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Marsh Management and Its Relationship to Vegetation, Waterfowl, and Muskrats

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Management of Iowa marshes is primarily aimed at waterfowl production with secondary considerations for furbearing animals and non-game wildlife. Difficulty in maintaining the hemi-marsh, which is considered optimum for avian production, prompted this study to examine the interrelationships between duck breeding populations, muskrat *(Ondatra zibethicus)* population densities, and emergent vegetation. Blue-winged teal *(Anas discors)* populations responded more closely to changes in percent of the area that contained emergent vegetation than mallards *(Anas platyrhynchos)*. Waterfowl populations were not totally dependent on vegetative conditions of the marsh. Muskrat populations were directly related to habitat quality but fall water levels were influential in regulating the number of muskrat houses and number of muskrats caught by trappers. The most beneficial management program for waterfowl production on glaciated marshes requires revegetation by man-induced droughts and maintenance of water levels until the open stage occurs, then the procedure should be repeated. Marshes are best managed individually by utilizing results from past management procedures.
INDEX DESCRIPTORS: Marsh management, waterfowl breeding populations, muskrat populations and harvests, emergent aquatic vegetation.

Prior to 1900, Iowa was dotted with thousands of sloughs, small marshes, and potholes. Bennett (1938) estimated there were about 6 million acres (2,430,000 ha) of tall grass prairie interspersed with marshes and potholes; by 1938, approximately 50,000 acres (20,250 ha) of prime marsh and pothold habitat remained (Bennett 1938). Mann (1955) reported 138,000 acres (55,890 ha) of water habitat in Iowa, including temporary flooded lands, swamps, and marsh areas — this acreage represents Iowa's potential for marsh habitat.

In the late 1930's the Iowa Conservation Commission initiated a wetland acquisition program, hoping to preserve a small remnant of this once vast prairie-marsh complex. Presently, the Commission owns approximately 26,700 acres (10,814 ha) of wetlands and 21,000 acres (9,505 ha) of surrounding uplands, not including large open-water lakes or man-made reservoirs.

Most marshes occur in north-central and northwest Iowa, last covered by the Wisconsin glacier, and characterized by flat to gently rolling land with many lakes, potholes and sloughs. Predominant soils are the rich Clarion-Webster soil association. Marshes surrounded by rich soils are more productive of food and cover, accommodating a greater variety and density of wildlife (Mosby 1963, Odum 1959).

Some Iowa marshes are in the process of changing into the wet-meadow stage because of man's influences. In many cases, drainage has lowered the water table and farming practices on surrounding uplands have accelerated soil erosion. Small natural lakes have become marshes because of siltation. Annual precipitation has a direct bearing on water levels and consequently on vegetative changes in a wetland. These factors are far more significant than changes in succession.

Iowa wetlands were classified using the system presented by Stewart and Kantrud (1971). Type III, IV and V wetlands are most desirable for waterfowl production and harvest. Wetland types and their use by waterfowl are listed according to zones within Iowa by Mann (1955).

To approach maximum wildlife potential, these areas must be managed to maintain habitat conditions that are optimum for the desired species. Natural water level fluctuations once managed this land and water complex; man has now intervened and imposed changes influencing natural marsh management. Once man so alters a natural system, he must make adjustments to achieve and maintain his goals.

The target species to be managed must be designated before a sound plan can be initiated for any area. Management methods vary for different species. For Iowa's wetlands, priority species are waterfowl: blue-winged teal, mallard, and wood duck, with secondary benefits directed toward fur-bearers, upland game, and non-game wildlifė. Marsh conditions ideal for ducks also are ideal for marsh bird species and furbearers. Management of uplands to benefit several species; minor manipulations of plant communities can provide for additional species, while fulfilling prime wetland-management goals.

STUDY AREAS AND PROCEDURES

Data were collected on the percent of emergent vegetation, muskrat numbers and harvest, and waterfowl breeding populations on four marshes in north-central Iowa.

Myre Slough, located in Winnebago County, is a 430 acre (174 ha) area with approximately 300 acres (122 ha) in marsh and 130 acres (53ha) in uplands. A control structure allows water level manipulation. The area lies in a relatively flat agricultural area, with a 1,260 acre (510 ha) watershed, consequently, the marsh is dependent upon annual precipitation. Myre Slough has been characterized during the past 10 years by good stands of emergent vegetation, with the exception of two brief open-water periods. Dominant emergent species are cattail (*Typha* spp.), river bulrush *(Scirpus fluviatilis)*, and arrowhead (*Sagittaria* sp.). Vegetation was identified using Gray's Manual of Botany (Fernald 1950).

Eagle Lake (Hancock County) is similar to Myre Slough in that it is a natural prairie marsh in a flat agricultural area, with a water control structure. This area consists of 913 acres (370 ha), with no state-owned grass uplands. High water levels, muskrats, and drastic draw-downs have caused closed and open vegetative conditions. Catttail and bulrush are the main emergent species. The watershed surrounding Eagle Lake is 6,866 acres (2,781 ha), too small to provide a dependable water supply.

Ventura Marsh, 750 acres (304 ha with 146 ha in marsh) in Cerro Gordo and Hancock counties, adjoins 3,600 acre (1,458 ha) Clear Lake; a control structure is present between marsh and lake. Water level manipulation is possible, but the extent of draw-down is limited by the lake level. Cattail is the main emergent, with some bulrush *(Scirpus* sp.) and phragmites (*Phragmites maximus*). Ventura Marsh, because of its unique features, has experienced only minor changes in percent of area covered by vegetation. The west end is shallow, and at crest has less than 31 cm of water depth, while the east end measures about 122 cm at crest. Usually the vegetation at the west end is too closed and the east end too open. Water levels have been held near crest to provide additional breeding habitat in the west end, thus sacrificing some emergents in the east end. For the past 7 years a gradual opening of the cattail stands has created slightly better interspersion of vegetation and water.

Harmon Lake, in northern Winnebago County, is a complex of three major water areas comprising 250 acres (101 ha) of water with less than 30% emergent vegetation, and 228 acres (92 ha) of upland. The total watershed is only 328 acres (133 ha). Three pools are designated as West, Middle, and East, with water control on the East Pool only. The West Pool is completely open and the Middle Pool is partially vegetated with the border ringed by a dense stand of cattail. The East Pool is generally open but in years following substantial draw-downs, emergent vegetation was present. The major emergent species are river bulrush and cattail.

Spring breeding-pair waterfowl ground-counts were made on Myre slough, Harmon Lake, and Ventura Marsh during the 2nd and 3rd weeks of May. Only mallards were counted on Ventura Marsh; aerial counts of mallards were made on all 3 areas for comparison. Additional ground counts were made throughout the nesting period.

Muskrat-house counts were made during winter months by walking the marshes. Muskrat harvest data were obtained from mandatory trapper reports for each area; trappers were required to have a permit to trap each state area, and to report their catch. Data on water levels and manipulation practices were available for most years from management records; percent of vegetation on each marsh was calculated from aerial photographs taken in August and September and from cover maps.

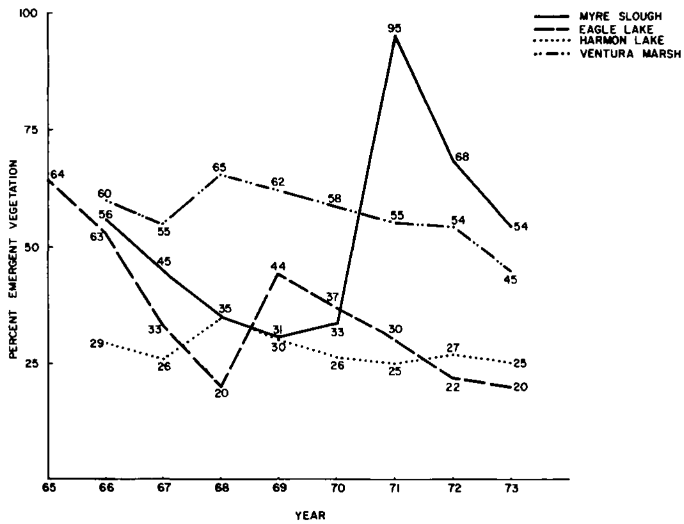

Fig. 1. *Percent of emergent vegetation by area by year.*

RESULTS

Water Level Management and Vegetative Response

Water level manipulation on prairie marshes with water control structures was directed toward establishment and maintenance of emergent vegetation. Two general approaches have been used by wildlife managers in Iowa: (1) complete draw-down to mud-flat conditions for an entire spring and early summer, or for the entire year to establish new stands of emergents; and (2) reduced water levels in early spring to maintain existing vegetation, encourage regrowth of muskrat-cut cattail stalks, and establish shoreline vegetation. After plant growth commenced, water levels were brought back to desired depths. Variations from these approaches have resulted from non-compatible weather patterns and public pressure.

Marshes were classified into 5 categories, reflecting response of marshes over a period of years to management or, where management was not possible, to natural water-level fluctuations: (1) open marsh (very stable, with less than 10% emergent vegetation usually confined to shorelines); (2) stable with sparse vegetation, 10-30% covered by emergents and little year-to-year change; (3) stable with emergent vegetation, 30-75% covered with emergents and little year-to-year change in percent coverage; (4) dynamic marsh, very responsive to man-made or natural changes, with marsh conditions varying from open to closed marsh; (5) closed marsh, very stable over 75% of area covered by emergent vegetation, usually shallow, with no water control.

Myre Slough and Eagle Lake were dynamic marshes, while Harmon Lake was a stable and sparsely vegetated marsh and Ventura Marsh was stable with vegetation.

Figure 1 shows percentage of water area covered by emergent vegetation each year. Myre Slough was about 50% vegetated during 1966, after being revegetated from a draw-down in 1964. Muskrats, high water, and wind action continued to open up Myre Slough until 1969, when only 31% of the area was covered with emergent vegetation. In the spring of 1970 the area was drawn down and kept dry through fall, resulting in a rank stand of annual plants, primarily beggar's tick (*Bidens carnus*), with some regrowth of bulrush and cattail. Reflooding in 1972 and 1973 reduced annual plants; emergents increased to approximately 60% in 1972. By 1973 the vegetative pattern and its ratio to open water returned to 1966 conditions.

Eagle Lake vegetation showed good response to a draw-down in 1964, but muskrat populations and high-water levels had reduced vegetation to 20% by 1968. A natural drought in the summer and fall of 1968 resulted in increased stands of cattail and bulrushes in 1969, but vegetation covered only about 20% of the area by 1973.

Harmon Lake consists of 3 major water bodies and 4 potholes. Ability to manipulate vegetation was restricted to the East Pool, the only pool with a water control structure. During this study, water levels in the East Pool were reduced each year with varying success, governed by rainfall and timing of draw-downs. The percent of emergent vegetation on the Harmon Lake complex varied only slightly during this period; change in emergents was predominately the result of natural droughts and periodic draw-downs of the east water segment. Harmon Lake thus represented a relatively stable open water area.

Ventura Marsh had fairly stable vegetative coverage during this study, maintaining an interspersion of open water and emergent vegetation attractive to breeding waterfowl. Marsh management was designed to reduce water levels in early spring, to avoid flooding muskrat-cut cattail stalks, and floating out cattail mats.

After complete draw-downs during 1964 on Eagle Lake, and in 1964 and 1970 on Myre Slough, dense stands of annuals germinated, along with some deep-water perennials. Reflooding brought about reduced stands of annuals and increased stands of emergent vegetation. Weller and Spatcher (1965) and Weller and Fredrickson (1974) described the vegetative patterns and dynamics resulting from lowered water levels on managed glacial marshes and defined five stages of marsh conditions: (1) low water, germination phase, vegetation prevalent on mud-flats or in water less than two inches deep; (2) newly flooded, with sparse and often well-dispersed vegetation, annuals and perennials dominating; (3) flooded, dense marsh, dominated by perennials; (4) flooded, hemi-marsh, involving openings in dense emergents; (5) deep, open marsh, rimmed with emergents. The extent of cattail and bulrush germination depended on the degree of draw-down and the timing of mud-flat exposure. Complete dewatering to mud flats was required to achieve good germination of perennials.

Although our procedures were sufficient to show major variations in emergent plant cover, they were not sensitive enough to depict smaller changes. Minor water level changes in spring and summer often caused some revegetation of the shallower areas or floating away of cattail plants along the margins of the larger beds. These variations possibly influenced the number of muskrats and breeding pairs of waterfowl.

Varying degrees of germination and regrowth resulted from the two

Table 1. *Muskrat harvest and lodges by area.*

	Area							
	Myre Slough		Ventura Marsh		Harmon Lake		Eagle Lake	
Year	Harvest	Lodges	Harvest	Lodges	Harvest	Lodges	Harvest	Lodges
1961	--	--	--	--	--	--	--	200
1962	--	1,331	--	560	--	892	10,000	3,632
1963	102	930	675	1,100	283	750	318	1,500
1964	31	--	980	500	154	--	52	--
1965	349	--	951	90	444	--	468	--
1966	1,632	842	409	38	705	255	2,329	1,510
1967	1,517	800	--	--	39	45	2,560	407
1968	915	357	--	--	21	20	685	640
1969	1,033	619	706	226	677	282	1,113	415
1970	128	--[1]	1,607	--	1,240	211	0	77
1971	250	95	3,008	--	150	53	387	376
1972	205	197	1,044	--	165	38	726	210
1973	2,596	496	1,380	240	163	55	1,372	892

-- No Data

--[1]Area dry; no muskrat activity.

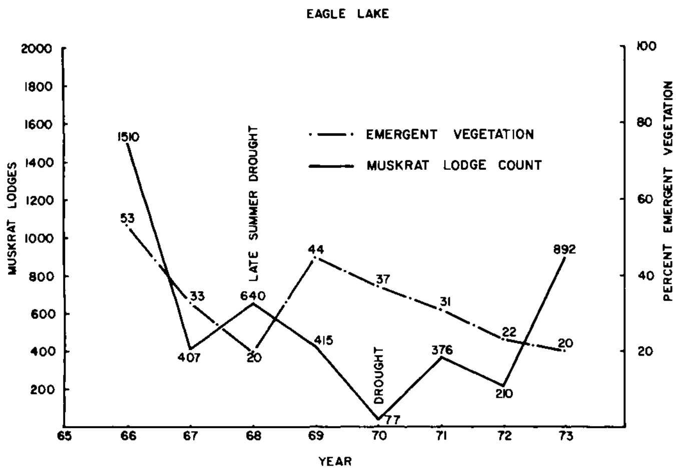

Fig. 2. *Percent emergent vegetation and muskrat lodge counts on Eagle Lake.*

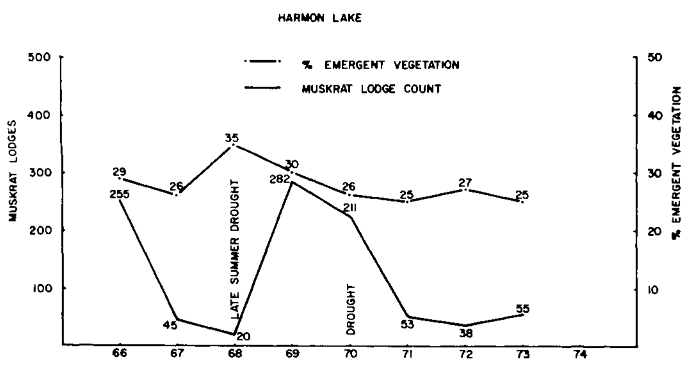

Fig. 3. *Percent emergent vegetation and muskrat lodge counts on Harmon Lake.*

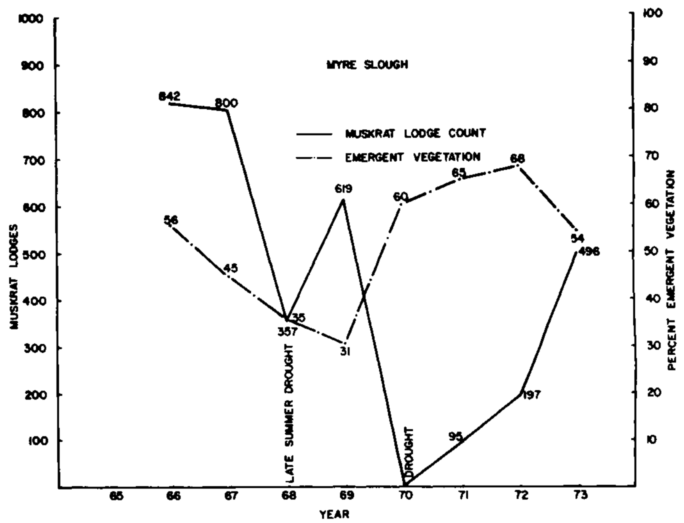

Fig. 4. *Percent emergent vegetation and muskrat lodge counts on Myre Slough.*

management procedures. These variations were attributed to physical characteristics of the individual marsh, soil structure, draw-down timing, size of watershed and amount of old cattail root-systems available.

Muskrat Populations

Data collected on muskrat lodges and harvest are presented in Table 1. Harvest data do not accurately indicate changes in muskrat numbers because trapping effort varied annually and the number of harvested muskrats reported by trappers was not entirely accurate.

Dozier (1948) and Errington (1963) suggest that lodge counts are fairly accurate indicators of muskrat populations. House counts were made in most years on 3 of the 4 areas. Figures 2, 3 and 4 show the relationship of muskrat populations to the percent of emergent vegetation in late summer.

Following establishment of vegetation resulting from extensive draw-downs, muskrat populations responded and house counts increased. In 1960, Eagle Lake was revegetated to 75% emergent vegetation; in 1961, 200 houses were counted. In 1962, 3,632 houses were counted and a record harvest of 10,000 muskrats was reported. A similar pattern was exhibited after the 1964 draw-down on Eagle Lake (Figure 2). Muskrat populations on Harmon Lake fluctuated to a greater degree than did emergent vegetation (Figure 3) due primarily to the large amount of open water with stable shoreline vegetation and late summer water levels which regulated muskrat activity.

Data from Harmon Lake show that muskrat populations dropped in years with higher percentages of emergent vegetation and increased in years of more sparse vegetation. Harmon Lake data suggest other factors are operating to control muskrat populations. In 1968 when plant cover increased, a late summer drought dried up the Middle and East Pool and potholes of Harmon Lake. Little muskrat activity was noted. In 1971 and 1972, the percent of emergents declined in the East Pool, which accounts for part of the decline in muskrat houses (Figure 3). Low fall water levels in 1971 on the Middle and East Pool also curtailed muskrat activity.

Drought conditions also affected muskrat populations on Myre Slough (Table 1). In 1968, house numbers dropped because of receding water levels along the shoreline. In 1970 the area was dry, and no active muskrat houses were counted. Drought conditions in late summer of 1971 limited water to the deeper portions of the marsh, limiting muskrat activity. Water levels were at crest condition in the fall of 1972 and 1973. Figure 4 indicates response of muskrats to favorable water and vegetative conditions. Fall water conditions, which either dry out or flood shoreline emergents, regulate muskrat populations to some extent.

Errington (1961), Errington et al. (1963), Neal (1968), and Weller and Spatcher (1965) indicate that muskrat populations were directly related to habitat quality. As emergent vegetation (especially cattails) increased, muskrat populations increased until their numbers utilized most available food supplies. The elimination of vegetation resulted in dramatic reduction of muskrats.

Even with annual trapping seasons, muskrats on Myre Slough and Eagle Lake increased after vegetation was established until eat-outs occurred, eventually resulting in significant decreases in muskrat numbers. Time taken to create open marsh conditions depended on water depth and muskrat numbers.

On Ventura Marsh, interspersion of water and vegetation has remained relatively constant, but with a slight decline in emergents, since 1968. Muskrat populations have fluctuated, but not as dramatically as on the other marshes, possibly because of annual draw-downs, marsh bottom topography, and intense trapping. Trapping pressure on Ventura Marsh is probably as heavy as on any marsh because of its close proximity to large human population centers. It is believed that intense trapping along with annual water lowering to avoid flooding cut cattail stalks have kept this balance.

Natural marshes in north-central and northwest Iowa have shown the relationship between good habitat conditions and high muskrat populations. Marsh management brought about the reestablishment of perennials. Afterwards, muskrats returned and opened up dense stands of cattail, improving interspersion and creating better conditions for nesting waterfowl.

Errington (1961, 1963), discussing the qualitative and quantitative aspects of muskrat population dynamics in different stages of marsh habitat, emphasized the intricate relationship between vegetation, water levels, and muskrats and pointed out how good management for one of these components benefits all. Errington (1963) and O'Neil (1949) describe how a muskrat eat-out caused by over population can nearly eliminate emergent vegetation from a marsh and thus reduce numbers of waterfowl and all wildlife present.

Muskrat harvest and water level draw-downs are the 2 most important mechanical factors in regulating populations. The key to proper marsh management is to maintain the optimum or hemi-stage (Weller and Spatcher 1965). Proper water level manipulation is difficult because many marshes lack adequate water control structures, and many lack the ideal 15:1 watershed to basin ratio necessary for proper water level control. Consequently, muskrat population management may be the ultimate key to prolonging the desired hemi-marsh stage of marsh cycle.

Waterfowl Breeding Populations

The response of some bird species to aquatic habitats has been discussed by Weller and Spatcher (1965) and Weller and Frederickson (1974). It was noted that the populations of different bird species peaked at different periods of the marsh cycle, but the overall peak of avian production occurred during the hemi-marsh stage where the water to emergent cover ratio was about 1:1, Weller and Spatcher (1965) and Weller and Frederickson (1974).

Myre Slough best shows the drastic changes in vegetation and response by waterfowl, especially blue-winged teal. Figure 5 depicts the relationship of teal and mallards to the percent of emergent vegetation. These data, however, are difficult to interpret because spring water levels make the impact of emergent vegetation less clear. The year of 1966 represented the 2nd year after the draw-down and reflooding of Myre Slough. The interspersion of emergents and open water was excellent through 1967. In April of 1967, spring water levels were lowered to prevent further loss of cattails because of floating. Nesting

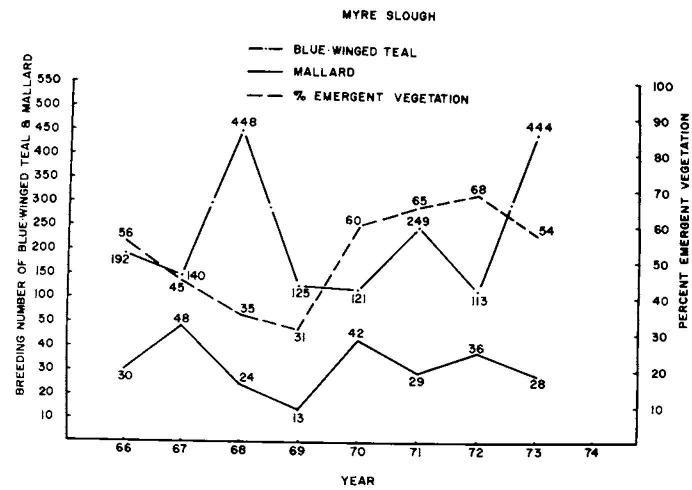

Fig. 5. *Relationship of nesting waterfowl and emergent vegetation on Myre Slough.*

blue-winged teal decreased, possibly as the result of reduced shoreline habitat. Mallards increased in 1967, indicating no adverse effect from lowered water levels.

Muskrat cutting and floating out of vegetation reduced the cover-water ratio to 35:65 in 1968 and a corresponding decline in nesting ducks was expected. Mallard populations dropped, but teal reached an all time high, possibly because of extremely dry conditions in the prairie pothole region of Canada as well as in Iowa and the Dakotas (Figures 6, 7) These data suggest some relationship between numbers of breeding waterfowl in Iowa and habitat conditions in Canada.

Habitat conditions continued to deteriorate in 1969 and a corresponding decline was observed for all breeding waterfowl. Marsh emergents covered 31% of the area in 1969 — nearly an open marsh situation for Myre Slough. Blue-winged teal breeding populations were almost the same in the spring of 1970 as in 1969, but mallards increased significantly. Drought conditions during late summer of 1970 caused the area to dry out, stimulating germination of aquatic plants.

Reflooding in the spring of 1971 decreased heavy stands of annual plants but created good breeding habitat for teal. Mallards declined in the presence of improved stands of emergents. Dry conditions prevailed again in late summer of 1971, creating growths of annual plants

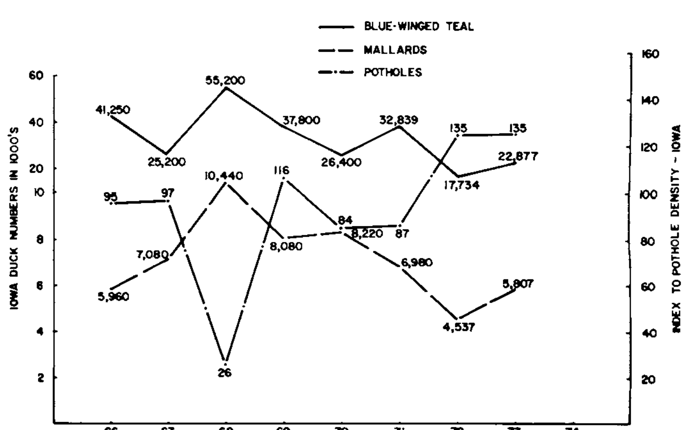

Fig. 6. *Waterfowl breeding populations and pothole density in Iowa.*

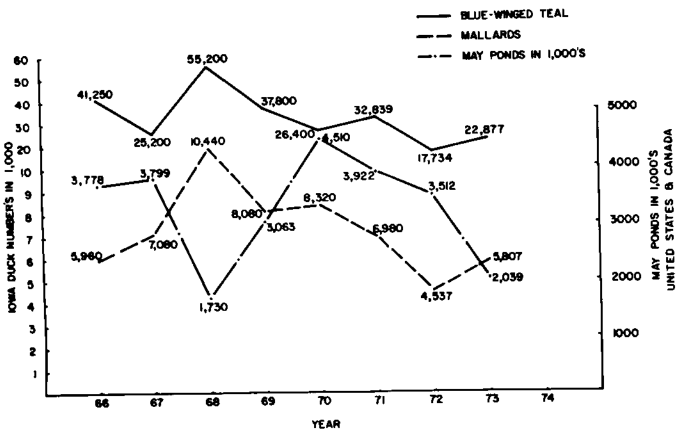

Fig. 7. *Waterfowl breeding populations in Iowa and May ponds in the United States and Canada.*

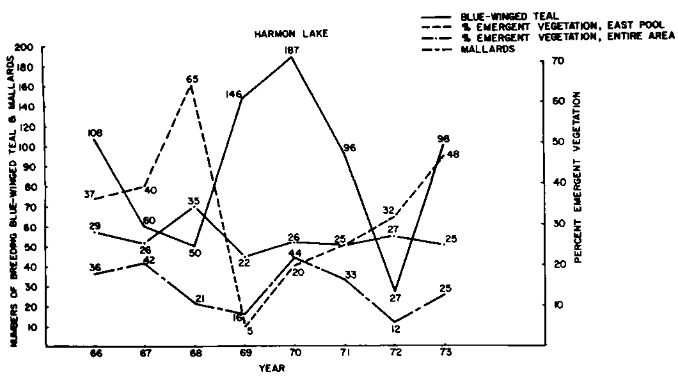

Fig. 8. *Relationship of nesting waterfowl and emergent vegetation on Harmon Lake.*

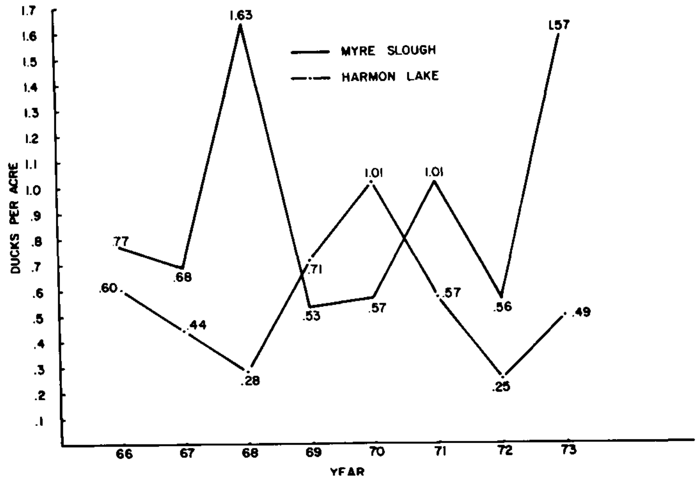

Fig. 9. *Comparison of numbers of breeding waterfowl on Myre Slough and Harmon Lake.*

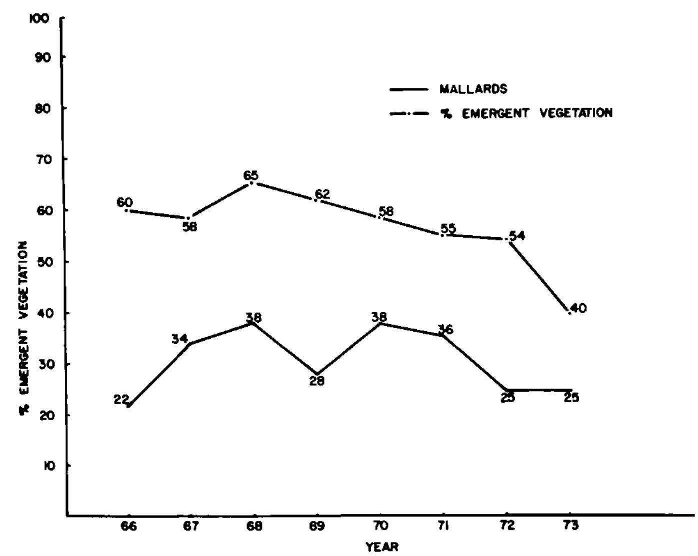

Fig. 10. *Number of breeding mallards and percent emergent vegetation on Ventura Marsh.*

and maintaining cattail and bulrush stands. It was noted that spring conditions in 1972 were ideal for vegetation but the water depth was down almost one foot below optimum, reducing the amount of breeding habitat along the interspersed shoreline. Waterfowl breeding populations showed a decrease for teal while mallard numbers increased.

Breeding populations across the entire state declined in 1972 for both mallards and blue-winged teal (Figure 6). We believe the decreased numbers of blue-wings in 1972 on Myre Slough was due to low water levels along the shoreline and relatively good habitat in the more northern breeding areas.

Data collected in 1973 show the return of Myre Slough to the hemi-marsh state, with teal reaching the previous high level of 1968. Figures 6, 7 indicate habitat conditions across Iowa and in the prairie pothole country of northern United States and Canada. Mallard populations increased statewide in 1973 while they dropped on Myre Slough; possibly some pairs spread into private land where many low areas were flooded. The tendency for mallards to show this behavior has been observed in the past; however, the data do not indicate this happening in 1972 under identical water habitat.

Blue-winged teal appear to respond more closely to changes in water conditions than mallards. Interspersion of water and vegetation as well as spring water-depths influenced the number of teal remaining to nest. Aerial photographs showed that the cover-to-water ratio sometimes varied from early spring until late summer, attributable to water levels and possibly explaining discrepencies between habitat and duck populations.

On Harmon Lake the stability of shoreline vegetation on 80% of the area, reduced drastic fluctuation in habitat conditions (Figure 8). Waterfowl population changes were attributed to vegetative changes in the East Pool, muskrat openings in the shoreline vegetation of the Center Pool and other outside factors.

Very little change in the percent of emergent cover was observed with the exception of 1968, when a summer drought created increased emergent growth in the Center and East Pools. Spring breeding habitat was much improved in 1969, but many annual plants that provided cover in the spring had been flooded out by fall and muskrat cuttings had further reduced the emergent cover.

Breeding populations of both teal and mallards attained high levels in spring 1970, corresponding with the opening of dense emergent stands in the Center Pool and with the reestablishment of emergents in the East Pool (Figure 8).

A drastic decline in duck numbers on Harmon Lake in 1972 corresponded to similar decreases in teal on Myre Slough. Good water habitat was present on private lands as well as further north. Observations on Harmon Lake indicated high teal use on the East Pool during years after reflooding. Mallards, however, tended to utilize the West and Center Pool and the four potholes with little use of the East Pool. High number of breeding mallards counted in 1970 were probably a combination of suitable habitat on the Center Pool and dry conditions on surrounding private land. Average waterfowl breeding populations were greater on Myre Slough, which averaged 55% emergent vegetation compared to 27% on Harmon Lake (Figure 9).

Data collected on Ventura Marsh does not indicate a close relationship between mallard numbers and minor changes in percent emergent vegetation (Figure 10). High breeding populations of mallards in 1968 and 1970 coincided with increased statewide mallard breeding populations and reduced water habitat on private land.

The ratio of emergent vegetation to open water has remained fairly constant since 1965, although some areas lost deep-water emergents, while other portions of the marsh gained vegetation. Spring water levels, which regulate duck use on certain shallow areas of the marsh, may have been one factor influencing number of spring mallards. With the exception of spring water levels in Ventura Marsh, it is doubtful that changes in habitat could account for variations in the mallard population, which are probably complicated by other, unmeasured factors.

DISCUSSION

The correlation between emergent vegetation and breeding duck populations is complicated by spring water habitat on private lands, water levels on the study areas and water conditions on the traditional breeding grounds in the Dakotas and southern Canada. In addition, data on mortality rates of Iowa ducks as they affect breeding populations are unclear. Mortality rates calculated from banding data cannot account for waterfowl population variations.

Some years or areas show a close correlation between blue-winged teal numbers and habitat quality while other areas or years do not. Mallards, however, did not show as close a relationship to minor changes in vegetation or spring water levels on the study areas as did blue-winged teal. Mallards appear more adaptable and, until emergent vegetation is thoroughly depleted, mallard nesting populations persist. Areas such as Myre Slough and Ventura Marsh, with good emergent cover, have higher breeding populations of mallards than the more sparsely vegetated Harmon Lake.

We believe that waterfowl populations definitely are influenced by percent coverage and interspersion of emergent vegetation and that marshes in the hemi-marsh stage are the most attractive to both teal and mallards. With dense stands of emergents, duck use is below its peak but, as muskrats and higher water levels open to these dense stands, teal and mallard breeding populations increase. As marshes become more open, breeding populations generally decline. Stages between completely open and dense vegetation stage are less influential than other factors such as spring water levels, flyway-wide breeding habitat, and population status.

Concerted efforts to maintain a true hemi-marsh condition are not warranted for maintenance of waterfowl breeding habitat. On areas such as Iowa's public marshes which are used for public hunting as well as production, disadvantages resulting from public criticism outweigh advantages in potential of higher breeding populations so long as marsh conditions do not approach completely open stages.

The energy cycle within the marshes appears to influence the magnitude of breeding populations. Marshes or areas of marshes that periodically go dry are used more intensively by breeding waterfowl. Newly flooded marshes are immediately pioneered by nesting teal and mallards and often have higher breeding densities than old established marshes. The influence that invertebrate populations have on breeding duck populations is still speculative but a definite relationship exists. It would be beneficial to periodically drain each marsh to revitalize the energy flow. Consequently, to maintain a marsh in the hemi-marsh stage for an extended period of years would not be truly beneficial. A cycle of 5 to 7 years between complete draw-down would be desirable.

Observations collected since 1965 on marsh management procedures strongly suggest that management should be on a case-history basis. A detailed log for each area on practices implemented, annual precipitation, and vegetative results should be kept. With several years of data a manager can, with fair accuracy, predict the response of a marsh under certain conditions.

We found that each marsh had a definite pattern of vegetation and open water. After the draw-down, reflooding reduced annual plants and deep-water perennials established in the same pattern as experienced under similar previous situations. Some areas established ideal interspersion of emergents and open water while other areas maintained heavy mats of vegetation and large bodies of open water.

Muskrat populations are influenced, and eventually regulated by, habitat quality. Muskrat cuttings that open up dense stands of emergents create better habitat for many bird species and benefit water fowl until vegetation is removed to more open stages. When muskrat populations exceed levels that the habitat base can sustain, drastic control is necessary; this can best be accomplished by regulated trapping and water manipulation. When trapping does not reduce the populations, early winter draw-downs which allow freezing to the marsh bottom will control muskrats.

On marshes where water control structures are not present, or where watershed ratios are not adequate to maintain desired water levels, particularly in winter draw-downs, it may be advantageous to have additional harvest of muskrats. This can be accomplished by special spring muskrat trapping seasons. This additional muskrat harvest would prolong the hemi-marsh cycle which in turn would sustain the highest numbers of breeding waterfowl and other bird life. The spring muskrat trapping season is a marsh management tool, beneficial in sustaining a more optimum muskrat population level rather than a boom or bust situation. Another advantage is that muskrat pelts are most prime in the spring and if breeding damage to pelts is minimal, then top pelt values also occur. One possible disadvantage is the capture of non-target species in traps such as mink, waterfowl and coot. Regulations on type of trap used, allowing sets in muskrat houses only and others, could reduce this non-target take.

Data presented indicates that the amount of emergent vegetation is not the only major factor influencing muskrat populations. When shoreline emergents are either dried out or flooded, the habitat base and capabilities of that area are changed, as was the case on Eagle and Harmon Lakes. Annual plants flooded after previous dry periods provide adequate house-building material and food, reducing dependence on cattails for the first year after reflooding.

We believe that muskrat numbers are regulated by the amount of food plants and house building material available and that management to maintain hemi-marsh conditions increases long-term muskrat populations and harvest. At moderate population levels, muskrats are valuable in management for waterfowl.

Management of emergent vegetation by water level manipulation is often tempered by public opinion which, in fact, has created the greater problems of marsh management in Iowa. Public opposition has altered management procedures, resulting in water levels higher than desired, incomplete draw-downs, or vegetation flooded prematurely, thus drowning emergents. Such less than desirable results create credibility gaps between the public and management officials, curtailing the ability of governmental agencies to manage marshes properly.

When draw-downs are anticipated on marshes utilized by the hunting public, an explanation of the goals and benefits should be presented to reduce public reaction and gain support. Equally important is the need for a unified departmental stand. A strong stand, even in the face of opposition, will create fewer problems in the long run to the agency, the public, and the resource, which is an aspect that cannot be stressed enough.

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