limiting factor in muskrat production believed caused by extreme and irregular fluctuations in water from wind tides and the lack of stable water levels. The 10,000 acres of foodless needlegrass-sawgrass-cordgrass marsh is a limiting factor also.
4. Investigations with dikes impounding three ranges of water levels:
   (a) Dike allowing entrance of high tidal water, but holding water at marsh level.
   (b) Dike allows high water in, but holds receding water 5 - 7 inches over marsh.
   (c) Diked marsh holding stabilized water level year round — tidal water taken in only when needed.
5. Test dike built in October 1948, has held average of 7 inches of water for year without apparent leakage.
6. Test dike in Northwest River Marsh held 5 to 7 inches more water than outside marsh through most of September.
7. Burning an effective means of prolonging life of marsh, but in Northwest River marshes it does not control or eradicate undesirable vegetation. Burning and flooding needlegrass-sawgrass types resulted in 75% to complete kill.
8. Mowings of needlegrass-cordgrass-sawgrass vegetation followed by flooding resulted in high to complete mortality in every plot. Mowings on dry marsh control vegetation temporarily, but do not kill.

9. Liquid form of sodium arsenite sprayed on 28 10-foot square plots of needlegrass-sawgrass-cordgrass-reed resulted in mortality ranging from 23% to 91% in unmowed plots and 12% to 70% kill in mowed plots. Reed affected least.

COMMENTS

A glimpse at the work accomplishments of the past two years shows most everything in its beginning, no objectives realized but a general forging ahead. Investigations on the effects of controlled water levels upon muskrat production have not revealed much light on the latter, but of the former promising strides have been made toward what I believe to be a fact; that wooden diking, or sheet piling as it is often called, will hold back water in tidal marshland of the boggy-peat variety in the Northwest River area on Currituck Sound without any apparent or visible loss from underground seepage or leakage. If the dikes continue to hold water, and there is no evidence or reason to believe they will not, this fact alone should be good news for muskrats and waterfowl. Many natives, however, do not share this optimism (do not believe holding water in marsh will benefit muskrats), but even if they did, one thing is certain. Diking at its best in Currituck Sound will always be largely limited to small creeks and guts or ditches in the marsh; waterways removed from agricultural lands. But in the Northwest River section alone there are hundreds of sites for small dikes of the 4 to 10 foot variety and doubtlessly additional hundreds of similar spots in other sections. If management investigations with the muskrat prove successful, all of these areas will be available. According to Cottam, there are approximately 625,000 acres of tidal marsh on the Atlantic Coast from Maine to Virginia. During the 1930's more than 30,000 miles of ditches dug under the guise of mosquito control ruined large sectors of marsh for muskrat and waterfowl. Quite conceivably then with the "know how" of the North Carolina diking studies, similar work could be done on the marshes of at least seven states along the coast with multiple benefits for all — muskrats and waterfowl included.

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