Control and management of cattails in southeastern Wisconsin wetlands. No. 112 1979

Beule, John D.
Madison, Wisconsin: Wisconsin Department of Natural Resources, 1979

https://digital.library.wisc.edu/1711.dl/CMRWTDCCCAWHB9E

CONTROL AND MANAGEMENT OF CATTAILS IN SOUTHEASTERN WISCONSIN WETLANDS

Technical Bulletin No. 112
DEPARTMENT OF NATURAL RESOURCES
Madison, Wisconsin
1979

ABSTRACT

The encroachment of cattails on shallow water marshes restricts species diversity and wildlife use. This study presents information on controlling cattails to create openings in large blocks of monotypic cattails, and other data pertinent to marsh management.

Activities such as injury to the developing shoot, cutting of mature cattails and scraping the dried out marsh in winter effectively controlled cattails. However, timing of control to coincide with the low point of carbohydrate storage and the presence of surface water over the cut or damaged stems were major factors affecting successful control measures.

Management guidelines are presented for three zones of water depths—deep water, intermediate and shallow, with the ultimate goal of providing food and cover conditions for optimum production of marsh wildlife.

CONTROL AND MANAGEMENT OF CATTAILS IN SOUTHEASTERN WISCONSIN WETLANDS

By
John D. Beule

Technical Bulletin No. 112
DEPARTMENT OF NATURAL RESOURCES
Madison, Wisconsin
1979

CONTENTS

INTRODUCTION

THE PROBLEM AND OBJECTIVES

In the 14 southeastern counties of Wisconsin, 61% of the wetlands were destroyed by 1971 (Kabat 1972). Losses have continued at an average rate of 1.7% during 1973-77 (Petersen, Cole, March 1978), mostly the result of drainage for agricultural purposes. Both studies also pointed out that the natural values of wetlands (e.g., diversity of wildlife, nutrient storage, sediment entrapment, reduction of flood peaks) have been reduced or eliminated by human alterations.

In view of the ever-increasing public demand for outdoor experiences of all kinds on these areas, the importance and value of the remaining wetlands continues to increase. Intensive management, especially on publicly owned areas, appears necessary to produce and perpetuate the greatest possible variety and numbers of wildlife.

Historically, marsh management in Wisconsin concentrated upon producing muskrats and attracting waterfowl for hunting. Management has attempted to reverse or interrupt the primary hydroseric successional pattern by which shallow, open water communities are invaded by cattail and/or aquatic sedges. Where these emergents, particularly cattail, are able to form undisturbed mats or floating bogs, the marsh will eventually convert to sedge meadow, followed by shrub-carr or wet prairie. The preservation and production of all species inhabiting these open water/emergent plant communities is now being recognized as important. Multi-species management within the earlier hydroseric successional stages is becoming a realistic goal for remaining wetland systems.

Within the United States, wherever dense stands of cattail (*Typha* spp.) have encroached upon shallow water marshes, valuable wildlife food and cover plants that once produced tons of seeds and tubers have been eliminated. Areas with good histories of waterfowl production and good plant and water interspersion are now often covered by solid masses of cattail. The great size and density of *Typha* physically restricts the use of these areas by most waterfowl and wading birds, and attempts to reverse or halt this situation have been well documented (Addy and MacNamara 1948; Heath and Lewis 1957; Martin, Erickson and Steenis 1957; Steenis, Smith and Cofer 1959; Nelson and Dietz 1966; and Weller 1975).

The existence of *Typha* as the dominant emergent plant in many areas of permanent but shallow water in southeastern Wisconsin has been confirmed (Belonger 1969; Modlin 1970; and Bedford, Zimmerman and Zimmerman 1974). An example of cattail invasion was documented at the Horicon Marsh Wildlife Area (Horicon) by cover maps drawn soon after flooding by Frank King in 1947 and 24 years later (1971) by Tom Janisch. Sedge-grass communities dominated the marsh's emergent vegetation in 1947 and cattails were present on only 30% of the vegetated areas as a subdominant species. Subsequent studies showed that by 1971 monotypic cattail stands accounted for 80% of all emergent plants on the area. However, field observations at Horicon Marsh indicated the domination of cattail in the marsh for many years before 1971.

Although extensive dense cattail stands generally restrict wildlife use and species diversity in many marshes of southeastern Wisconsin, they fur-

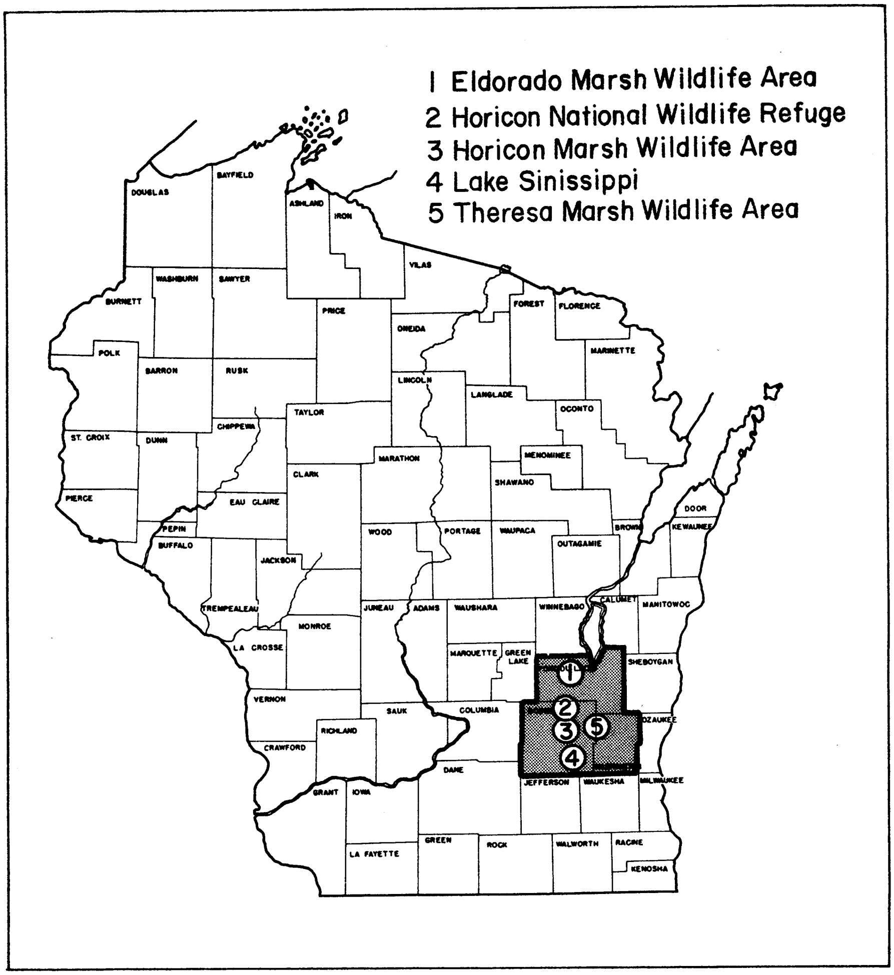

FIGURE 1. *Location of study areas.*

nish excellent nest cover for a large variety of birds when properly interspersed with open water. The value of cattails to muskrats as food and nest building material is well known and of great importance. Dense cattail provides protective cover for deer and green shoots are utilized as food. A recent study showed the importance of wetland cover, including cattails, to pheasants in this region during the critical winter period (Gates and Hale 1974).

Jahn and Moyle (1964) stated that the degree to which waterfowl will use fertile ponds and marshes is largely determined by the patterns of interspersion between open water and emergent aquatics. Weller (1975) recommended a 50:50 cover: water ratio for optimum bird use and overall production. Because cattails are both abundant and dominant in southeastern Wisconsin, they, more than any other plant, determine the degree of interspersion present in our shallow water marshes. Future efforts to maintain continuous high levels of wildlife production in these areas may well depend upon our ability to manage cattail communities.

Recognition of cattail as a management problem in southeastern Wisconsin developed slowly although many hundreds of acres were occupied by continuous dense cattail stands at Horicon and other area marshes. In 1969, a study to determine the best techniques to control cattails was initiated. The first part of the study has now been published under the title, "Cattail— the significance of its growth, phenology and carbohydrate storage to its control and management" (Linde, Janisch and Smith 1976).

The purpose of the second part of the study was to generally assess known cattail control methods that were considered practical, apply modified techniques, develop new ones and evaluate both the practices and wildlife use. A compilation of this information, combined with pertinent data from concurrent studies believed to be important to marsh management, is reported here, and includes (1) the reactions of cattail and other marsh plants to water level manipulations and carp removal; (2) efforts to create permanent openings in large blocks of monotypic cattails that would provide open water and make the entire area more useful to the local avifauna; (3) avian use of area marshes, especially emergent cover for nesting, openings and other habitats created by our efforts to control cattails; and (4) the basic characteristics and management potentials of fertile marshes and a discussion of management methods.

STUDY AREAS

Cattails were studied at Eldorado Marsh Wildlife Area (Eldorado), Fond du Lac County; Horicon Marsh Wildlife Area (Horicon), Horicon National Wildlife Refuge (Horicon NWR) and Lake Sinissippi (Sinissippi), Dodge County; and Theresa Marsh Wildlife Area (Theresa), Dodge and Washington Counties (Fig. 1).

This entire region is one of gently rolling fertile soils. Dairy farming leads all agricultural pursuits and principal crops are corn, small grains, hay and vegetables for canning. Marsh soils are typically fertile soft mucks. Poff (1961) reported that carbonates (total alkalinity) averaged 195 ppm in east central Wisconsin where the three marshes are located. General water chemistry parameters and detailed water chemical analyses suggest that the marshes studied were above-average in fertility when compared to other waters of the region (Tables 1,2).

Most marshes in the region are shallow basins with poor drainage. Water is supplied to these basins by seepage, ground water discharge, runoff from the surrounding fields and/or by slow-flowing streams with little summer volume. Low gradients and an average annual rainfall of about 30 inches makes many of these marshes difficult, if not impossible, to drain and dry out. When drained, however, they are equally difficult to refill except during the periods of spring runoff. Detailed geographic, hydrographic and geological data of the region were described by Poff (1961), Kernen et al. (1965) and Weber et al. (1969).

BACKGROUND INFORMATION

Cattail Species and Ecotypes

The ranges of *Typha latifolia* and *Typha angustifolia* in Wisconsin were mapped by Hotchkiss and Dozier (1949). In Wisconsin, where the ranges overlap, the natural hybrid *T.* x *glauca* Gordon is produced (Smith 1962). Ecotypic variations in *Typha* have also been documented and show that temperature differences affect seed

TABLE 1. *General water chemistry parameters from study areas*.*

Study Area	Year	Total Alkalinity Range	Total Alkalinity Avg.	Corrected Conductance Range	Corrected Conductance Avg.	pH Range	pH Avg.	Color Range	Color Avg.	Turbidity Range	Turbidity Avg.
Horicon	1968	82-492	287	192-1199	713	7.1-8.5	7.9	65-320	167	12-100	41
	1969	140-542	305	364-1239	755	7.3-8.5	7.8	35-220	109	5-65	25
Theresa	1969	112-440	313	313-864	706	7.1-8.1	7.5	15-240	85	0-42	14
	1970	250-380	317	608-893	730	7.2-7.9	7.6	25-260	121	0-60	25
Eldorado	1969	82-556	314	307-1788	870	6.9-8.0	7.3	20-1260	147	3-495	35
	1970	232-648	321	667-1751	970	6.6-7.7	7.2	0-300	138	0-85	28

*From samples taken weekly and/or monthly for a two-year period.

TABLE 2. *Detailed water chemistry from study areas*.*

Parameter	Horicon	Theresa	Eldorado
Date of Collection	8 February 1972	17 February 1969	3 March 1969
Calcium	147	112	-
Magnesium	49	51	-
Iron	-	0.4	0.44
Sodium	34	10	47
Phosphorus (sol)	0.841	0.30	1.0
Phosphorus (total)	0.75	0.21	1.2
Nitrogen (organic)	2.32	1.2	1.98
Nitrogen (free NH_3)	2.45	0.68	2.07
Nitrogen (nitrites)	0.065	0.047	0.004
Nitrogen (nitrates)	0.67	1.0	0.20
Chlorides	30	23	105
Manganese	-	0.17	1.2
Zinc	-	0.1	0.02
Copper	-	0.03	0.02
Potassium	11.2	4.0	7.2

*Water samples were collected at outlet structures and tested at the DNR Laboratory at Delafield and the Wisconsin State Laboratory of Hygiene, Madison

germination, period and rate of growth, flowering patterns, the ratio of root weight to shoot weight, biochemical features and photosynthetic requirements (McNaughton 1966). This author also noted that *T. latifolia* from northern climates was more responsive to modification.

I did not include an examination of *Typha* species in my study. Judging only by gross external characteristics, most plants occupying study areas were the hybrid *T.* x *glauca.* Weller (1975) recognized this same hybrid as robust and often dominant in the marshes of central and northwestern Iowa.

The manager should recognize the possibilities of hybridization and ecotypic variation, and that ecotypes may exhibit a broad latitude of responses to various control and management practices.

Growth and Physiology

An understanding of cattail growth and physiology throughout the growing season is essential in order to address problems of cattail control and management and their solutions. The study conducted on Horicon Marsh Wildlife Area during 1971-73 showed that the maximum level of total nonstructural carbohydrates (TNC), stored principally in the old rhizomes (Fig. 2), occurs during the early winter. TNC gradually declines to a minimum in late June. Beyond this, carbohydrates are being produced in excess of the plant's immediate needs and are translocated to the rhizomes for storage.

The low in TNC in late June coincides phenologically with the emergence and shedding of the pistillate spathe leaf, and represents the critical period when the plant is most susceptible to injury. A more detailed treatment of phenology, growth, physiology and food manufacture and storage is presented in Linde et al. (1976).

Physical Structure and Biomass of the Cattail Community

Cattails growing in the soft fertile soils of southeastern Wisconsin and covered by 2.5-46 cm (1 to 18 inches) of surface water have near ideal surroundings. In these situations, the annual production of plant parts is probably influenced most by the general growing conditions. Temperature appears to be one of the most important influencing factors, for when leaves are growing actively, greater growth rates occur during periods of high average temperatures (Linde et al. 1976). In 1973, 1974 and 1975, the tallest leaves measured at Horicon were generally between 3.2 to 3.4 m (10 to 11 ft). After the hot season of 1976, plants that measured 3.8 m (12.5 ft) tall were not uncommon.

Overall, 837 samples were taken throughout the study in undisturbed cattail stands adjacent to experimental areas, with hoops of two sizes: 0.5 m^2 (4.9 ft^2) and 0.7 m^2 (7.1 ft^2). Cattail plants averaged 41 stems/m^2 and 2.3 m (90 inches) in height. An average of 5 plants supported a fruiting head. In September, after all possible plants were full grown, 393 (83%) of 474 quadrats sampled contained only cattails. The remaining quadrats (17%) averaged 7 plants of other species per quadrat (Table 3).

In 1971, the above and below ground seasonal crop of *Typha* at Theresa was determined to be 1,852 individual plants and 1,600 g/m^2 (oven dry weight) (Klopatec 1974). This represents a total biomass of 15 tons/acre to be broken down chemically and/or biologically or to remain on the area as organic debris.

A substantial part of this annual biomass—principally underground rhizomes—remains intact into the next year. New roots and rhizomes become entwined with these plant parts

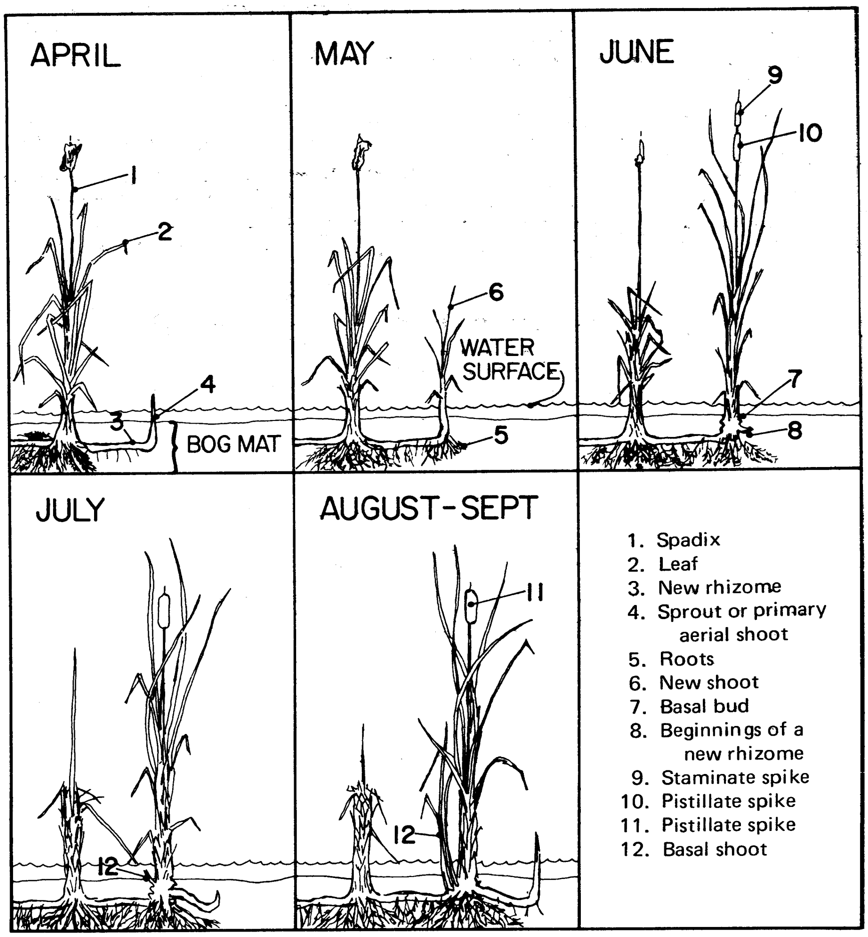

FIGURE 2. *Typical growth of cattail plant with fruiting head.*

of previous years and debris from plant tops to form what we call the "bog mat" (Fig. 2). This mat is a physical part of any cattail and a barrier between bottom soils and surface water.

Weller (1975) examined what he considered to be a newly established cattail stand at Round Lake, Iowa in 1963, where single shoots with fresh rhizomes could be pulled from the soil with little evidence of other rhizomes. By 1966, he found several interwoven layers of rhizomes in the same area that formed a mat 35 to 43 cm (14-17 inches) thick. Basal rhizomes were still hard and buried in the soil; those at the soil surface were still firm but black, and the most recent rootstocks were growing on the mat surface without any contact with the soil.

Similar bog mats from 28-33 cm (11-13 inches) thick were measured at several Horicon locations. Old blackened rhizomes were very tough and difficult to cut or tear.

Seed Germination and Seedling Survival

It is important to recognize conditions that trigger cattail seed germination and support seedling survival, for these factors can quickly negate programs intended to maintain good interspersion by controlling adult cattails.

Laboratory and greenhouse tests have shown that some conditions necessary for cattail seed germination are the prescence of light, low oxygen pressure and an optimum temperature of 30°C (86°F) (Sifton 1959). It was generally thought that cattail seeds would germinate in the laboratory at any water depth with sufficient light penetration, if other influencing factors were favorable. Subsequent tests by Bedish (1967) and Weller (1975) showed that the best germination occurs in the shallowest water (2.5 cm; 1 inch) although some occurred in depths up to 40 cm (16 inches).

Cattail seed germination under field conditions was much more restrictive than laboratory tests would indicate. Only once, in a shallow bay of Lake Sinissippi, were seedlings found that may have germinated under shallow water. In all other situations examined, *Typha* seed germination occurred only after mud flats had been exposed. Generally, germination was not found where any surface water remained.

Similar observations were made during the 1962 drawdown of Horicon Marsh by Linde (1963) who reported that "very little (cattail) germination occurred in areas containing even minor amounts of surface water", and "bur-reed seeds were able to germinate and grow in as much as 6 inches of water but all other species seemed to require moist mudflats on which to germinate".

Sites where germination occurred include those where repeated crushing activities on localized areas often created excellent seed beds on which as many as 150 cattail seedlings/m^2 germinated. Seedlings also germinated profusely upon floating layers of organic material and soils disturbed by crushing. Similar germination was also observed on floating mats of debris caused by natural conditions in 30-90 cm (1-3 ft) of water. Under favorable conditions, *Typha* seeds germinated from May through September with the greatest numbers seen in June and the fewest in September.

Flooding cattail seedlings soon after germination may cause seedling mortality, but Weller (1975) flooded plants that were 30 to 35 days old with 15, 30 and 40 cm (6, 12 and 16 inches) of water without significant loss. In August and September of 1972, *Typha* seedlings of that year were flooded by 30-60 cm (1-2 ft) of water at Horicon. Water levels remained high over winter without noticeable loss of plants.

Although not studied for this report, dry conditions after germination appear to be more destructive to cattail seedlings. Even rootstock plantings could not survive in dry soils (Bedish 1967).

RESPONSE OF MARSH PLANTS TO WATER LEVEL FLUCTUATIONS AND CARP REMOVAL

INTRODUCTION

A program to eradicate carp from the upper Rock River system provided an opportunity to study the responses of marsh plant communities to various water level manipulations and carp removal. Work began at Theresa in the spring of 1971 by releasing the water from the marsh. By late summer, the remaining water and carp were confined to the original river channel and the carp were killed by applying the fish toxicant, antimycin. The marsh was reflooded in October.

Similar plans were laid for Horicon and Sinissippi in 1972, and with this intent the dams at Horicon and Hustisford were opened in December 1971. After the 1972 spring runoff, water levels declined steadily until July when repeated heavy rains reflooded both areas in spite of the open dams. The fish eradication program could not proceed under these conditions and intermittent flooding continued through the winter and sping of 1973. After the spring runoff of 1973, water levels dropped rapidly and by late summer the remaining water was confined to the main river channels. Antimycin and rotenone were applied in late August 1973 to eradicate the carp.

The water levels recorded at the Horicon dam during these years (Fig. 3) also reflect the same general fluctuations that occurred at Sinissippi during this period. Lake Sinissippi was reflooded in September 1973, but the Horicon dams remained open until the spring of 1974.

PROCEDURES

One year prior to the drawdown, a permanent line transect was established across open water sections of Theresa Marsh. The transect was about 10,000 ft long and was marked by steel posts set at 500-ft intervals. Single, 10,000-ft transects were similarly established on Horicon, Horicon NWR and Sinissippi. Each year, vegetation was sampled at each post and at four stations equidistant between posts for a total of 100 samples/study area. Steel posts was also used to mark the predrawdown of an established, but isolated, cattail community at Horicon.

Plant composition was documented during 1970-75 at Eldorado and Theresa, and 1971-76 at Horicon and Sinissippi. Because transect lines were originally placed through open water areas, only submergent plants were present prior to the drawdowns. During drawdown years (1971 at Theresa and 1972 and 1973 at Horicon and Sinissippi) only emergent plants were sampled. After areas were reflooded, both emergent and submergent plants were sampled.

Three subimpoundments were constructed at Horicon in 1973, and submergent plant composition was also documented in the open water of these areas.

All emergent plant stems within a circular quadrat (either 0.5 m^2 or 0.7 m^2 in size) were counted by species at each of the 100 sample stations along each transect. Average stems/m^2 and importance values for each species were determined from these sample quadrats. Importance values equalled the sum of the relative densities and relative frequencies for each species and were determined as follows:

$$\text{Relative density} = \frac{\text{Total no. stems for a species}}{\text{Total no. stems for all species}} \times 100$$

$$\text{Relative frequency} = \frac{\text{No. plots in which a species occurred}}{\text{Total no. plots in which all species occurred}} \times 100$$

Submergent plants were sampled in open water by using a fine-toothed rake specially designed to grasp and hold supple underwater stems of all sizes. Small, free-floating plants were recorded as being present or absent at each sampling station.

An index to submergent plant densities was obtained by estimating the total amount of vegetation gathered with each rake sample as a percentage of a full rake. This index will be referred to as "rake density" in the remainder of the report.

Floating circular quadrats (0.5 m^2) were used in shallow water areas when both emergent and submergent plants were present. The number of emergent stems was counted in the usual manner and the percentage of the area within the quadrat that was occupied by each submergent species was visually estimated. Jessen and Lound (1962) reported that visual estimations of this kind were not significantly different from rake samples when used to measure the abundance of submergent vegetation. In the report, this density index is referred to as "hoop density".

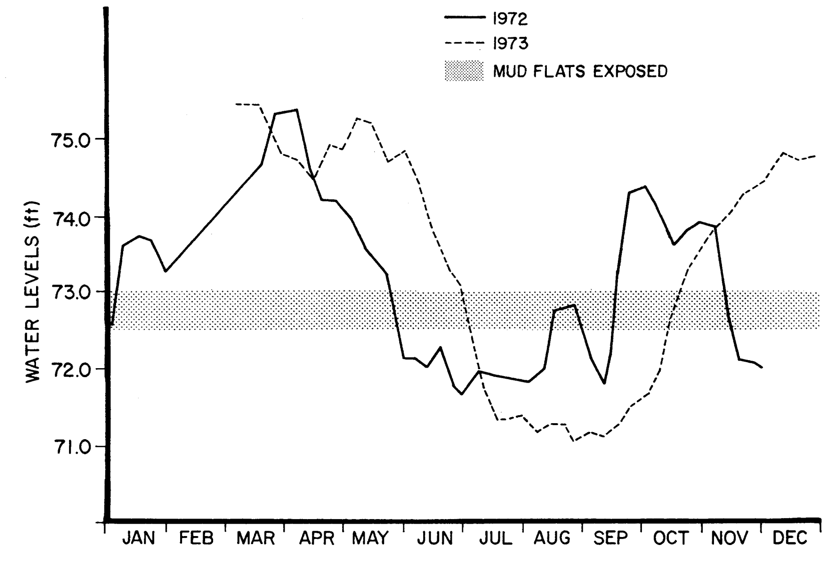

FIGURE 3. *Water levels at the Horicon dam during drawdown, 1972-73.*

TABLE 3. *Plants growing under cattail communities in southeastern Wisconsin—found in 81 (17%) of the total (474) plots.*

	No. Plots Found	Percent Total Plots	Avg. Stems/m^2
Assorted moist soil species	22	5	5
Scirpus fluviatilis	15	3	5
Carex sp.	12	3	18
Galium sp.	9	2	Stems not counted
Phalaris arundinacea	9	2	Stems not counted
Sparganium eurycarpum	8	2	12
Polygonum spp.	7	1	4
Sagittaria sp.	6	1	1
Phragmites maximus	4	1	9
Sium suave	2	1	2
Eleocharis sp.	1	1	Stems not counted
Acorus calamus	1	1	6
All species			7

RESULTS AND DISCUSSION

Emergent Plants

Germination on Exposed Mud Flats

Impoundment soils at Theresa were exposed from mid-April to October 1971. At Horicon and Sinissippi, the first year of the drawdown was 1972 and impoundment soils were exposed from July or August to October.

The relatively high gradient of Theresa allowed for the comparatively rapid removal of water. Gradients at Horicon and Sinissippi were much lower and the release of water was generally much slower. Exposed soils dried out quickly at Theresa except when moisture was supplied by rainfall, while soils on the other areas were kept moist by water trapped within the marsh.

Emergent plants did not germinate on these marsh soils until all surface water disappeared and soil surfaces were exposed to air. Extensive areas at Sinissippi remained covered by a few centimeters of water during the 2-year drawdown without the germina-

TABLE 4. *Species that invaded exposed mud flats during drawdowns and were soon eliminated by reflooding.*

		Importance Values					
		Theresa - 1971		Horicon		Sinissippi	
Common Name	Scientific Name	Shallow Section	Deep Section	1972	1973	1972	1973
Nutgrass	*Cyperus esculentus*	0.8	-	29.0	0.7	35.2	42.5
Sticktight	*Bidens cernua*	4.8	3.9	3.7	15.9	10.9	17.1
Pigweeds	*Amaranthus* sp.	6.5	9.2	2.1	12.6	0.5	4.5
Smartweeds	*Polygonum hydropiper* *Polygonum punctatum*	11.5	19.5	-	-	0.7	1.7
Blue vervain	*Verbena hastata*	11.9	20.2	-	-	-	-
Nodding smartweed	*Polygonum lapathifolium*	3.5	9.4	5.3	7.0	0.5	4.4
Spike rush	*Eleocharis* sp.	2.0	-	5.2	6.4	4.6	3.6
Yellow cress	*Rorippa islandica*	8.7	8.7	0.4	0.2	-	3.4
Popple	*Populus* sp.	-	-	12.3	0.7	2.4	1.0
Wild millets	*Echinochloa* sp.	-	-	2.6	6.9	2.6	3.1
Monkey flower	*Mimulus ringens*	6.3	2.3	-	-	1.9	4.3
Dock	*Rumex* sp.	1.0	1.0	5.8	-	5.2	0.5
Bonset	*Eupatorium perfoliatum*	2.2	3.2	-	-	-	-
Water horehound	*Lycopus* sp.	0.7	-	-	-	-	-
Nettle	*Ortica dioica*	3.5	-	-	-	-	-
Sow thistle	*Sonchus arvensis*	1.2	0.5	0.9	-	0.5	-
Buttercup	*Ranunculus* sp.	2.9	-	-	-	-	-
Meadow grass	*Glyceria grandis*	2.4	-	-	-	-	-
Smartweed	*Polygonum sagittatum*	0.3	1.2	-	-	-	-
Smartweed	*Polygonum pennsylvanicum*	-	1.4	-	-	-	-
Panic grass	*Panicum capillare*	1.0	-	0.1	-	-	-
Canada thistle	*Circum arvense*	-	-	-	-	-	1.0
Maple	*Acer* sp.	-	-	0.1	-	-	-
Clearweed	*Pilea pumila*	-	-	0.1	-	-	-

TABLE 5. *The history of aquatic and water-tolerant plants at Theresa that invaded exposed mud flats on two different soil levels and remained after reflooding.*

		Avg. Stems/m^2									
		Shallow Water Section*					Deeper Water Section				
Plant Name	Scientific Name	1971	1972	1973	1974**	1975[1]	1971	1972	1973	1974	1975
Canary grass	*Phalaris arundinacea*	223	96	T	-	0	549	86	T	0	0
Sedges	*Carex* sp.	41	2	T	-	0	33	0	0	0	0
Cattail	*Typha* sp.	18	22	20	-	36	1	T	T	0	3
Soft-stem bulrush	*Scirpus validus*	4	7	11	-	0	1	2	0	T	1
Burreed	*Sparganium eurycarpum*	3	8	16	-	18	T	T	0	0	2
Water smartweed	*Polygonum* sp.	1	4	T	-	2	1	1	1	0	0
Rice cutgrass	*Leersia oryzoides*	5	2	1	-	0	8	0	0	0	0
Total stems		295	151	48	-	56	593	89	1	T	6
Avg. water depth (cm)		0	47	45	-	3	0	79	77	37	41

* Soils of shallow section exposed about 15 April 1971.
Soils of deep section exposed about 1 May 1971.
** No samples were taken because transect lines and posts were concealed by 9-11' cattails.
[1] In 1975 samples were taken in the vicinity of the original transect.
T Less than 0.5 stems/m^2.

TABLE 6. *The histories of aquatic and water-tolerant plants that invaded exposed mud flats at Horicon and Sinissippi and remained after reflooding.*

		Horicon Avg. Stems/m^2					Sinissippi Avg. Stems/m^2				
Common Name	Scientific Name	1972	1973	1974	1975	1976	1972	1973	1974	1975	1976
Soft-stem bulrush	*Scirpus validus*	224	163	77	16	1	66	27	0	T	0
Cattail	*Typha* sp.	33	19	14	27	13	19	31	28	28	12
Arrowhead	*Sagittaria* sp.	7	22	28	2	T	7	15	2	0	0
Burreed	*Sparganium eurycarpum*	1	3	4	2	1	T	2	3	T	0
Willow	*Salix* sp.	13	1	1	T	T	2	1	0	T	T
River bulrush	*Scirpus fluviatilis*	2	4	2	T	0	T	2	T	0	0
Rice cutgrass	*Leersia oryzoides*	4	8	6	0	0	5	6	1	0	0
Purple loosestrife	*Lythrum salicaria*	1	5	5	1	0	0	0	0	0	0
Total stems		285	225	137	48	15	99	84	34	28	12
Avg. water depth (cm)		dry	dry	67	67	49	dry	dry	91	91	82

T - Less than 0.5 stems/m^2.

tion of emergent plants.

Small green plants were usually discernible after soil surfaces had been exposed for several weeks. Sometimes, however, other factors such as moisture or temperature delayed germination or favored certain species.

Plant Composition on Exposed Soils

The available viable seeds, weather conditions during germination and growth, and the ability to compete are important factors that determine final plant composition on drawdown marshes. Plants that germinated on exposed soils at Horicon, Sinissippi and Theresa were divided into two groups: (1) those plants that were eliminated in the first year by reflooding (Table 4), and (2) those plants that re-occurred after reflooding and whose histories were followed (Tables 5 and 6).

Plant compositions at Horicon and Sinissippi were basically the same, but were different from Theresa during the first year of the drawdown. Softstem bulrush, cattail (Table 6) and nutgrass (Table 4), in that order, were the most important invading species at both Horicon and Sinissippi. By comparison, three entirely different plants, canary grass, sedges (Table 5), and blue vervain (Table 4) were the most important at Theresa and were absent entirely at Horicon and Sinissippi. Apparently, the viable seeds present at Theresa at the time of the drawdown differed greatly from those on the other areas.

A short history of the areas may explain the seed source.

Theresa is a relatively new marsh, flooded for the first time in 1968. Before flooding, canary grass and sedges were dominant vegetative types on this marsh (Schwengel 1969 pers. comm.), and seeds of these species could be expected throughout the marsh in great numbers. The fact that they reappeared in large numbers after the drawdown was evidence that these seeds, along with others not found on the other two areas, remained viable during the three years of flooding (Figs. 4-6).

The state-owned portion of Horicon Marsh was flooded to its present levels in 1934 and water was partially removed in the 1950's and again in 1962-63. There is no record of a former drawdown at Sinissippi which has been flooded since 1847. Sources of viable seeds for these marshes originate from present-day plants living within the marsh, plants produced by previous drawdowns or plants whose dispersal mechanisms assures them wide general distribution.

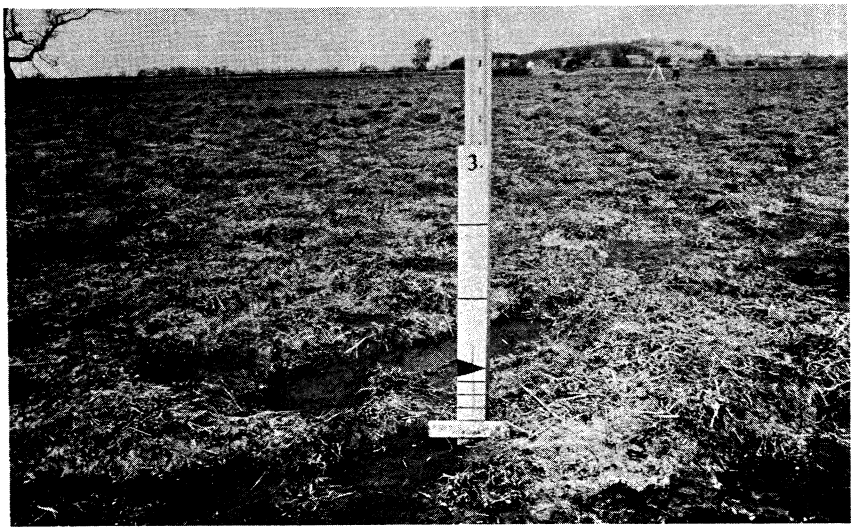

FIGURE 4. *Bare, exposed soils after drawdown at Theresa, 19 May 1971.*

FIGURE 5. *Seedling growth on soils exposed by drawdown, Theresa, 21 June 1971.*

FIGURE 6. *Adult plant growth on soils exposed by drawdown, Theresa, 8 September, 1971.*

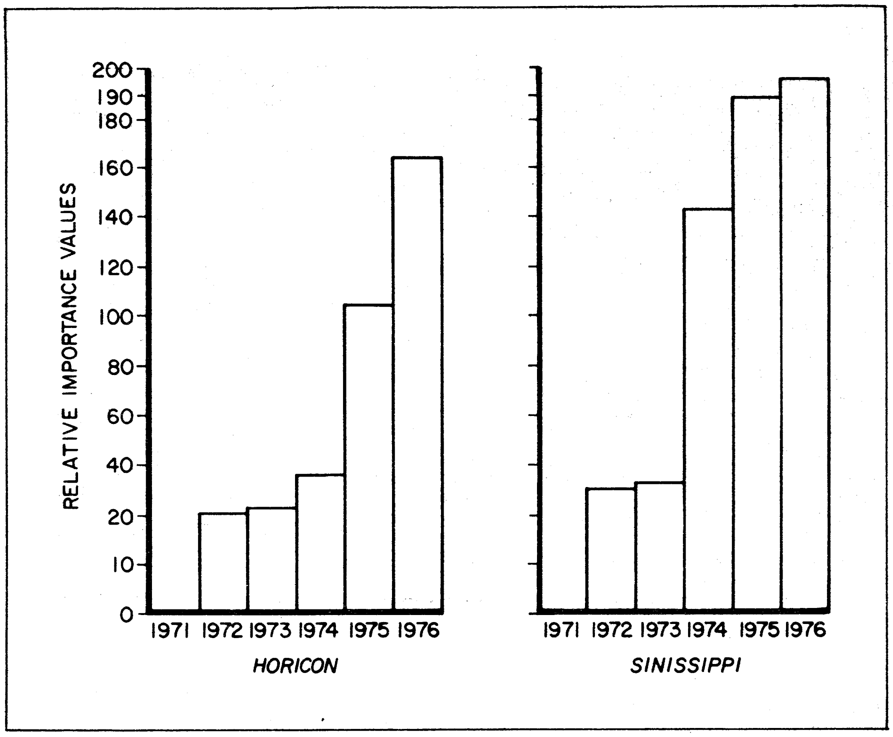

FIGURE 7. *Relative importance values of cattail to all other emergent plants during the drawdown (1972-73) and reflooding.*

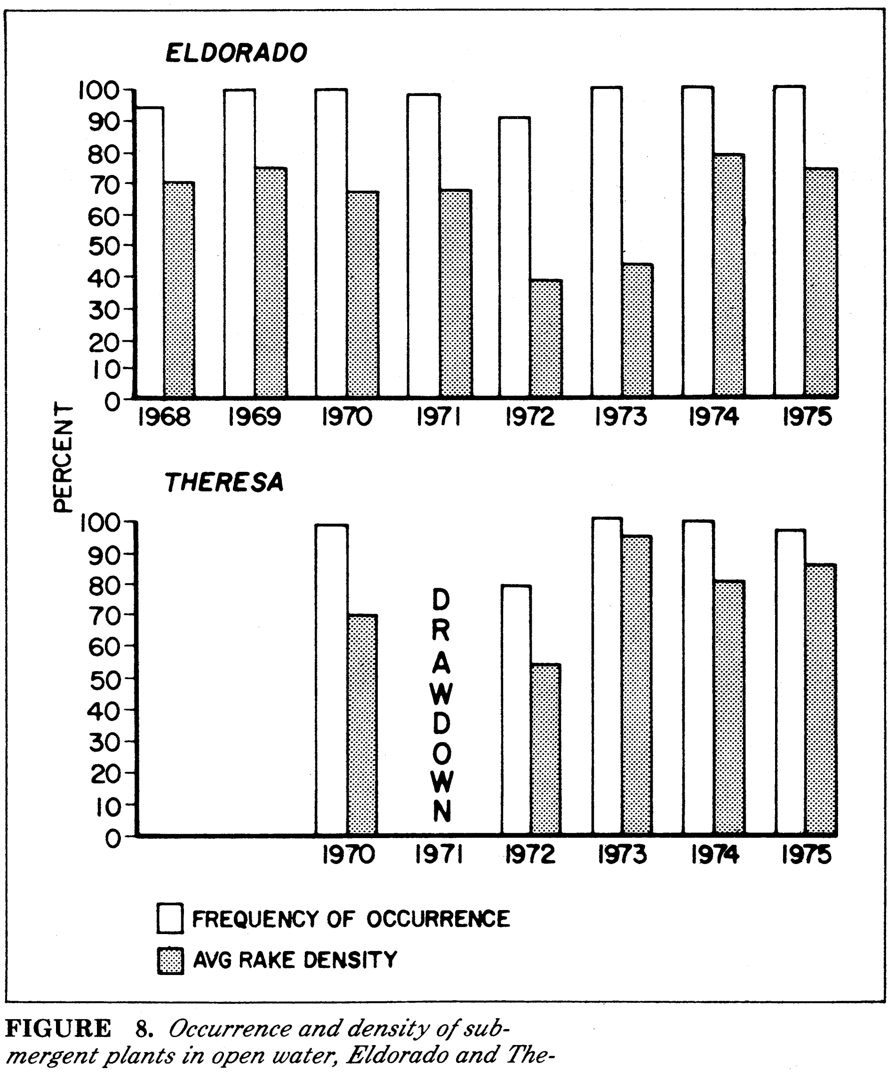

FIGURE 8. *Occurrence and density of submergent plants in open water, Eldorado and Theresa marshes.*

Plant Composition After Partial or Initial Reflooding

Theresa. Canary grass, the dominant invading plant at Theresa, was practically eliminated after the first year of reflooding. The sedges and rice cutgrass survived the 45 cm (18 inch) reflooding in the shallow level for one year, but neither survived the first year of reflooding (90 cm; 35 inches) of the deep section. Cattail and burreed increased and prospered in the shallow section creating a mass of emergent plants in an area that was formerly open water. The deep section returned to its predrawdown status with only an occasional clump of emergents present in otherwise open water. Theresa is a good example of how other shallow water areas in Wisconsin would quickly convert to cattail-dominated communities following either natural or induced drawdowns.

Horicon and Sinissippi. A period of heavy rainfall that began in July 1972, caused unplanned reflooding of about half of Horicon in August and over the entire marsh by September (Fig. 3). Although water levels on Sinissippi were not monitored, they also fluctuated with the heavy rainfall and by September most of the original lake bed was reflooded.

The release of water from both Horicon and Sinissippi continued in 1973 and after mid-July, levels were lower than at any time in 1972. Plant communties in these newly exposed portions of the marsh were much like those found in 1972 which were exposed then and contained new seedlings for the first time. The greater portion of both areas had been exposed in 1972. These areas were populated by a group of water-tolerant perennial plants dominated by softstem bulrush, cattail and arrowhead (Table 6). Cattail seedlings that were 0.9-1.5 m (3-5 ft) tall in 1972 were 1.5-2.1 m (5-7 ft) tall in 1973.

Although softstem bulrush was the dominant plant on both areas in 1972, its numbers were greatly reduced on both areas by 1973 (Table 6). Nutgrass was almost eliminated at Horicon in 1973, where it was required to compete under the canopy of other plants (Table 4). At Sinissippi, nutgrass flourished on those areas exposed for the first time in 1973 and its importance value was greater in 1973 than in 1972.

Plant Composition After Continued Reflooding

Sinissippi. Normal high water levels were restored to Sinissippi in September 1973 and remained there

TABLE 7. *Underwater plants present on areas surveyed.*

				Horicon			
		Eldorado	Theresa	Wildlife Area	Impoundments	Nat'l Wildl. Refuge	Sinissippi
Submergent and floating leaf plants							
Coontail	*Ceratophullum demersum*	X	X	X	X	X	X
Small leaf Potamogetons	*Potamogeton* sp.*	X	X	X	X	X	X
Sago pondweed	*Potamogeton pectinatus*	X	X	X	X	X	X
Bladderwort	*Utricularia vulgaris*	X	X	X	X	X	X
Common elodea	*Elodea canadensis*		X	X	X		X
Arrowhead	*Sagittaria* sp.**				X	X	X
Muskgrass	*Chara vulgaris*				X	X	
Water moss	*Fissidens* sp.	X	X				
White waterlily	*Nymphaea odorata*			X			X
Horned-pondweed	*Zannichellia palustris*				X		
Water milfoil	*Myriophyllum* sp.				X		
Water smartweed	*Polygonum natans*		X				
Flatstem pondweed	*Potamogeton zosteriformes*		X				
Curly pondweed	*Potamogeton crispus*						X
Wild celery	*Vallisneria americana*					X	
Spatterdock	*Nuphar luteum*		X				
Totals		5	9	6	9	7	8
Small free floating plants							
Star duckweed	*Lemna trisulca*	X	X	X	X	X	X
Little duckweed	*Lemna minor*	X	X	X	X	X	X
Big duckweed	*Spirodela polyrhiza*	X	X	X	X	X	X
Watermeal	*Wolffia* sp.	X	X	X	X		X
Liverwort	*Riccia fluitans*		X	X	X		X
Liverwort	*Ricciocarpus natans*			X			X
Totals		4	5	6	5	3	6

* Mostly *Potamogeton pusillus* and *Potamogeton foliosus*.
** The underwater form of *Sagittaria* sp. was considered as a submergent.

for the duration of this study. At the end of the 1974 growing season, deep flooding (91 cm; 3 ft) along the transect had eliminated all annuals and some of the aquatic and water-tolerant species. Emergent plants were suddenly dominated by cattail (Fig. 7) although stable numbers of burreed remained. Cattail withstood this deep flooding through 1975 with stem densities the same as 1974 (Table 6). However, their light green color, very narrow leaves and the absence of fruiting heads indicated stress and many plants did not survive into 1976 when stem densities averaged 57% lower. All emergent plants were eventually killed at these water depths by 1977.

Horicon Marsh Wildlife Area. Emergent plants at Horicon reacted differently than those at Sinissippi. Flooded in the early spring of 1974, softstem bulrush continued to dominate the vegetation, although the stem densities declined more than 50% by the end of the 1974 growing period. Although there were some gains and losses, all former aquatic and water-tolerant species were again present in 1974 (Table 6). The average water level along the Horicon transect was 67 m (26 inches) which was 25 cm (10 inches) lower than at Sinissippi. Lower water levels were probably responsible for the more gradual demise of flooded plants at Horicon.

By 1975, cattail was clearly the dominant emergent species, but in 1976 its average stem densities were also reduced by more than 50%. As at Sinissippi, two years of deep flooding were required before established cattail began to die, and both areas were beginning to revert back to their original open water conditions. This process was temporarily interrupted at Horicon in 1976 by yet another late summer and fall drawdown intended to restrict the water area available to migrating geese.

Submergents, Floating Leaf and Free Floating Plants

A total of 22 species were found generally in the open water sections on all areas during the sampling. Fifteen of these were true submergents or floating leaf plants, 6 were small free floating forms, and one (*Sagittaria* sp.) was an emergent that remained mostly in its ribbon-like underwater form and as such was considered to be a submergent (Table 7). For general discussion all species will be referred to collectively as submergents.

Annual submergent plant surveys from Theresa are summarized in Figure 8. Similar data gathered from Eldorado are included as an example of submergent plant communities present on a marsh which did not undergo drawdown during the study period. Small numbers of carp were present at Eldorado during all years and at Theresa in 1970 before the drawdown and carp eradication. However, carp were not considered to be a problem on either marsh. The low rake density values of all submergents at Eldorado in 1972 and 1973 were attributed to exceptionally high water in the late summer of 1972 that scoured the marsh and flushed tons of submergent plants over the dam prior to our sampling efforts.

After the drawdown and chemical elimination of carp from Theresa in 1971, submergent plant rake densities were low in 1972 before reaching new high rake densities (78-94%) for the next 3 years (Fig. 8). Submergent plants were widely distributed throughout both Eldorado and Theresa, as frequency of occurrence figures indicate the presence of submergent plants at almost every sampling site.

TABLE 8. *Comparisons of pre-treatment inventories of warm water fishes and submergent vegetation - Rock River marshes*.*

Area	Avg. No. Fish/Mile			Submergent Vegetation		Year of Surveys
	Carp	Bullheads	Other	Mean Rake Density All Species	Different Species Present	
Horicon	101	16	2.4	1%	2	1971
Sinissippi	49	3	1.0	24%	4	1971
Horicon NWR	8	1	3.0	55%	6	1971
Theresa	**			68%	9	1970

* Fish populations were sampled with a D.C. stream shocker during daylight hours (Priegel 1974).

**Flooded in 1968. No apparent carp problem - Fish survey not made.

TABLE 9. *Total crops of submergent plants growing in open water and under different cattail stem densities, 1976.*

Location	Total Densities of Submergent Plants	
	Horicon	Sinissippi
Open water*	91%	60%
1-8 cattail stems/m^2**	26%	38%
9-25 cattail stems/m^2**	19%	28%

*Rake.
**Hoop.

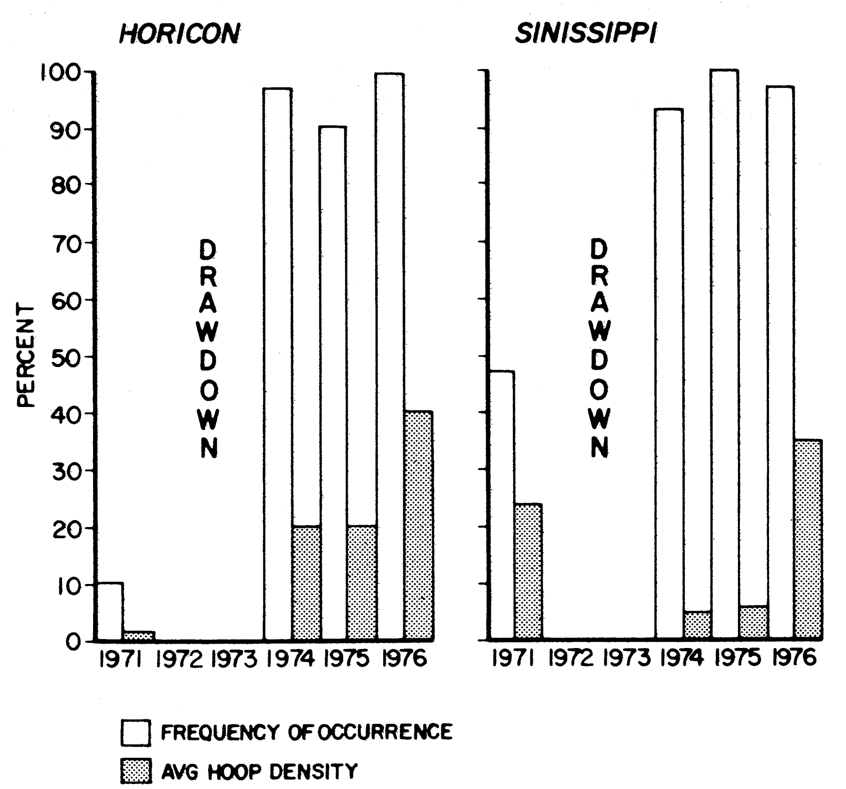

FIGURE 9. *Occurrence and density of submergent plants beneath a cattail overstory.*

Predrawdown status of submergent plants and their relationship to carp was documented on the state and federal portions of Horicon and on Theresa and Sinissippi before they were dewatered and chemically treated to eliminate carp. These data are compared in Table 8 to the pretreatment fish inventories taken on the same areas during the same years (Priegel 1974). The apparent inverse relationship between carp numbers and number of submergent plant species and rake densities point out the negative impact that excessive carp populations can exert upon submergent plants.

The presence of cattail at Horicon and Sinissippi apparently did not preclude the reappearance of submergents when these marshes were reflooded in 1973 and 1974. Although cattails were well established, submergents were quick to invade on these marshes under both flooded cattail overstories and in areas of open water. During the first year of reflooding (1974), submergents were present at 94-97% of the sample sites on both marshes (Fig. 9).

Although submergent plants were widely distributed under flooded cattail, their hoop densities were low (5% at Sinissippi and 20% at Horicon) and they remained at these levels in 1975. When the number of cattail stems decreased by more then 50% on both areas in 1976, submergent hoop densities increased to 35 and 40% (Fig. 9). Total crops of submergent plants under different stem densities are shown in Table 9.

For further comparison of submergent plant densities and their associations with cattail, all sample sites at both marshes were divided into three categories. Categories included "open water", cattail stem densities 1 through 8/m^2 and cattail stem densities 9 through 25/m^2. On both marshes highest submergent rake densities were found in the open water. Submergent hoop densities were greatly reduced when relatively small numbers of cattail were present and diminished even further as cattail stem numbers increased (Table 9).

SUMMARY

1. Thirty-three plant species grew on the exposed mud flats created when the Rock River marshes were drained. Nine species withstood some degree of flooding, but 25 were soon eliminated.

2. Softstem bulrush, cattail and nutgrass, in that order, were the dominant pioneering plants at Horicon and Sinissippi. Canary grass, sedges and

blue vervain were dominant at Theresa. Seeds of these species from Theresa had remained viable through three previous years of flooding.

3. The numbers and species of viable seeds present in the newly exposed soils largely determined the general plant composition that appeared on a given area. Final plant composition was influenced by the particular conditions that affected seed germination and/or seedling survival after the soils were exposed.

4. After reflooding, cattail soon dominated all other emergent plants on the study areas. Once established, cattails at Horicon and Sinissippi withstood deep flooding (56 to 123 cm; 22 to 48 inches) for a 2-year period without apparent loss or thinning of plants. After 2 years of deep flooding, about half of the cattails did not produce living sprouts and stem densities were 50% lower than the previous year.

5. Twenty-two submergents or free floating plants were found in the three Rock River marshes. Before the marshes were dewatered, submergent plant rake densities were inversely proportional to estimated carp populations. Following drawdowns and the use of toxicants to kill the carp, submergent plants increased on all areas. Rake densities ranged from 5 to 95% in open water sections of these marshes.

6. Submergents were not generally associated with established cattail communities in less than 15 cm (6 inches) of water or those that lost surface water during the summer. Submergents quickly invaded all sections of Horicon and Sinissippi during the first summer of reflooding. Although the distribution of submergents was widespread even under a cattail overstory, their percent hook densities were reduced as stem densities of emergent cattails increased.

EXPERIMENTS TO CREATE PERMANENT OPENINGS IN STANDS OF MONOTYPIC CATTAIL

STUDY AREAS

Eldorado Marsh Wildlife Area

A 4.8 ha (12 acre) site of mostly monotypic cattail was selected at Eldorado Marsh Wildlife Area (Eldorado) to test cattail control techniques. Since the study area was located downstream from the marsh's dam and main impoundment, water level control was not possible.

The presence and depth of surface water over the test site was determined from measurements taken several hundred meters to the east of the site, below the dam, at a permanent stake located on the test site and from water depth measurements taken on the test plots when the entire area was flooded. Water levels on the test site (Fig. 10) generally reflect alternate periods of flooding (winter and spring) and dryness (summer and fall).

The accumulation of old cattail debris was burned on 20 May 1970 before these activites began.

Horicon Study Area

The Horicon Marsh study area (Horicon) was a 400 ha (1,000 acre) block of wet marsh and uplands (Fig. 11). Three subimpoundments were developed on the area during the winter of 1973. Water levels were controlled by structures installed in each subimpoundment. Water levels in the outside marsh were regulated by a dam located within the City of Horicon.

Horicon was used as a site for various mechanical control and herbicide tests from 1973 to 1977.

CATTAIL CONTROL EXPERIMENTS

Covering

An early attempt at cattail control consisted of covering five plots (6 m; 20 ft in diameter) of cattails in Eldorado with black polyethylene tarps. The first three were covered on 5 June, when the ground still lay under very shallow water (10 cm; 4 inches). Cattails on these plots were stepped upon and bent over before the tarps were put in place. Tarps were tied down to stakes driven into the ground at plot peripheries (Fig. 12). Plot 1 remained covered for 27 days, Plot 2 for 63 days, and Plot 3 for 91 days.

The upward pressure from cattails that continued to grow allowed the wind to get beneath and cause movement and tearing of the tarps. Heat of the sun apparently also caused deterioration of the tarps within a month. It became necessary to patch the holes and tears with tape to keep the tarps usable. After this, tree branches and cattail tops were piled on the tarps to hold them firmly in place (Fig. 13).

The remaining two plots were covered later, when the surface water had disappeared: Plot 1-A on 2 July 1970, and Plot 2-A on 7 August 1970. Cattails in these plots were too tall to be simply bent over, and were therefore cut off at ground level before the tarps were put in place. Tarps were covered with tree branches and cattail tops. The tarps on both of these later plots were removed in mid-October, making the total cover time for Plot 1-A 106 days, and for Plot 2-A, 70 days.

In early October 1970, stem counts were taken in Plots 1-3 (1-A and 2-A were still covered). Covering destroyed actively growing plant tops wherever complete cover was maintained for a minimum of 60 days, but difficulties with tarps apparently obscured the complete picture of covering. Living stems were present where tarps had been torn and repairs were inadequate. Covering did appear to stimulate the development of adventitious buds (Fig. 2). The effect of covering was a total elimination of sunlight, but not of air, from the covered area.

Stem counts taken again in spring 1971 showed that in three plots stem densities were greater than densities in adjacent "control" areas (Table 10). (Stem densities on control areas and experimental plots were not determined before the test plots were covered in June and July. If there was a difference in pre-test densities of control and experimental areas it was considered insignificant since all test sites were in a very uniform monotypic stand of cattail.) Only Plot 1-A, established in July and covered for 106 days, had a much lower stem density (38%) than the adjacent cattail which was not covered. The establishment of this plot at the time when food storage in the rhizomes was low (Linde et al. 1976) probably contributed to its success. In addition, a general weakening effect on the following year's (1971) plants was noticeable. Mean stem height for cattail in all test plots was below the mean height of adjacent plants, and the percent difference in size appeared directly proportional to the amount of time the plot remained covered (Table 10).

A more sturdy cover that could be weighted down and left in place regardless of water depths could conceivably control cattails and other rooted macrophytes on small areas. However, because application of this method of cattail control on large areas appeared limited, further testing was discontinued. Whether or not an opening of this kind would become attractive to waterfowl was not determined.

Crushing

Crushing was reported by Nelson and Dietz (1966) to be a fast and economical method of controlling cattails in Utah especially when crushed areas were reflooded. The effectiveness of crushing as a control was also tested in three Wisconsin marshes.

Crushes were conducted at Eldorado in 1970, 1971 and 1972 and at Horicon and Theresa in 1973 and 1974. Detailed evaluations of these activities

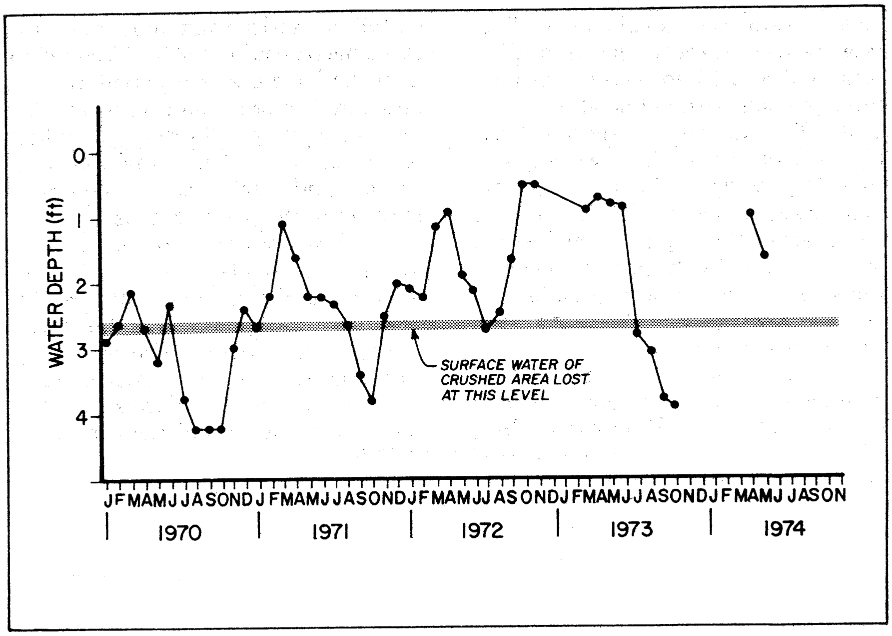

FIGURE 10. *Average monthly water depths at Eldorado, 1970-74.*

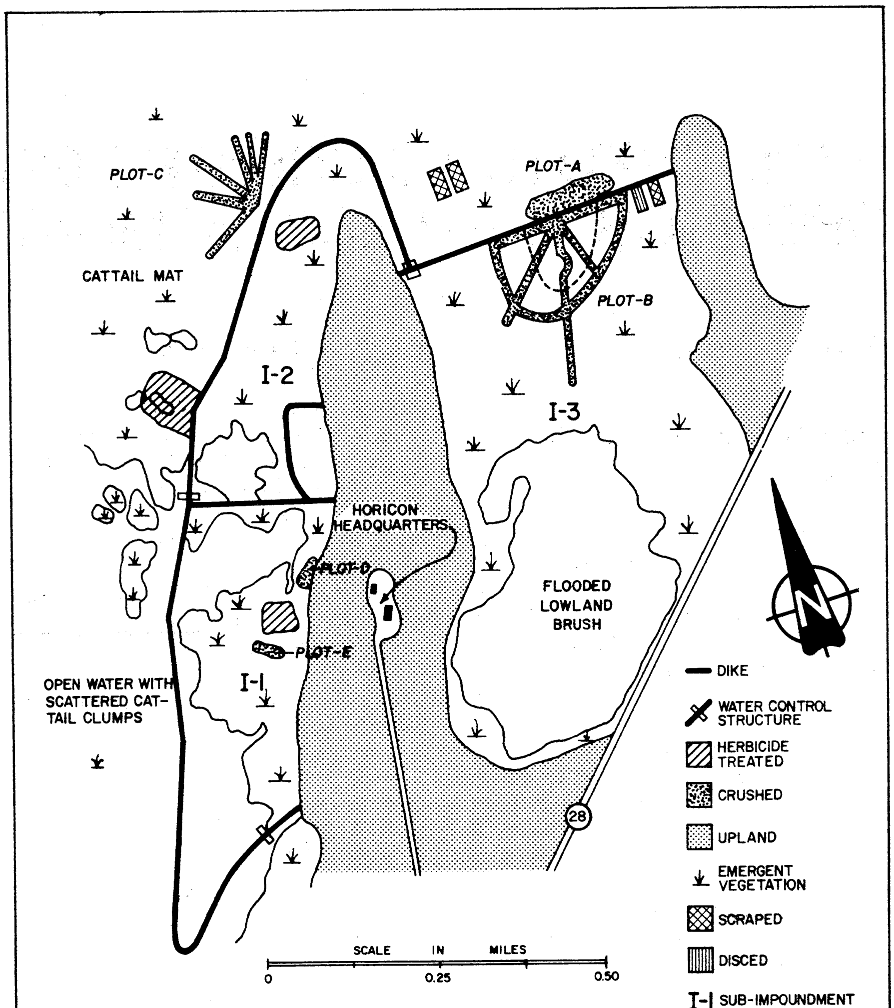

FIGURE 11. *Features of the Horicon study area.*

FIGURE 12. *Plot covered by black polyethylene tarp (Eldorado, 6 May 1970).*

FIGURE 13. *Plot covered by black tarp and cattail leaves (Eldorado, 14 August 1970).*

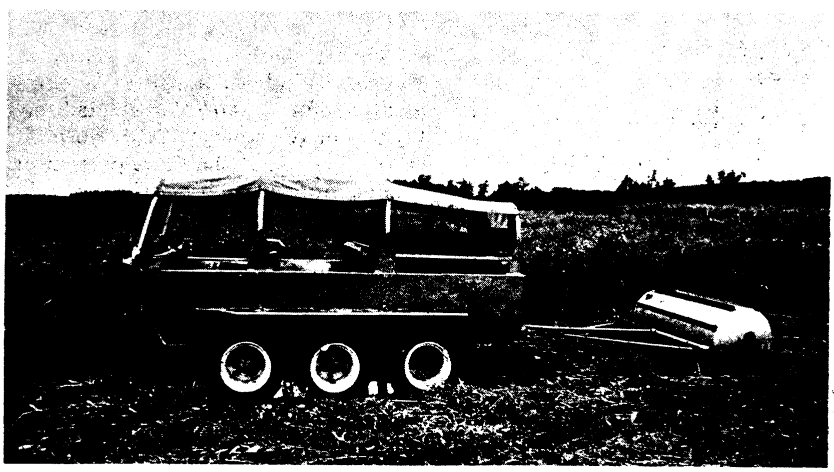

FIGURE 14. *All-terrain vehicle and rolling crusher.*

were made through 1975 with some plots observed into 1977.

Procedures

A Busse all-terrain vehicle (ATV) was used to pull the various crushers in the soft marshes (Fig. 14). Fitted with hard rubber tracks, this vehicle was capable of pulling the crushers in water depths less than 15 cm (6 inches). In 1974, we had the brief use of a John Deere 350 crawler fitted with extra-wide tracks (81 cm; 32 inches). It easily pulled a heavy marsh disc through dense cattails in water depths of 30 cm (12 inches). Our capabilities for testing mechanical cattail controls would have been much greater had the wide-track crawler been available throughout the study.

Three crushing devices were constructed. One was a section of a conventional drag which had tines fastened in a horizontal position, and which was weighted down and pulled behind the ATV. Another, a rolling crusher, was built from a 55-gallon drum. Eight angle-iron cleats were welded at equal intervals along the length of this drum, and removable metal blades, 10 cm (4 inches) wide with sharpened edges, were bolted to the cleats. Before use, the drum was filled with as much water as could be pulled under existing soil and water conditions. A second, longer rolling crusher was constructed from an 80-gallon water heater (Fig. 14). Construction features were generally the same as those of the barrel crusher, except that its greater length allowed crushing of the entire distance between ATV tracks.

Factors Influencing Effectiveness

All crushers flattened cattail stems and leaves effectively and after several weeks these parts were completely brown and apparently dead. However, many factors were recognized as affecting the success or failure of crushing. Included were: (1) the amount and kind of physical injury inflicted by equipment to the underground plant parts; (2) the timing or date of crushing; (3) the number of times a given area was crushed; (4) the presence and depth of surface water after crushing; and (5) the impacts of biological factors such as deer, muskrats and insects.

Physical Injury to Underground Rootstocks. Physical injury to rootstocks was generally influenced by the amount of surface water present, the mass of green tops flattened by crushing and the number of times equipment was pulled over a given plot.

TABLE 10. *Response of cattails to covering (Eldorado, 1970).*

Plot No.	Date Plot Covered	No. Days Covered	Avg. Stems/m² 2 Oct 70	Avg. Stems/m² 26 May 71	Tallest Stem (cm) on 2 Oct 70	Avg. Stem Height (cm) on 26 May 70
1	5 Jun 1970	27	1.50	39	137	51
2	5 Jun 1970	63	0.75	29	56	48
3	5 Jun 1970	91	0.39	47	34	38
1-A	2 Jul 1970	106	-	20	-	25
2-A	7 Aug 1970	70	-	45	-	40
Controls				32		80

TABLE 11. *Status of cattail one year after crushing. Eldorado Wildlife Area - 1972*.*

Plot No.	Date Crushed	Mean Water Depth at Plot (cm) On Crush Date	Mean Water Depth at Plot (cm) 1 Jun 1973	Evaluation of Crush	Leaf Heights Before Crush (cm)	Avg. Stems/m² Before Crush	Avg. Stems/m² Sep 1973	Percent Control
18	26 May 1972	13	49	Good	70	42	21	50
19	2 Jun 1972	13	40	Good	73	35	22	37
20	16 Jun 1972**	?	46	Good	141	39	17	56
21	22 Jun 1972	6	37	Poor	152	39	39	None
22	30 Jun 1972	14	47	Good	179	44	7	84
23	7 Jul 1972	6	45	Fair	190	42	5	88
24	28 Jul 1972[1]	0	44	Poor	226	43	15	66
25	28 Jul 1972	0	44	Poor	226	43	39	9
						41	21	51

*All measurement figures are the mean of 10 random samples (0.6503m²) taken within each plot.

**Equipment breakdown before crushing was completed. Finished 22 June 1972.

[1]Four-inch metal blades attached to drum cleats before crushing.

TABLE 12. *Relationships between surface water and cattail control two years after crushing (Plot B, Impoundment 3, Horicon*).*

Number of Samples	Range of Water Depths (cm)	Cattails: Percent Frequency of Occurrence	Cattails: Avg. Plants/m²
22	43-61	77	10
14	64-67	21	2
14	70-88	0	0

*This plot was crushed 6 July 1973 and sampled 14 July 1975. Each year, water levels over the plot were reduced by an estimated 0.5 m (1.5 ft) after 15 July. Evapotranspiration caused additional loss of surface water after this time.

Dry bog mats were very tough and restricted penetration by our equipment. When covered by several inches or more of water they became soft and much easier to penetrate. Under the cover of surface water, the initial disturbance by crushing equipment caused much of the old protective organic material to float. The removal of this protective debris allowed greater penetration by subsequent passes of the equipment.

Cattail leaves at all ages are very tough and were not cut by the crushing equipment even when the sharpened blades were used. In May and early June plant tops were relatively small. This allowed easy access by equipment to vital rootstocks. Some surface water was usually present during these months which also aided penetration by the equipment. Several shoots floating on the water surface were evidence that injury was sometimes severe (Fig. 15). The objection to early crushing was the creation of excellent seed beds where cattail seedlings flourished (Fig. 16). However, another crushing in late summer would destroy the seedlings.

In 1971 and 1972 we tried to physically destroy cattail plants by injuring the rootstocks and pushing the flattened green leaves into the soft muck. To accomplish this, crushers were pulled over some plots many times with criss-crossing and circular motions. Crushing was discontinued when a quagmire developed and the ATV no longer had sufficient footing to pull the crusher.

Timing or Date of Crushing. The time of crushing is an important consideration based on the hypothesis that the mechanical destruction of cattail leaves at the time of the lowest reserves of total nonstructural carbohydrates (TNC) should produce maximum cattail control (Linde et al. 1976). Field tests of this theory were limited, but some responses of cattails to the time of leaf destruction were apparent.

The seasonal changes of TNC in cattail rhizomes were determined weekly for the hybrid *T.* x *glauca* at Horicon (Linde et al. 1976) and bimonthly for *T. latifolia* at Madison, Wisconsin (Gustafson 1976). Both investigators found the same pattern of decline from the onset of growth in spring until the leaf area was sufficient to produce the plant's total food requirement. Linde et al. (1976) determined the TNC low point to be 7 July in 1971 and about 2 weeks earlier (21 June) in 1972. The presence of a large number of fruiting plants in 1972 may have used the stored reserves earlier and at a faster rate. Gustafson (1976) found lowest amounts of TNC in *T. latifolia* (about 10% dry weight) on 14

TABLE 13. *Control of cattails by annual or repeated crushing at Eldorado.*

Plot No.	Original Crush	Recrushed 1971	Recrushed 1972	Avg. Stems/m² in September 1971	1972	1973	1974	1975	Percent Control in September* 1971	1972	1973	1974	1975
4	14 Jul 1970	25 Jun 1971	-	21	3	4	9	30	49	93	90	78	27
6	14 Jul 1970	26 Jul 1971	7 Jul 1972	22	0	0	8	13	46	100	100	80	68
8	18 Jun 1971	26 Jun 1971	19 May 1972 28 Jul 1972	21	7	9	12	24	49	83	78	71	41
10	2 Jul 1971	-	30 Jun 1972	10	6	8	10	13	76	85	80	76	68

*Compared to the mean stems/m^2 (41) determined from 837 plots in undisturbed cattails adjacent to study plots.

June in both 1973 and 1974. However, in this species, amounts were not appreciably higher on the next test date, 1 July, in either year.

In 1972, eight Eldorado plots were crushed between 26 May and 28 July. Records were kept of water depths at the time of crushing, and equipment operators judged each crushing performance as either "good", "fair" or "poor", based upon the degree of penetration of equipment into the bog mat, the mix of cattail plant parts into bottom soils and the suspected injury caused to rootstocks. Cattail stem densities were sampled (0.7 m^2 quadrats) in each plot before crushing and were used for comparison with plants remaining one year later (Table 11).

A wide range of cattail control (0 to 88%), as measured 13-15 months later, occurred on the crushed plots. Overall control was 51%. The excellent reduction in stem densities on Plots 22 and 23 crushed on 30 June and 7 July indicated that timing could be an important ingredient of cattail control. Yet Plot 21 crushed on 22 June was without any cattail control one year later and again suggested the involvement of other factors, one of which may have been inadequate crushing.

The Presence of Surface Water After Crushing. There appears to be a direct relationship between the amount of cattail control achieved by crushing and the presence of surface water after crushing. Low spots on crushed plots on both Eldorado and Horicon that retained water were found to have more cattail control than the remainder of the plots. This is illustrated by the Eldorado experimental plots (Fig. 17).

Also on Eldorado, random weekly water level measurements on the crushed plots revealed differences in water depth of up to 30 cm (12 inches). The present control of cattail was significantly correlated with the number of days a plot was covered by surface water (P= <0.01). Although crushing

FIGURE 15. *Plot crushed in early spring (Eldorado, 19 May 1972).*

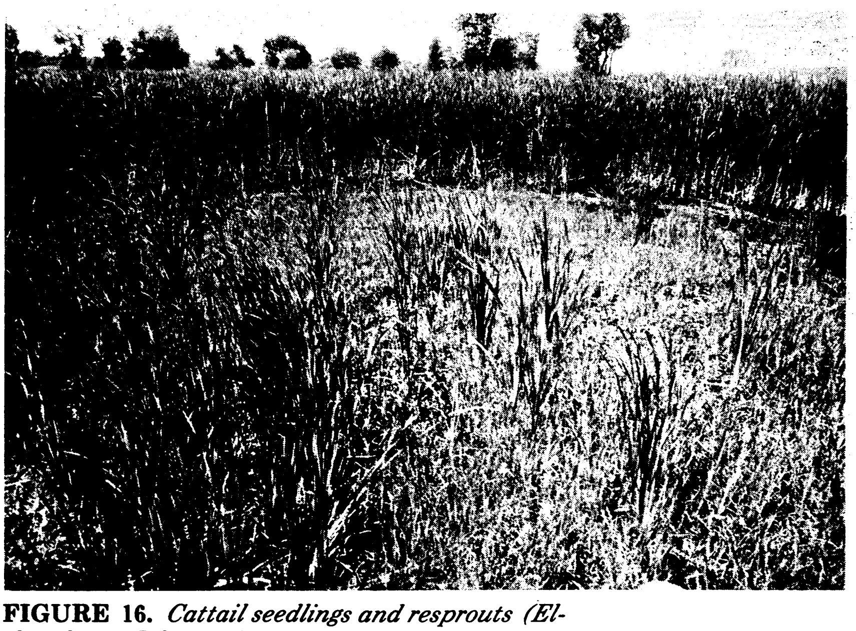

FIGURE 16. *Cattail seedlings and resprouts (Eldorado, 28 July 1972).*

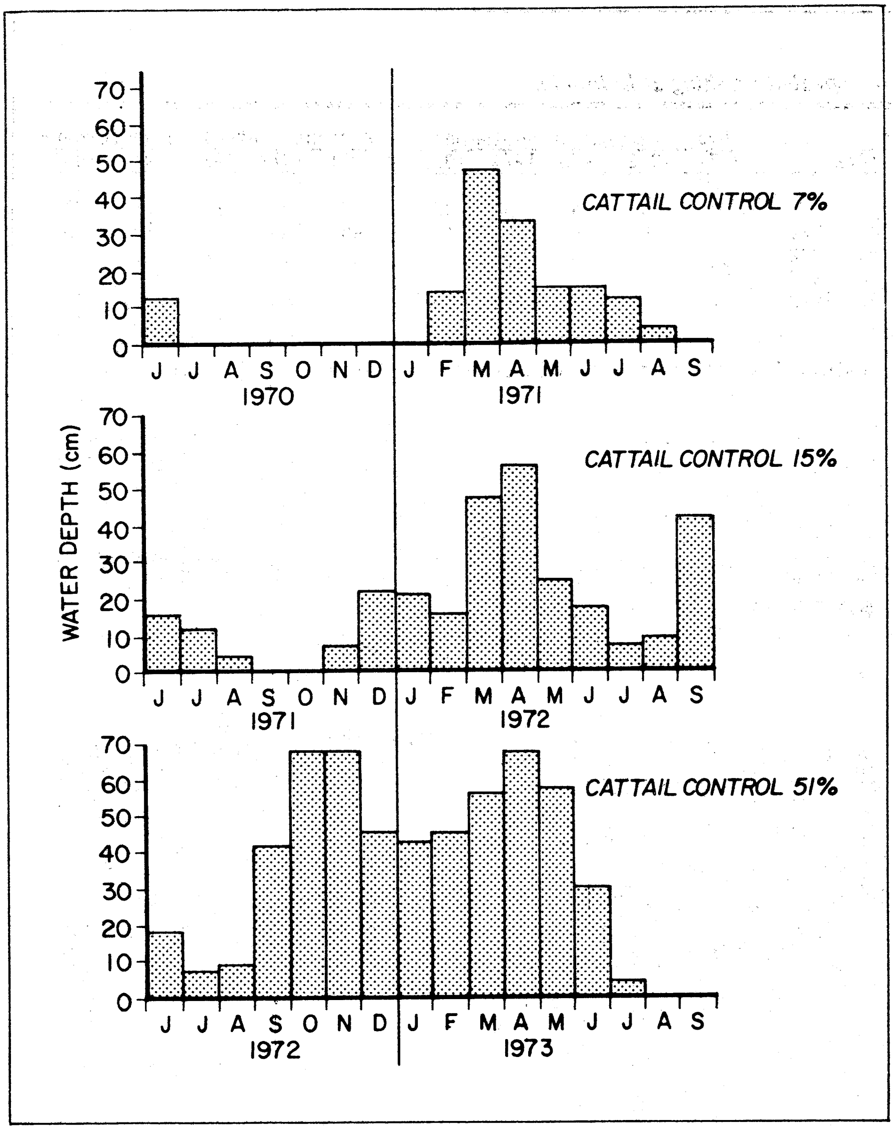

FIGURE 17. *Comparisons of standing water and cattail control (Eldorado, 1970-73).*

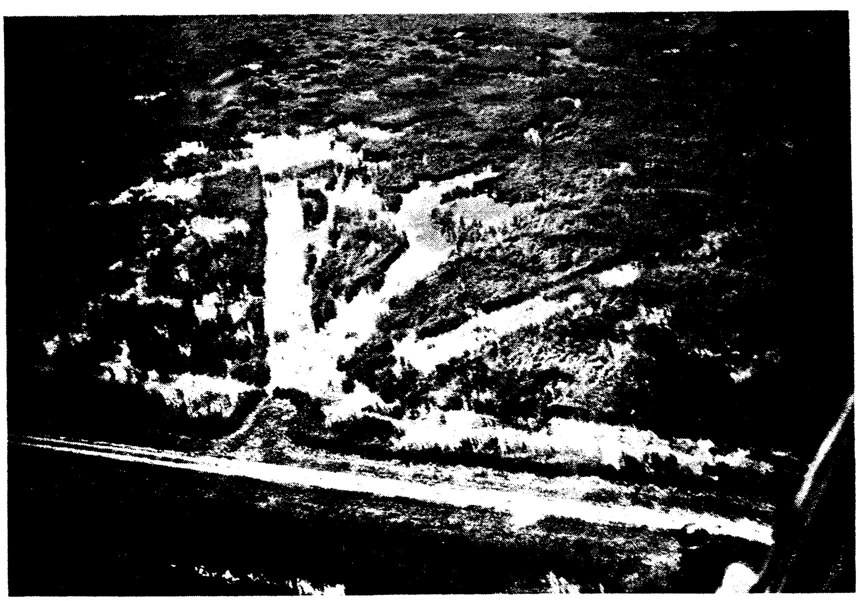

FIGURE 18. *Aerial view of Horicon Plot B two years after crushing.*

occurred when TNC storage was suspected to be low, an absence of surface water or possibly inadequate crushing appeared to negate the effects associated with the proper timing of this injury.

On Horicon, 50 random samples (0.5 m^2 circular quadrats) were taken in the deep section of Plot B—cattail stems were counted and water depths measured. Cattails did not survive on the lower soil surfaces covered by the deepest water depths of 70-88 cm (2.3-2.9 ft) (Table 12). However, an average of 10 stems/m^2 was present on the shallowest plots (underwater depths of 43-61 cm (1.4-2.0 ft)). At underwater depths of 64-67 cm (2.1-2.2 ft) only a few stems were found. The excellent, continuing control on the deeper section of Plot B is evident from Figure 18.

Plots Crushed More than Once. The annual or repetitive destruction of cattail tops by activities such as crushing was used effectively to create and maintain openings in *Typha* stands. The cumulative effects of destroying the food-producing leaves for two or more consecutive years resulted in the death of many cattail plants.

Four representative plots at Eldorado with various histories of recrushing are shown in Table 13. Control on these plots was especially successful in 1972 and 1973 when surface water over the area was deeper and lasted for a longer time. Cattails were eliminated altogether for 2 years in Plot 6 after 3 successive annual crushes. On Plot 4, cattail stems were reduced by 49% after successive annual crushes but many remaining plants were seedlings. Deer fed extensively on these and other developing seedlings during the summer of 1972 and by fall, stem counts were greatly reduced. Although Plot 8 was crushed twice each year in 1971 and 1972, cattail control was not as successful as on some other plots crushed less often.

A high degree of cattail control (71% and above) continued through 1974 (Table 13). With 12 or fewer stems/m^2 these plots continued to provide acceptable open water habitat for breeding waterfowl, marsh birds and their broods. Plots 6 and 10 remained desirable for these activities through 1975.

Cattails were eliminated from a trail where the ATV had made periodic trips through Horicon during the drawdown of 1972 (Fig. 19). The ATV and crusher traveled the same path at Eldorado in 1971 and 1972 to gain entry to study plots. This path also was still without cattails two years later (Fig. 20).

Although formulas to control cattail in shallow water areas were not developed from these activities, the potential to create and maintain acceptable openings was demonstrated. Timing annual crushes to coincide with the low point of TNC storage should maximize and hasten cattail control.

Biological Control Factors. Whenever mechanical control activities were imposed, other factors, mostly physical and biological, were also present and imparted their own particular measure of control. Except for surface water, these factors were often subtle and difficult if not impossible to separate out under field conditions.

On one of the Eldorado crushed plots, deer ate the entire tops of succulent seedlings less than 46 cm (18 inches) tall and the basal portions of resprouts less than 1 m (3 ft) tall. However, deer would not be expected to have similar effects on larger crushed areas even if these animals were abundant.

Muskrats have a more important effect, for they continually use this plant for food and housebuilding material. Cattail shoots are eaten by muskrats from the time they are formed in July. Continued muskrat feeding on the shoots and resprouts often eliminated cattails altogether from these areas (Fig. 21).

Cattails furnished by far the greatest amount of housebuilding materials in these marshes. Mature stems were cut below the water surface and all stems within a 3-12 m (10-40 ft) radius of the house were often taken.

Herbicide Use

The effective use of herbicides on cattails has been reported many times. Our studies were designed to not only evaluate the effectiveness of our herbicide applications, but also to measure the habitat created by these activities, the use of the newly created openings by waterfowl and marsh birds, and the time required for those areas to return to cattail-dominated communities.

On 16 July 1970, five Eldorado plots were treated with a different application rate of Amitrol T or Radapon (Table 14). Applications were made from an elevated position on the ATV using a gun-type high-pressure sprayer which covered a width of 3-4 m (10-13 ft). Cattail fruiting heads had recently lost their pollen-bearing staminate tops, and soils on the site were wet but without noticeable surface water.

In the late summer of 1973 a helicopter, rigged for spraying, was present at Horicon. This equipment was used on 16 August and the herbicide Dowpon was applied to 3 plots (Fig. 11). A concentrated mixture of Dowpon and water was prepared, but

FIGURE 19. *Cattail killed along trail used by ATV in 1972 (Horicon, 1 August 1973).*

FIGURE 20. *Trail made by ATV and crusher at Eldorado two years previously (Eldorado, 28 June 1974).*

FIGURE 21. *Cattail eat-out around muskrat house (Horicon, 1975).*

spray rates were difficult to determine because the pilot did not follow the preset markers as instructed. Rates were later calculated to be between 5.6-10 kg/ha (5-9 lb/acre) and were different for each plot.

Both Amitrol T and Radapon killed most of the cattails in trial plots at Eldorado. However, the higher application rates of these chemicals resulted in better continuing control for the next 3 years (Table 14). After the first year, when cattails were almost eliminated from all plots, it became more difficult to accurately measure the recovery of sprayed plants or the production of new plants because shoots from healthy cattails bordering the narrow plots readily invaded from both sides. Certainly some of the stems included in the 1972-73 counts were produced in this manner. Nevertheless, herbicide sprays were effective in creating and maintaining openings at Eldorado that remained for at least the next 3 years.

Although the herbicide at Horicon was applied late in the season and at a rate lower than desired, (approximately 5.6-10 kg/ha), the kill of cattails was generally good on the I-1 plot and on the outside marsh (Fig. 11). The I-2 plot was flooded when sprayed and had the lowest herbicide application rate. Results were spotty and less permanent. Cattails in all plots began to turn brown within a week after spraying and remained brown throughout 1974. Residual plant parts of cattails killed at this time of year by herbicides appeared to be tougher and longer lasting than fully matured plants finally killed by frost.

Killing cattails by spraying did not create the expected and desired open water areas at Horicon. When all marsh areas were flooded one year after spraying (1974) the entire bog mat became buoyant and floated to the surface. In many places this mat was thick enough to hold a man's weight. Seedlings of emergent aquatics and moist soil plants grew on the floating mat but most were not thrifty and did not reach maturity.

TABLE 14. *Results of herbicide sprayed 16 July 1970 on cattail - Eldorado Marsh Wildlife Area.*

Plot No.	Application Rate*	Mean Stems/m^2** 24 Sep 71	29 Sep 72	1 Jun 73
Aa	3.4	1.8	12.3	22.2
Ab	4.3	0.7	8.0	20.8
Ra	20	1.2	17.2	22.5
Rb	24	0.0	13.4	16.6
Rc	30	0.6	4.9	12.4

*Pounds active ingredient/acre.

**Ten samples of m (7 ft^2) each taken in each plot. Stem densities in adjacent control areas averaged 41 stems/m^2.

Injury

Three types of injury that involved cutting developing shoots or rhizomes were inflicted upon cattails. An area of monotypic cattails on Horicon was used in 1973 for this purpose. Five aerial shoots were severed with a knife for each of three types of injuries on three dates (9 May, 30 May, and 13 June) (Fig. 22). The severed portions were placed either in a natural marsh environment or glass jars with their basal portion in marsh soils. The responses of both parent plants and the severed parts were monitored to determine permanent injury or recovery and continued growth (Table 15).

(1) Developing shoots (in May) were cut 13-15 cm (5-6 inches) above the base curve or 8-10 cm (3-4 inches) above the juncture of shoot and rhizome. When the injury occurred in June, recovery was no longer assured; only 1 of 5 recovered.

(2) Developing shoots were cut at the juncture with the rhizome, which usually left some adventitious buds on

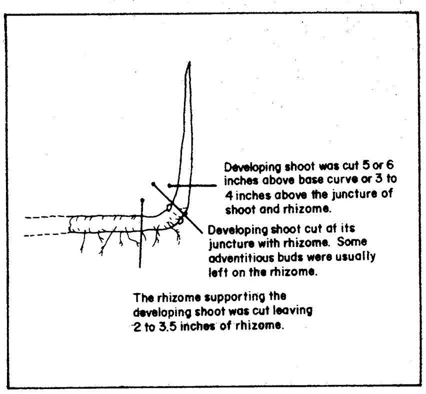

FIGURE 22. *Cattail rhizome and upturned aerial shoot showing location of cuts made for injury tests.*

the rhizome. The earliest injuries (May) allowed for the best recovery by the development and growth of remaining adventitious buds. After May, little recovery was noted.

(3) The rhizome supportng the shoot was cut, leaving 5-9 cm (2-3.5 inches) of rhizome on the plant. No recovery was apparent at any time. This suggests that new shoot-producing buds are not readily formed upon cattail rhizomes. Some buds may have been produced at a later date but this was not observed.

Plant parts from the first two types of injuries involving the cutting of developing shoots did not survive when placed in water in either a glass jar or in a natural marsh environment. The severed portion of the third type of injury included a 2-4 inch (5-10 cm) section of the rhizome. These lived in the jars and in the natural marsh but only when a portion of the shoot was exposed to the air. Death resulted whenever the entire section was covered with water. These tests identify one reason why the continued presence of surface water is important to good cattail control after mechanical injury.

Cutting

Nelson and Deitz (1966) in Utah tested this control method by cutting cattails at different heights above and below surface water of varying depths. Their plots were cut in July when pistillate spikes were well formed but not mature. Resprouts were cut later whenever they attained a height of 60 cm (2 ft). Their research indicated that water depths over the cut stems was the key to cattail control. When at least 7 cm (3 inches) of water remained over cut stems, more than 90% of the cattail reproduction was killed by the first cutting and a total kill was achieved after resprouts were cut. In contrast, no apparent kill resulted when cattails and their resprouts were cut 7 cm (3 inches) above water surface. Weller (1975) also demonstrated the effectiveness of this method in Iowa.

In cutting experiments at Delafield Pond in Wisconsin, Mathiak (1971) found that higher than normal water levels killed most of the cut cattail stems, and weakened the plants with uncut stems.

On our study areas, we tested timing of cutting and water depth and their effect on cutting as a cattail control measure. The earliest plot was cut at Eldorado on 16 April 1971. Growth had not begun and upright shoots were held in frozen soils although covered by 15 cm (0.6 ft) of water. All shoots were cut as low as possible in this and all subsequent plots with a corn knife. Growth began after 23 April and as new shoots extended above soil surfaces they too were cut at ground level. However, many of the shoots cut in this manner continued to grow. When the inhibiting factor, surface water, was lost in June, the regeneration of cut plants followed swiftly.

At Horicon a series of 1.8 x 1.8 m (6 x 6 ft) cut plots was established in 1971 (Table 16). Visits were made to each plot twice a week and the range of water levels over the plots determined by a series of measurement at each visit.

The earliest cut (May 14) appeared to stimulate the greatest shoot production in the plot. By the following September, stem numbers were 25% greater than those originally present. Stem numbers declined to the original number by July 1972 and no cattail control was indicated.

Plots cut on or after 1 June showed increased control for each successively later cutting date by September of the same year. Some of this early control might be attributed to the progressively shorter periods for recovery except that the same level of control continued into 1972 for the July and August plots and was greater than for the June plot. The plot cut in August showed the greatest cattail control one year later.

Shallow surface water covered most of the plots in 1971 from the time they were cut until 28 September (Table 16). Exposed soil was recorded only once in the highest portion of the June plot, but the surfaces of cut stems were exposed for a time in all plots. During the winter of 1971-72, water levels over the plots were maintained at or above the 28 September readings.

As long as cut plants remained completely covered, varying water depths apparently had little influence upon cattail control in these plots. Under these conditions, timing of the cut appeared to be an important influence, for cattails cut in May recovered completely while 80% of those cut in August were destroyed.

When cattails are cut below the water surface as a control measure it is equally important that old residual stems still standing from previous years be cut along with the green stems of the current year. The importance of cutting all stems was determined at Horicon after the creation of subimpoundments in which water levels could be maintained throughout the year. On 5 July 1974, when the development of cattail fruiting heads indicated the low point of energy reserves, four 1.8 x 1.8 m (6 x 6 ft) plots were cut in water depths of 22-32 cm (3/4-1¼ inch) (Table 17). Stems were cut as close as possible to soil surfaces and plot boundaries were marked with permanent corner posts. In Plots A-1 and A-2 care was taken to cut all stems, both old and new, that extended above the water surface (Fig. 23). On plots B-1 and B-2 all residual stems were left standing while all green stems were cut.

By fall, important differences were apparent between the A and B plots, and one year later, July 1975, an average of 82% of the cattails in the A plots were eliminated compared to an average of only 12% of the stems in the B plots (Table 17). In the A plots, the only new sprouts were located within 30 cm (1 ft) of plot borders, the apparent progeny of plants outside of the cut areas. Control in the center of both A plots was 100% (Fig. 24). Recovered cattails were evenly distributed throughout the B plots.

Plot C (Table 17) was cut on 17 October 1974 to test possible suffocation overwinter. Cattails, already killed by frost, were cut 8-18 (3-7 inches) below the water surface in water depths on 24-40 cm (9.5-16 inches). All stems that extended above the water were cut and removed from the plots. Results were similar to those of the A plots (Table 17). The only cattails that recovered were again within 30 cm (1 ft) of the plot edge and by July 1975 control was 81% overall.

Continuous submergence of cut stems was also required for cattail control in Wisconsin. Proper timing and the cutting of all old stems in addition to the green stems were also important to achieving the best control.

The effects of cutting were also documented at Lake Sinissippi after the drawdowns in 1972-73 had resulted in miles of solid cattail along its shallow shorelines. Many cottage owners, with sickle and scyth, cut paths through the cattail from boathouses to open water (Fig. 25). Most of these paths were cut after 1 July and effectively controlled the cattail. Water depths at these sites were 30-120 cm (1-4 ft).

TABLE 15. *Results of various injury types to parent cattail plants.*

Date Cut	Number Cut	Injury Type	Date Inspected	Results
9 May 73	5	I	30 May 73	4 - recovered 1 - cut off by muskrats
30 May 73	5	I	10 Jul 73	5 - recovered
13 Jul 73	5	I	10 Jul 73	1 - recovered - 3 leaves 1 foot above water 2 - grew 8" above water then died 2 - no change*
9 May 73	5	II	30 May 73	4 - adventitious buds showing small growth 1 - no development of buds - 31½" shoots growing from base of parent plant
30 May 73	5	II	10 Jul 73	1 - small growth of one bud 4 - no change
13 Jun 73	5	II	10 Jul 73	1 - not found 2 - no change 2 - appear to be rotting at cut surface
9 May 73	5	III	30 May 73	5 - no change
30 May 73	5	III	10 Jul 73	5 - no change
13 Jun 73	5	III	10 Jul 73	5 - no change

*No recovery from injury.

FIGURE 23. *Plot in which all stems were cut below water levels (Horicon, Plot A-2).*

FIGURE 24. *One year after cutting (Horicon, Plot A-2).*

TABLE 16. *Effects of water depth and timing on cutting as a cattail control measure (Horicon Marsh Wildlife Area - 1971).*

	Stems/m^2			Water Depths (cm)			Percent
Date Cut	Original Cut	28 Sep 71	1972 Regrowth	Range	Mean	28 Sep 71	Control 5 Jul 72
14 May 71	37	46	37	2.5 - 30	15	23	0
1 Jun 71	38	30	17	0.0 - 24	10	15	55
1 Jul 71	40	14	15	2.5 - 18	9	18	63
3 Aug 71	45	11	9	1.3 - 10	5	10	80

Scraped Openings

Horicon Marsh was again drawn down in 1976. Drought conditions late that summer and fall and a continuing winter season with very little snow produced very dry conditions over the dewatered marsh. I took advantage of this situation to test "scraping" as a method of controlling cattail.

In February 1977 a John Deere 450 crawler tractor with a bucket was used to scrape away all residual cattail and 5-10 cm (2-4 inches) of the bog mat from five plots in the shallow marsh where monotypic cattail prevailed (Fig. 26). Openings created were 0.2-0.4 ha (½-1 acre) in size.

The majority of upturned shoots were severed by these activities and horizontal rhizomes were sometimes cut longitudinally by the blade. In some places, frozen ground did not allow enough overall penetration by the blade, and it sometimes passed over those shoots growing from small depressions in the soil surface. Equipment with more power and weight was considered essential by the operator for future work on a large scale.

The number and species of plants found growing in these openings were determined in July 1977. Emergent plants were counted in 0.9-m^2 (3-ft^2) randomly selected circular quadrats. Submergent and free floating plants were recorded as either present or absent at each sample site.

The creation of openings by scraping in winter was a successful method of controlling cattails at Horicon. Surface water covered the openings after the spring runoff and by July scattered adult cattails were present in only 20-55% of the random sample plots (Table 18). Compared to an average of 41 stems/m^2 in plots of undisturbed cattails, stem densities in the openings indicated a 92-98% cattail loss due to scraping.

Exposure to air or freezing temperatures during the drawdown may have increased the germination potential for burreed seeds since this species grew abundantly in open water areas throughout Horicon in 1977. It germinated and grew under water depths of up to 60 cm (2 ft) and by July was the most abundant species in the openings (Table 18). Only those plants that had actually emerged are included in Table 18, but many others, still submerged, were present. Opening #4, with the shallowest mean water depth (14 cm-5.5 inches), was covered by hundreds of emergent burreed stems. Burreed was not found at opening #5. Muskrats (two active houses were present at the edge of this opening) may have been the reason for its absence. Muskrat houses were not present at any of the other openings.

These openings provided good expanses of open water in otherwise restrictively dense cattails (Fig. 27), and were used by a variety of marshbirds and waterfowl. However, cattail control by this method would have only limited application in Wisconsin since the marsh must be dewatered and remain dry until scraping can be completed. The physical structure of many marshes defies easy drainage, and with an average annual rainfall of 76 cm (30 inches), considerable moisture can be added at any season. Late fall and winter rains or winter thaws could easily result in saturated surfaces that would be difficult to penetrate when frozen. Unless marshes are easily drained, success of this method would be unpredictable.

TABLE 17. *Extent of cutting and its effects on the control of cattail.*

Plot No.	Extent of Cut	Date Cut	Avg. Stems/m^2 Original Cut	15 Oct 74	9 Jul 75	Avg. Water Depths 5 Jul 74	15 Oct 74	9 Jul 75	Percent Control 9 Jul 75
A-1	Green stems	5 Jul 74	51	4	14	22	34	27	73
	& residual								
A-2	stems	5 Jul 74	56	1	5	24	36	23	91
		Avg.							82
B-1	only green	5 Jul 74	39	12	30	26	34	12	23
B-2	stems cut	5 Jul 74	36	19	37	24	34	24	0
		Avg.							11
C*		17 Oct 74	37	-	7	32	-	31	81

* Both green stems of the current year and old stems of the previous year were cut at ground level.

TABLE 18. *The status of emergent plants growing in scraped openings, Horicon, July 1977.*

Opening No.	Percent of Frequency of Occurrence: Cattail	Burreed	Sedge	Softstem Bulrush	Spikerush	Arrowhead	Avg. Stems/m^2: Cattail	Burreed	Sedge	Softstem Bulrush	Spikerush	Arrowhead	Avg. Water Depth (cm)
1	35	30	5	5	0	20	1.4	1.3	0.3	0.6	0.0	0.6	22
2	25	45	5	0	0	30	0.7	3.7	0.1	0.0	0.0	1.1	24
3	55	50	0	5	10	20	3.0	3.7	0.0	0.1	30.0	0.4	24
4	20	90	0	10	0	40	0.9	90.0	0.0	0.1	0.0	0.6	14
5	50	0	0	0	0	20	3.2	0.0	0.0	0.0	0.0	1.1	18

Fire

Fire has been used on state-owned wildlife areas for many years to dispose of accumlated cattail debris, to set back the succession of woody plants and to allow accessibility to the marsh surface by an assortment of birds. The usual period for burning begins in late fall after heavy frosts have killed and dried plant tops and extends into spring before returning birds begin using this cover for nesting.

Burning is a controversial practice. It destroys residual cover but provides no actual cattail control because viable plant parts are normally buried in ice or frozen soils. Occasionally a fire that burns into the peat layer of a dried out marsh will kill the cattails and deepen the area by consuming the peat. Peat burns of this type will benefit most

FIGURE 25. *Paths made through cattail by cutting below water levels in summer (Sinissippi).*

FIGURE 26. *John Deere 450 crawler tractor and bucket used to scrape openings (Horicon, 1977).*

FIGURE 27. *Scraped opening after summer growth (Horicon, 11 July 1977).*

marshes by providing additional areas of open water. In many regions, however, burning is subject to air pollution restrictions.

Burning cattail marshes cannot be planned with any certainty. The practice is dependent upon water depths, winds, snow depths and moisture conditions previous to and at the time of the burn. Ideally, burning would take place in spring and on a dewatered marsh, following a winter of little moisture. The day should be sunny with a light but steady wind blowing away from any populated area in the vicinity. Conditions of this kind prevailed at Horicon in 1977 and the "best burn ever" occurred (James Bell pers. comm.; Fig. 28).

Cattails can sometimes be burned in winter when the formation of solid ice allows mobility by burn crews. Often, however, accumulation of blowing snow in cattails precludes burning.

The thick bases of cattail plants and the stalks that supported fruiting heads the previous year are the last to dry and are the most difficult to burn. If these plant parts are split with a knife their general moisture content can be assessed by rubbing the fingers along the cut surfaces.

Even with favorable conditions, successful burning is difficult to accomplish over the same area in subsequent years. Usually the accumulated debris from more than the current year is necessary to carry a hot, consuming fire.

Drying

In 1971, the outer edges of a mature, but isolated, cattail community at Horicon were marked by steel posts and spray painted so that any edge extensions or withdrawals during the drawdown could be measured. Paint was still visible in December 1972 when edges were repainted. A series of 0.7 m^2 (2 ft) circular quadrats were sampled each year within the area to measure possible changes in plant composition.

In the fall of 1972, the mature cattails of this established community were easily distinguishable from the surrounding 0.9-1.5 m (3-5 foot) cattails that grew from seeds on the exposed mudflats. There was no clear advance or withdrawal of the mature cattail edge and this condition continued in 1973, when the 1972 seedlings reached heights of 1.5-2 m (5-7 ft). The final assessment of the mature edge in 1976 showed an extension of 1-2 m (3-6 ft) at 2 posts, a withdrawal of 1 m at another and little change at the 3 remaining posts.

Mean stem density within this cattail community in predrawdown 1971 was 42 stems/m^2; almost exactly the same as the overall average of 41 stems/m^2 determined from 837 sample quadrats in undisturbed stands. Burreed was the only other plant present (Table 19). Stem densities of mature cattail within the plot increased during the partial drawdown and fall flooding in 1972. In 1973, water levels receded to lower levels and this recession remained longer than it did in 1972 (Fig. 3). The peat soils were allowed to dry. By fall, cattail stems/m^2 were reduced by one-half and 9 different moist soil species in varying numbers had invaded the plot (Table 19). Nelson and Deitz (1966) reported that drying for 2 years effectively controlled cattail in Utah. Although this method also appears to have some use in Wisconsin, our inability to effectively drain many of our marshes and our high annual rainfall make drying an uncertain control method in many marshes.

Discing

A special heavy marsh disc was used at Horicon on 12 September 1974 to make narrow trails through adult cattail in I-3 and through plot A on the outside marsh (Fig. 11). Cattails were rooted out and otherwise injured severely by this equipment and portions of these plants became tightly caught between the discs and the frame. The rotating action of individual disc blades was halted much of the time. The following year openings were present at both locations but cattails returned rapidly thereafter.

Plots were also created with a conventional disc at Horicon during February 1977 when the marsh was dewatered. Located in I-3 and the outside marsh, these plots did not create the desired open water. When water returned in spring the flattened cattail tops floated and completely covered water surfaces. Green stem numbers on the plots appeared normal in 1977.

INVASION OF PLANTS OTHER THAN CATTAIL

Cattails eliminated by control activities were soon replaced by other plants especially when soils were exposed in summer. Species composition of these invading plants was documented in September 1972 on the cat-

TABLE 19. *Changes within a mature cattail community during the drawdown of Horicon.*

Plant Species		Avg. Stems/m²		
Common Name	Scientific Name	1971	1972	1973
Cattail	Typha sp.	42	53	27
Burreed	Sparganium eurycarpum	3	3	T*
Sticktight	Bidens cernua			95
Clearweed	Pilea pumila			11
Nodding smartweed	Polygonum lapathifolium			7
Purple loosestrife	Lythrum salicaria			5
Nutgrass	Cyperus sp.			2
Wild millet	Echniochloa sp.			2
Spikerush	Eleocharis sp.			2
Pigweed	Amaranthus sp.			2
Nettle	Urtica dioica			1

*T - less than 0.5 stems/m^2.

tail control plots at Eldorado. All plant species within 10 circular quadrats randomly selected within each plot, were identified and counted.

Because of the wet summer season in 1972, surface water began to accumulate on the plots in August. This abnormal situation terminated the germination and continued growth of many plots early in the season and the increased water depths in September presented a physical barrier to the sampling process. Because of these conditions, plant densities and diversities as presented here are considered to be minimal.

A total of 23 crushed and 5 herbicide plots were surveyed at Eldorado. Emergent plants were not found on the 5 plots crushed after 21 June 1972 or on 2 other plots. Another plot had returned to monotypic cattail with the exclusion of all other plants. These 8 plots were omitted in our analysis and only the data from the remaining 15 plots where other emergents were present were included in Table 20.

A total of 25 plants species replaced cattails in experimental plots at Eldorado and 19 of these also came in on dewatered soils on other study areas (Tables 4, 5 and 6). Canary grass occurred most frequently in the total samples from both crushed and herbicide plots and completely dominated several of the crushed plots. Other plots contained good mixtures of 6 to 8 species with little or no canary grass (Fig. 29). Many of the invading species were good producers of known duck foods.

SUMMARY

Covered Plots. Control of cattails by covering with a black plastic tarp was proportional to the amount of time the plot remained covered. The longest period of covering (106 days) resulted in a 38% decrease in stem densities the following year. Mean stem height of all cattails covered was less than mean stem height of uncovered cattail the following year.

Weather resistant covers could be effective in maintaining openings in cattail, but the practice appears limited only to small areas.

Crushing. Crushing had the immediate effect of opening up solid stands of cattail and making surface water, if present, available to birds. However, it is a temporary practice on areas where soils are exposed in summer and must be repeated annually to maintain the desired openings under these conditions.

The continued presence of surface water after crushing appeared to be a major factor affecting the eventual control of cattail. Openings were preserved for 4 years after a single crush when adequate surface water (15 cm; 6 inches or more) was maintained over the plot. The timing of crushing to coincide with the low point of carbohydrate storage should maximize and hasten control.

Herbicides. Amitrol T, Radapon and Dowpon were used successfully to kill cattail. The time of spraying is important in light of the carbohydrate storage cycle and should correspond to the period when the bulk of the food is being manufactured in the leaves and

FIGURE 28. *Burning cattail at Horicon Marsh, 1977.*

FIGURE 29. *Good mixture of plants (mostly nutgrass and burreed) invading crushed area (Eldorado, 1973).*

TABLE 20. *Plants that invaded crushed and herbicide plots - Eldorado September, 1972.*

Common Name	Scientific Name	Crushed Plots Percent Occurrence		Herbicide Plots Percent Occurrence	
		In Total Plots (15)	In Total Samples (150)	In Total Plots (5)	In Total Samples (50)
Canary grass	Phalaris arundinacea	73%	37%	60%	28%
Bedstraw	Galium sp.	27	6	100	20
Unidentified Sedge	Carex sp.	20	2	100	16
Softstem bulrush	Scirpus validus	47	22	60	8
Burreed	Sparganium sp.	27	8	60	12
Common skullcap	Scutellaria epilobiifolia	7	1	80	18
Water plantain	Alisma triviale	40	9	40	4
Water smartweed	Polygonum natans	33	9	40	8
Water horehound	Lycopus sp.	13	1	60	16
Mint	Mentha sp.	13	3	40	8
River bulrush	Scirpus fluviatilis	13	8	20	2
Spikerush	Eleocharis sp.	7	4	20	2
Buttercup	Ranunculus sp.	7	1	20	6
Willow	Salix sp.	27	8		
Nut grass	Cyperus sp.	27	5		
Arrowhead	Sagittaria sp.	7	1		
Smartweed	Polygonum lapathifolium	7	3		
Panic grass	Panicum capillare			60	12
Sweet flag	Acorus calamus			20	2
Sticktight	Bidens cernua			20	2
Reed grass	Phragmites communis			20	2
Hedge Nettle	Stachys sp.			20	2
Blue flag	Iris sp.			20	6
Blue vervain	Verbena hastata			20	2
Dock	Rumex sp.			20	2

is being transported underground to form the new rhizomes. Herbicides were very effective at Eldorado when applied after pollination was completed and staminate tops were being lost. Openings were created at Eldorado by spraying cattails, but not at Horicon, where the bog mat floated to the surface the following year.

Injury. Early injury to the developing shoot allowed for good recovery, while injuries later in spring resulted in little recovery. When the rhizome was severed, no recovery was apparent at any time.

Cutting. Cutting mature cattails, 8 cm (3 inches) or more below water surfaces, was an effective means of controlling cattails. Control was effective only when residual plant parts as well as green stems were cut. Cattails were not killed when cut ends were exposed to air.

Scraped Openings. Scraping the dried out marsh in winter physically removed old plants and the dormant shoots and rhizomes located within the top (5-10 cm; 2-4 inches) layer of the bog mat. A 90% reduction of cattail stems was achieved by the next summer. This action usually requires water level control.

Fire. Fire provides no actual cattail control because viable plant parts are protected by soil or water, except where the fire burns into the peat layer of a dried out marsh, killing the cattails and deepening the area by consuming the peat.

Drying. Drying reduced the cattail stem density by one-half, and 9 different moist soil species in varying numbers invaded the plot by fall.

Discing. The openings created the following year from the rooting out or injury of cattail stems by discing were soon filled with cattails. Discing during drawdown resulted in reflooded surfaces of the water clogged with flattened tops.

USE OF AREA MARSHES BY WATERFOWL AND MARSHBIRDS

In this section my findings on the use of area marshes by wildlife and the various habitat elements used by a variety of nesting birds are presented first, in order to better evaluate the wildlife use of openings and other habitat changes brought about by attempts to control cattail.

SPRING BIRD COUNTS

Spring bird counts were conducted each year along with breeding pair counts for waterfowl by two observers who simultaneously walked along different portions of a 2 km (3½ mile) transect route at Horicon (Fig. 30). Each year 4 counts were scheduled between 15 and 25 April and a second series of 4 counts between these same dates in May. Counts were not taken in rain, snow or winds over 24 kmph (15 mph). Weather allowed only 7 counts in 1973.

The group of birds in the miscellaneous category did not include some of the other species that were also common to the area. Counting some species was difficult and did not represent the number of birds actually present: e.g. rails (sora, Virgina and king), bitterns (least and American), and the common gallinules, which spent much of their time in heavy cover and were not easily flushed; the very active and mobile terns (black and Forster's), blackbirds (red-winged and yellow-headed) and long-billed marsh wrens; and great egrets, black-crowned night herons and little green herons that occasionally used the area for feeding.

Mallard ducks and Canada geese are early arrivals in the Horicon Area. They will return in February if open water and food are available and leave again if weather conditions shut off these necessities. Many species return in March and after the first two weeks of April both migrant and resident birds are present on the area. Those species that use Horicon from 15 April to 22 May are shown in Table 21.

Sixteen duck species were recorded. The type of shallow marsh found at Horicon is probably better adapted to the needs of the dabblers, and 70% of all ducks seen were in this group. Blue-winged teal were the most common species observed and made up 43% of the entire duck population. Redheads were second in abundance (14%) followed by mallards (11%).

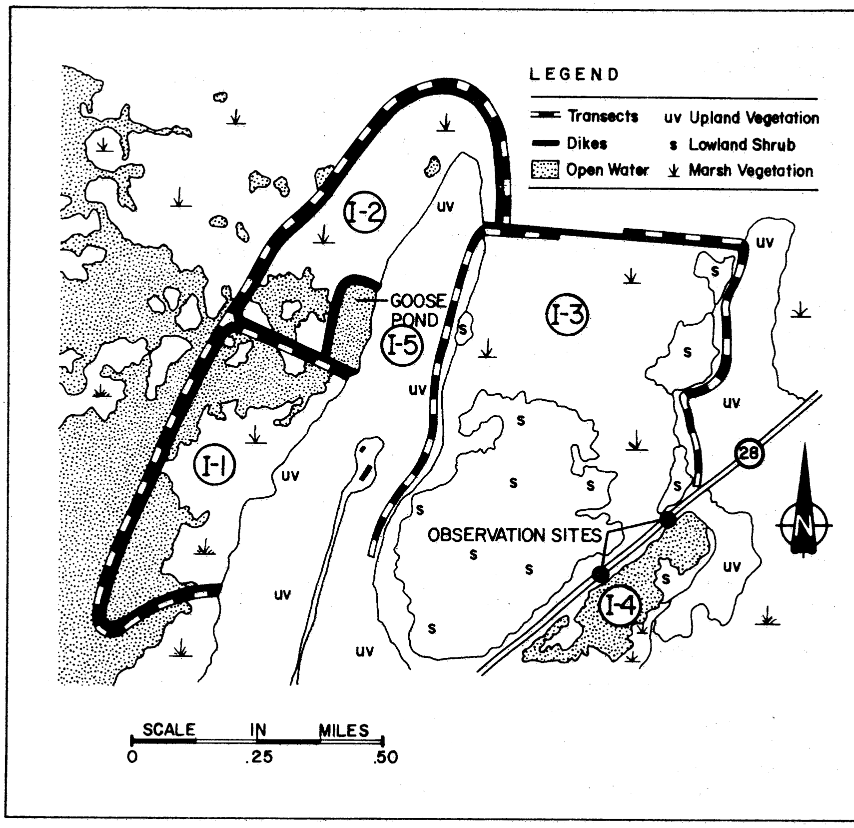

FIGURE 30. *Map of Horicon study area showing bird transect routes.*

NEST SEARCHES

The Horicon subimpoundments, I-1, I-2 and I-3 (Fig. 30), generally represent managed portion of Horicon marsh and were the sites of intensive searches for nests of all kinds. Searches were usually conducted by 4 persons who examined an area of 1.5-1.8 m (5-6 ft) on either side as they waded through the marsh at 3-4 m (10-12 ft) intervals.

On I-1 and I-2, alternate strips of 30 and 60 m (100 and 200 ft) were measured and marked with tall stakes painted a fluorescent orange. The 30 m strips (or 1/3 of the area) were searched for nests. The entire marsh section of I-3 was searched and together with the other impoundments totaled 50.6 ha (125 acres) searched. Nest locations and their association with emergent vegetation were recorded.

Wading the marsh in search of nests was a slow and laborious task and each year only enough manpower was available for one search of the designated areas. Searches were conducted between mid-May and mid-June. The number of nests found must be considered as the minimum present for all species. Late nests or renests would not be present during early searches, and early nests that had either hatched or were already destroyed could easily be unrecognizable in the later stages of nest searching.

For most species, each nest found indicated a laying hen, but this was not true for the long-billed marsh wren. Because of its habit of constructing 2 to 3 extra nests that are not used (Bent 1948) nesting wren populations would not exceed 1/2 to 1/3 of the total wren nests found.

Differences in the structure, placement and concealment of nests and the reaction of the parent birds to the searchers were also factors that influenced visibility and made nests of some species easier to find than others. The nest of the pied-billed grebe was constructed of floating debris and usually placed in openings surrounded by

TABLE 21. *Spring counts of waterfowl and some marsh birds present on the Horicon Study Area**.

	Avg. No. Seen/Count* 1973	1974	1975	1976	4 Year Avg.	Percent of Totals
Dabbling Ducks						
Blue-winged teal	51	78	115	99	86	60
Mallard	18	24	32	17	23	16
Shoveler	11	16	12	3	11	8
Gadwall	13	11	6	4	9	6
Wigeon	4	2	3	19	7	5
Green-winged teal	5	3	7	1	4	3
Wood duck	0	0	2	2	1	1
Pintail	1	1	0	0	1	0
Totals	103	135	167	145	142	100
Diving Ducks						
Redhead	28	19	41	22	28	46
Scaup	16	15	27	5	16	27
Ringneck	3	2	7	26	10	17
Ruddy duck	9	1	1	1	3	5
Bufflehead	2	2	5	0	2	3
Canvasback	3	0	0	0	1	2
Hooded merganser	0	1	0	0	0	0
Common goldeneye	0	0	1	0	0	0
Totals	61	40	82	54	60	100
Miscellaneous						
Canada geese	5	16	8	7	9	
Coot	197	246	115	236	198	
Pied-billed grebe	1	3	3	4	3	
Great blue heron	4	0	2	3	2	

* 7 Counts between 13 Apr 73 and 21 May 73
10 Counts between 15 Apr 74 and 22 May 74
8 Counts between 21 Apr 75 and 22 May 75
8 Counts between 16 Apr 76 and 20 May 76

TABLE 22. *Results of nest searches on 50.6 ha (125 acres) of wet marsh (Horicon, 1974-76).*

Species	Total Nests Found 1974	1975	1976	Avg. Nests/Year	Avg. ha/Nest
Marsh wren	-	142	170	156	0.3
Coot	125	142	117	128	0.4
Red-winged blackbird	-	33	145	89	0.6
Black tern	13	9	20	14	3.6
Pied-bill grebe	9	21	9	13	3.9
Yellow-headed blackbird	-	7	17	12	4.2
Sora rail	18	12	3	11	4.6
Redhead	6	8	6	7	7.2
Mallard	4	8	7	6	8.4
Least bittern	0	3	9	4	12.7
Virginia rail	3	3	2	3	16.9
Blue-winged teal	2	2	2	2	25.3
Common gallinule	1	3	2	2	25.3
American bittern	0	2	1	1	50.6
Canada goose	1	1	0	0.7	76.9
Ruddy duck	1	1	0	0.7	76.9
King rail	0	1	0	0.3	151.8
Totals	183	398	510	363	7.2

much other floating material. The eggs were always covered and departing hens even covered hatching eggs before the arrival of search crews. Unless searchers knew what to look for, these nests were easily overlooked. Coots built fairly large nest structures which were often placed in an area of little residual cover (Fig. 31). Nests of this type were easily seen and most coot nests were probably found. The nest structures of redheads were equally large but were usually well concealed in thick cover and difficult to find. Sora and Virginia rail nests were characterized by small nesting bowls well concealed from all directions. Many rail nests were presumably not discovered.

As searchers approached, most birds left nests quietly without being seen, but parent black terns and some red-winged blackbirds openly harassed the searchers and directed them to nest locations.

Marsh wrens and blackbirds were not counted in 1974. In 1975 blackbird counts were taken only on a portion of the search area.

All of the dabbling duck species recorded in my spring counts are known to nest at Horicon. Of the diving ducks, only the redhead and the ruddy commonly nest in the area and most of the other species continue to nesting grounds farther to the north and west (Table 22). However, in 1976, flightless canvasback young were night-lighted and banded at Horicon showing that occasionally some of these other species do nest in the area.

Over the years Horicon has developed an important population of breeding redheads. Fourteen percent of all of the ducks counted in the spring were redheads and, over the 3 years, one redhead nest was found for each 7.2 ha (18 acres) searched. If similar nest densities occur throughout the marsh, which they seem to do, and assuming that 1/2 to 2/3 of the 12,145 ha marsh is suitable habitat for nesting redheads, a 30% nest success averaging 5 ducklings raised to maturity would produce between 1,250 and 1,700 redheads at Horicon annually.

Based on spring counts, the blue-winged teal was by far the most abundant duck using Horicon. Shallow areas of open water close to uplands attracted and held breeding pairs of teal that nested on the adjoining uplands. Each year 2 teal nests were found in the wet marsh located either on a clump of heavy plant debris or on long-abandoned muskrat houses.

The mallard is usually considered to be an upland nesting bird but is most adaptable and was also found nesting within the wet marsh. Active muskrat houses, the bases of flooded shrubs and the larger clumps of plant debris furnish the usual bases for the placement

FIGURE 31. *Typical early coot nest in area of open residual cover (Horicon, 1974).*

TABLE 23. *Nest placement and vegetation associations (Horicon, 1974-76).*

	Total Nests	Nest Placement Sites*													
		Cattail		Burreed		Sedge		Shrubs		Soft-stem Bulrush		Other		On Muskrat House	
		No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Coot	505	346	69	66	13	40	8	35	7	8	1	10	2	0	0
Redhead	33	30	91	2	6	0	0	1	3	0	0	0	0	0	0
Sora rail	27	12	44	3	11	12	44	0	0	0	0	0	0	0	0
Mallard	24	0	0	0	0	2	8	10	42	0	0	0	0	12	50
Least bittern	21	20	95	0	0	0	0	0	0	1	5	0	0	0	0
Virginia rail	10	3	30	1	10	3	30	0	0	1	10	2	20	0	0
Common gallinule	9	7	78	2	22	0	0	0	0	0	0	0	0	0	0
Blue-winged teal	6	2	40	0	0	0	0	0	0	0	0	0	0	4	60
Canada goose	3	0	0	0	0	0	0	0	0	0	0	0	0	3	100
American bittern	3	3	100	0	0	0	0	0	0	0	0	0	0	0	0
Ruddy duck	2	2	100	0	0	0	0	0	0	0	0	0	0	0	0
King rail	1	0	0	0	0	0	0	0	0	1	100	0	0	0	0
Totals	643	425	66	74	11	57	9	46	7	11	2	12	2	18	3

*Nest placement sites were either solid stands or dominated by the species named.

of nests. One-third to one-half of all mallard nests found at Horicon were within the wet marsh. Mallard nest densities for the three years averaged 1 nest/8.4 ha (1 nest/21 acres) of marsh searched.

Canada goose numbers normally represent only the local nesting adults, but in 1974 also included a small group of subadults that remained together on the area all summer. Geese nested very early in the season and placed their nests on the top of active muskrat houses. Most geese were through nesting before searches began and the remnants of their nests were soon covered by the activities of the muskrats. Five to 6 goose broods were recorded annually during the May bird counts and were considered to be a good estimate of goose production on the area.

Coots were consistently abundant in all years and averaged 2.5 nests/ha (1 nest/acre) over the three years. Spring counts of grebes on Horicon were not directly related to the number of nests eventually found. In 1975, when grebe nests on the area more than doubled, spring counts showed no change from other years.

Black terns nested in small groups or colonies of 3 to 5 pairs and selected open areas where floating debris was generally plentiful. Although one group of terns nested in the same general area each year, others appeared to select different sites annually.

Small but stable nesting populations of Virginia rails, common gallinules, and American bitterns were present each year. Judging from the numbers of nests found, sora rail populations were highest during the first year of reflooding (1974) and declined steadily thereafter. Least bittern populations reacted in an opposite manner and more nests were found in each succeeding year. I have no explanations for these trends.

Based upon the 1976 counts, red-winged blackbirds are probably the most numerous nesting bird throughout Horicon.

If one-third of all wren nests found were considered to be active, the total number of nests for all species would average 7/ha/year. Because these

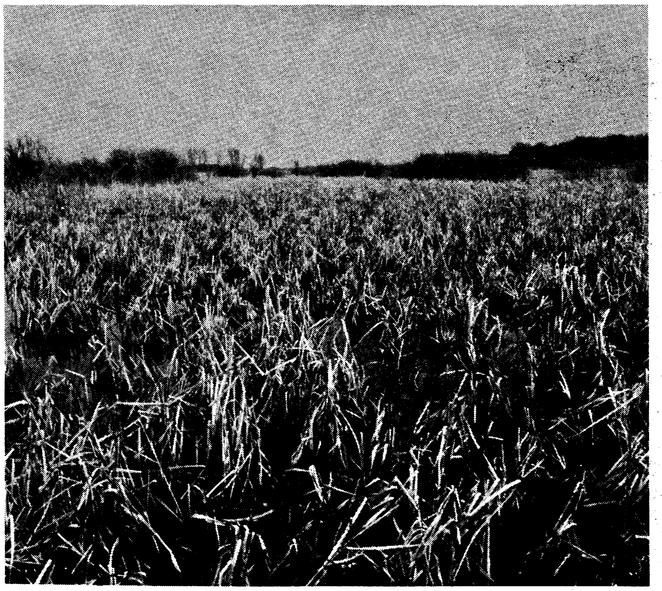

FIGURE 32. *Site of many sora rail nests (Horicon, 1940).*

FIGURE 33. *Openings created by crushing after two years (Horicon, 1975).*

figures are minimal, the actual numbers of nests present could easily average 8 to 10/ha (3 to 4/acre), representing 17 different species.

VEGETATION USED FOR NEST SITES

Black Terns and Pied-billed Grebes. Nests of the black tern and the pied-billed grebe were placed in openings without any apparent association with green plants. They are not included in Table 23 showing the major plant communities and their use as nest sites by the marsh-nesting species on Horicon.

Coots. Coot nests were found in all of the vegetation types in about the same proportion as these types existed on the area. Their use of relatively open cover early in the nesting period made most vegetation types acceptable for nesting as long as residual plant parts for nest building were available. It appeared that the spacing between coot nests was of greater importance than the cover type in which the nest was located.

Redheads. Redheads showed a decided preference for nesting in dense stands of cattail with 90% of all nests in this vegetation type. One nest was built at the base of a flooded shrub clump and two others were built in dense burreed. Redheads showed a preference for dense vegetation and this was best furnished by cattail on Horicon.

Sora and Virginia Rails. Forty-four percent of all sora rail nests were found in cattail communities. However, a similar number were placed on the tops of sedge clumps that were surrounded by water (Fig. 32). This would indicate a strong preference for the sedge clumps since this vegetation type occurred on less than 10% of the study area. The gradual loss of this cover type after reflooding in 1974 could account for the fewer numbers of sora rail nests found in subsequent years.

Virginia rails used cattail and sedges for nesting in the same proportion (30%), but they utilized other vegetative types as well. The flooded sedge clumps apparently were also preferred nest sites for the Virginia rail.

Mallard. Fifty percent of the mallards nesting in the wet marsh used active muskrat houses and another 42% placed their nests at the bases of flooded shrubs. Mallards appeared to require a base for the placement of marsh nests.

Least Bittern. The great majority of bittern nests were located in tall dense cattails. Least bitterns nested later in the season than many of the other birds. By this time cattails had reached their maximum growth and strength. Nest platforms were interwoven between and supported by tall cattail stems and leaves one foot or more above the water surface. One nest was found in softstem bulrush.

Less Abundant Species. The few American bittern and ruddy duck nests found were in monotypic cattails. The common gallinule also preferred dense cattail for its nesting site.

The blue-winged teal, like the mallard, appeared to need a platform of some type when it used the wet marsh for nesting. Old muskrat houses were used four times and dense clods of tipped and floating cattail were used twice.

The only nest of the king rail found at Horicon was studied in a solid stand of softstem bulrush at a time (1975) when only small areas of these plants remained on the study area.

AVIAN USE OF HABITAT CREATED BY CATTAIL CONTROL MEASURES

Crushed Plots

Openings created by crushing cattails provided temporarily usable habitat on plots in all three study areas (Fig. 33). Increased activities by breeding pairs of mallards and blue-winged teal were evident on the 3.3 ha (3.2 acre) experimental site at Eldorado. For the first time, water levels were also apparently high enough to furnish acceptable nesting habitat for coots. Cattails had returned to normal stem densities in 6 plots, leaving 19 crushed openings and 4 narrow sprayed strips on the area. Openings ranged from open water (Fig. 34) to sparse cattail regrowth or isolated mature clumps (Fig. 35).

A search of the area on 14 June revealed that 25 coots and one least bittern used the area for nesting. Six of the coot nests were located within crushed plots, 10 within 6 m (20 ft) of a crushed or sprayed opening, and 4 more than 6 m from an opening. Whether or not coots would have nested in this area if the openings were

FIGURE 34. *Crushed opening with no residual nesting cover (Eldorado, 1973).*

FIGURE 35. *Crushed opening with short residual nesting cover (Eldorado, 1973).*

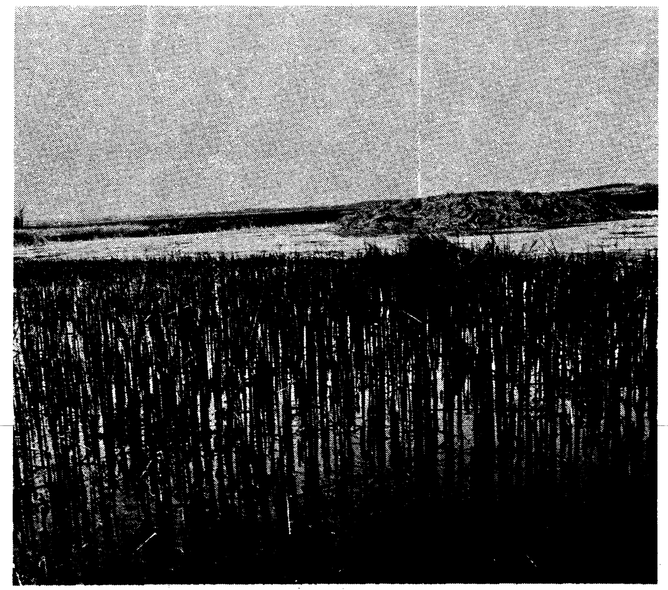

FIGURE 36. *Scraped opening around which the old residual cattail had been burned . . .*

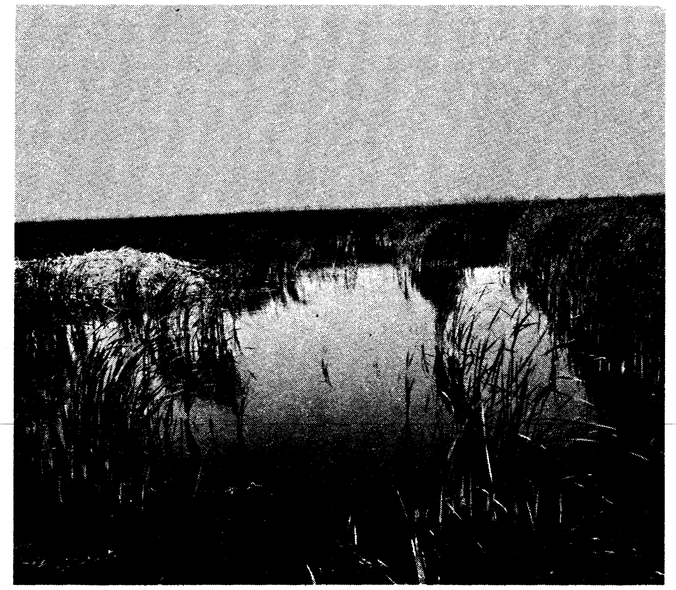

FIGURE 37. . . . *showing new cattail growth in the burned area (Horicon, 1977).*

not present is not known. Their clear preference for nest sites near openings would appear to indicate that the coot population nesting in that part of the marsh would at least have been much smaller if the openings had not been present. The Eldorado nest densities of coots at 7.5/ha (3/acre) were three times greater than those found on Horicon in subsequent years.

When crushed plots at Horicon were covered with shallow water they were used by breeding pairs of blue-winged teal, mallards, shovelers, redheads, ruddies, and coots. Great blue herons, black-crowned night herons and great egrets were frequently seen feeding on the area.

Herbicide Plots

Bird use of openings created by spraying varied with the nature and location of the sprayed plots. Generally, however, openings were used by breeding pairs of ducks and coots and by feeding herons and egrets. The residual cover killed by spraying contained higher nest densities of blackbirds, marsh wrens, rails and coots than were found in the surrounding marsh.

One opening of approximately 1.2 ha (3.2 acres) was different than the others because it began at the marsh edge and included an area of burreed along with the cattail, and a peninsula of living cattail, inadvertently not sprayed, which proceeded from the marsh edge into the middle of the opening.

During the fall of 1973, this opening was used by more than the normal numbers of ducks and geese found in the area; and in the spring and fall of 1974 larger flocks of these waterfowl flew into the opening each morning and evening. Because none of the other sprayed plots were used in this manner, I believe that some food resource had either become available or was being produced in this habitat. The entire study area was protected from hunting and human disturbance, so

TABLE 24. *Nest densities and nest placement found at a 1.2 ha opening created by spraying, Horicon, 1974.*

Bird Species	No. Nests Found Cattail Peninsula	Dead Residual Cover on Sprayed Area	Border of Green Plants Around Sprayed Area	Totals
Red-winged blackbird	1	17	4	22
Yellow-headed blackbird	1	0	0	1
Rails-Virginia and Sora	1	5	0	6
Coots	0	6	1	7
Marsh wren	8	1	8	17
Redhead	0	0	1	1
Totals	11	29	14	54
Mean ha/nest				0.02

this was not a factor.

Searches of the area on 26 and 27 June included the green cattail peninsula, the dead residual cover of the sprayed area and the 6 m (20-foot) section of living plants (burreed and cattail) bordering the opening. The mean of 0.02 ha/nest in this plot was less than the 7.2 ha/nest found on searches made earlier in the season on the surrounding wet marsh (Table 24). The tangled, dead mass of residual cattail that remained one year after spraying was a preferred site for nesting by red-winged blackbirds. Marsh wrens favored the cattail peninsula and the living green cattail adjacent to the sprayed area. Coots and rails used the dead debris of the sprayed opening for nest sites. The 6 rail nests were twice the number found on all of the remaining search strips in this part of the study area (Fig. 30).

Use of Scraped Openings and Burned Areas

The three scraped openings north of the Horicon Study Area were visited on 21 March 1977. The defensive behavior of single pairs of Canada geese on two of the openings strongly indicated that they had already been chosen as nesting sites. A flock of 25 geese were flushed from the third opening.

Old residual cattail had been burned in the area of the scraped openings (Fig. 36). Large numbers of Canada geese were using and continued to use the burned habitat until they resumed their northward migration. The burned areas were also popular feeding areas for herons and egrets after they returned in May.

The mounds of debris present at scraped openings appeared to be excellent nest sites for geese, yet this function was not documented because the openings were not revisited at the right time. In July, however, the droppings from young goslings were plentiful on all three openings showing use by goose broods and strengthening our suspicions that geese had also nested there. Mallards, blue-winged teal, coots, egrets and both heron species were using the openings during the July visit and the calls of young coots were heard constantly from the adjacent cattail. A regrowth of dense, tall cattail in the rest of the burned area (Fig. 37) once again restricted use of this habitat to all but a few species.

During the spring bird counts, the scraped opening was the single most popular area for breeding pairs. This was especially true in May when 4 drake mallards, 3 drake blue-winged teal, 1 drake green-winged teal, a pair of pintails and several coots were consistently counted on this opening.

Sandhill cranes have recently been added to the list of breeding birds at Horicon. A single crane was found at the scraped opening in I-3 and was seen later on another scraped opening north of the Horicon Study Area.

SUMMARY

Study marshes were widely used by a variety of waterfowl and other water and marsh birds as migration and nesting habitat.

Openings created by cattail control measures provided additional temporary habitat for these species.

MANAGEMENT GUIDELINES

FACTORS THAT INFLUENCE CATTAILS

The many factors affecting cattail status in Wisconsin can be divided into four categories, physical, biological, chemical and economic. Some information on these factors is common knowledge, some was acquired from this study and some incidentally, but all of it has a place in the management concept of cattails in Wisconsin marshes.

Physical Factors

Water Levels

Water levels appear to be the single most important factor affecting cattails in Wisconsin. Cattails probably grow best when water levels are relatively stable and water depths range from saturated soils to 45 cm (1.5 ft). Healthy communities are sometimes present in water depths varying between 45-76 cm (1.5-2.5 ft). Once established, cattails can endure periods of dry soils or deep flooding and exist under constantly changing water levels.

Wave Action

Wave action is not a problem on most state-owned marshes. It is a problem, however, in the bays of area lakes where the combination of high water and strong winds often undermine the outer edges of these communities. Portions of the cattail bog are then torn off and float away.

Ice Action

In late winter or early spring, runoff water sometimes gets below winter ice and causes it to float. If plant tops are still held in frozen ice, the plants are either broken off or lifted from the bottom soils. Cattails lifted in this manner will tip and continue to float on water surfaces.

Ice action of this type has only been documented in areas with sparse stem densities.

Bottom Conditions

Cattails will grow when bottom conditions are hard, soft or merely ooze. The thriftier plants are found on soft soils where they are also easier to dislodge by wave and ice action.

Temperatures

Cold temperatures did not affect new cattail shoots even when they exposed and separated from their usual protective cover of ice and snow. In 1977, the Horicon Area experienced record cold for the month of January. Ice was absent on the dewatered marsh and the shallow snow depths offered little protection to new shoots that often protruded above the snow. Cold did not affect these shoots nor did it injure other shoots that were exposed on 4 February when the protective organic debris was scraped away.

Warm nights and hot daytime temperatures during the peak of the growing season resulted in accelerated cattail leaf growth and generally taller plants (Linde et al. 1976). The warm temperatures in 1976 resulted in 3.5 m (11.5 ft) cattails in many areas at Horicon.

Deposition of Organic Materials and Silt

Cattails annually deposit large amounts of organic materials on their own rootstocks. It is readily incorporated into the bog mat and has not been known to deter cattail growth or development.

Chemical Factors

The large size and dominance of cattails in marshes of southeastern Wisconsin indicate that the existing water chemistry parameters of this area (Tables 1 and 2) are near optimum for this northern location. Extensive areas dominated by cattails occur in those regions where soils are most fertile and nutrients in large quantities are available.

Biological Factors

Plant Associations

Cattails are not known to be influenced by crowding, shading or toxic associations of other plants. Rather, cattails often appear to impose at least some of these conditions on other plants, depending on water depth.

When compared to open water areas, total submergent plant densities were much lower under canopies of emergent cattails. When the canopy was thinned by a 50% reduction of cattail stem numbers, submergent plant densities increased significantly (Table 9).

Some of the free floating forms, notably the liverworts (*Riccia fluitans* and *Ricciocarpus natans*) were often present in greater numbers under thin stands of emergent cattails. Arrowheads (*Sagittaria* sp.) and bladderwort (*Utricularia* sp.) were also commonly associated with sparse cattails although they were more luxuriant in open water sites. Although *Potamogeton,* as a group, often grew on open water several meters away, they were seldom present under emergent cattails.

Fish

Carp, buffalo and sheepshead are known to root out and ingest aquatic plants. Before the drawdowns, plant densities on the study areas were inversely related to fish populations (Table 8). The rooting action of fish is often detrimental to cattails located on the edges of bogs where these actions often help to undermine established cattail stands.

Insects

Although insect relationships were not a formal part of this study, a new species of moth was found that, at times, may have a considerable effect upon the overall condition of cattails and their ability to produce viable shoots for the following year.

On 31 July 1973, during the second year of the drawdown, cattails, over a large area of the outside marsh at Horicon, were short with an overall brownish appearance due to dead and dying leaf parts. It was discovered that a moth larva had entered the leaf bundle 30-60 cm (1-2 ft) above the plant base and had eaten its way to the center of the plant and then continued down into the plant base. The center portions of both vegetative and fruiting head plants were eaten before they fully developed and some of the outside leaves were also injured and brown. The larvae, 5-7 mm (1/4 inch) wide and 40-50 mm (3/4 inch) long, left a hole comparable to their width in the center of each plant which was readily apparent when the plant was cut.

By the time this situation was discovered, most larvae had pupated and departed pupal burrows as adults. However, some larvae were collected and preserved in alcohol while others were allowed to develop as adults. Similar specimens were not present in the collections at the University of Wisconsin-Madison and the insect was finally identified as *Leucania scirpicola* by personnel at the National Museum, Washington, D.C.

Cattails infected by these larvae were subsequently found at Sinissippi, Theresa and other Horicon area locations in 1973 and to a lesser extent in 1974 and 1975.

The heaviest infestation by this insect occurred in cattails after surface waters were released or where water levels where substantially lowered. In 1973, normal high water levels were maintained in I-2 just across the dike from the infected cattails on the outside marsh. Cattails in the impoundment were tall and green and no sign of this insect could be found.

University of Wisconsin entomologists did identify several species of parasitic wasps and flies associated with the *Leucania* moth larvae and because of their presence, commented against the possibility of a serious outbreak of this insect.

A few other leaf mining and defoliating insects fed upon cattails. They appeared small in stature and numbers and their activies seemed to influence little more than the local plant part upon which they fed.

Birds

Birds are not known to use any part of the adult cattail for food. On their wintering grounds, blue and snow geese have been reported to grub out and consume cattail rhizomes. However, they are usually present in Wisconsin for only a limited time in fall and spring and then only in relatively small numbers. The Canada goose is abundant in the area in spring and fall. In September it is known to eat small cattail seedlings that have germinated in late summer on exposed mud flats. However, during the drawdown of 1976, geese preferred the seedlings of softstem bulrush and burreed over cattails on the Horicon National Wildlife Refuge (Nisson 1976).

Mammals

Muskrats are the single most important biological factor affecting abundance of Wisconsin cattails. Muskrat-cattail relationships are discussed in more detail in other sections of this report. Where water depths are sufficient to allow muskrats to live in winter, they often maintain an acceptable balance of emergent cattails and open water. Cattails become the greatest problem in shallow areas where muskrats cannot survive the winters.

Cattail seedlings and resprouts produced by control activites at Eldorado were eaten by deer during the summer when most other plants had reached maturity. Except in isolated cases, deer would not be considered a control factor of any importance.

MARSH MANAGEMENT FOR CATTAILS

Management guidelines presented here are directed toward managing cattails with the ulimate goal of providing food and cover conditions for the optimum use by marsh birds, furbearers and waterfowl.

Although field testing of cattail control methods in Wisconsin is by no means complete or conclusive, results obtained during this study together with the results of past efforts, provide some general guidelines.

Each marsh has its own potential for cattail management. This potential is largely controlled by the capability to manipulate water levels at any season of the year. In southeastern Wisconsin, water level manipulation is generally the most important management tool available. Water levels can often determine both submergent and emergent plant succession and the attendant crops of animal life. The ability to manipulate water levels depends primarily upon the available water supply, the size and location of the marsh basin in relation to the surrounding uplands, and the outlet structure. These abilities can be further modified by constructing subimpoundments, pumping facilities and other features within the marsh itself.

The highly manageable marsh has a dependable, all-season water supply, such as a flowing river of adequate volume, and is situated so that drainage is easily and quickly accomplished through an outlet structure. The marsh with little management potential is, for example, the depression that depends primarily upon field runoff for its surface water supply and whose only water release mechanism is percolation, evaporation and transpiration. Between these two extremes lie many possible gradations of flooding and drainage that ultimately determine the manageability of individual marshes. A suggested method of rating the basic management potential of an individual marsh based only on water supply is shown in Table 25.

A fertile marsh with a rating of 62 or above will usually be manageable for bird production while those with ratings below 62 can be expected to have continuous problems with little chance that they will be easily or permanently resolved.

Marsh size also affects management potential. Water levels are generally manipulated with greater ease and efficiency on marshes of 405 ha (1,000 acres) or less. On larger marshes, reflooding or the release of water through hundreds or thousands of acres of wet bog is often a slow and uncertain process.

The management potential of a large marsh is often increased when subimpoundments are constructed. Pumping may then become a realistic method of water level management and the smaller impoundments can be managed independently of each other or the main marsh.

Linde (1969) detailed many of the physical problems associated with the development and maintenance of shallow marshes in Wisconsin and the mechanical options for controlling water levels. This basic information should be consulted by those wishing to develop and manage a wetland.

A comprehensive rating system incorporating all the major variables in marsh management would be a useful tool. It is obvious, for example, that water supply can be compensated for by subimpoundment development. Unfortunately, I was unable in this study to evaluate the impact of inherent or manageable techniques on a broad scale. Clearly, however, this approach needs further investigation.

A fertile marsh (Tables 1,2) whose water levels can be controlled may be divided into 3 zones for practical management considerations. Divisions are best made according to water depths because this factor, more than any other, usually determines the potential problems of each zone as well as the type and intensity of control necessary to resolve them. Water depth zones can be classified as shallow (2.5-30 cm; 1-12 inches), intermediate (30-76 cm; 12-30 inches) and deep (over 76 cm; 30 inches).

Deep Water Zone

Emergent aquatics do not generally occupy the deep water zone and, therefore, are not a problem. However, these plants do invade deep water zones during drawdowns and cattail

TABLE 25. Water supply conditions for rating the management potential of a given marsh.

	Point Value	Point Value of an Individual Marsh
CONDITION OF WATER SUPPLY		
1. Ample at all season	50	
2. Ample through May or June - then uncertain	25	
3. Unreliable at any season	0	
WATER LEVEL CONTROL POTENTIAL		
Condition of Marsh Basin		
1. Gradient allows good natural drainage	25	
2. Gradient allows slow natural drainage	13	
3. No gradient - no natural drainage	0	
Condition of the Outlet Structure		
1. Structure sufficient to release floodwaters rapidly and drain the marsh at any season	25	
2. Structure allows slow release of floodwaters - slow or incomplete drainage of marsh	12	
3. No structure	0	

By choosing the appropriate marsh condition and extending the proper point values, the management potential of a given marsh can be evaluated in a general way.

will remain for several years after reflooding.

Stands of deep-flooded cattails were not known to form dense, restrictive communities but instead appeared to furnish good nest sites for overwater nesting birds and good brood cover for ducks and coots. Muskrats also took advantage of this food supply and quickly took up residence in these areas. Here they impose their own measure of biological control.

Well-established cattail in the deep zone at Sinissippi and Horicon remained for 3 years after reflooding. However, stem densities declined by one-half after the second year.

Although cattail in this zone usually benefited wildlife production, it may become a problem in shallow lakes by restricting boating and other activites deemed more important by people living in the area.

Unwanted cattail in the deep zone can be controlled by aquatic nuisance control permit only or by mechanical means. Dowpon at 22.5 kg/ha (20 lb/acre) was an effective herbicide spray used to kill deep-flooded cattail at Sinissippi in 1975. Mechanical weed cutters (Fig. 38) have also been effective when cattail stems are cut well below water surfaces and plants are cut after they have completed their growth for the year (usually late July).

In the initiation of new flowages, careful water level management will prevent the formation of dense cattail stands.

Intermediate Zone

Water Levels

The intermediate zone is typified by water depths of 30-76 cm. It was usually favored for nesting by redheads, ruddy ducks, coots, gallinules, grebes, bitterns, geese, yellow-headed blackbirds and terns. Large numbers of long-billed marsh wrens also nested in the intermediate shallow zones. If bird production is the goal, it is probably the most important zone in southeastern Wisconsin. Although the amount of area in this zone is primarily dependent on bottom contours, water levels should be managed so that the largest area of marsh lies within this range of depths.

Ideally, the manager should strive to maintain an interspersion of small, irregular-shaped areas of open water and cattails and/or other emergent aquatics. An overall ratio of 50:50 for this combination should provide adequate nest sites and feeding areas required by a large variety of nesting birds and their offspring.

In the deeper water of this zone (60-76 cm), it appears that only a few of the best-adapted cattail ecotypes can survive constant flooding. Established cattails were generaly eliminated at Sinissippi and Horicon after 3 years of flooding at these depths. Mathiak (1971) also attributed the elimination of established cattail to high water and muskrats in similar water depths after an earlier drawdown at Horicon and Fox Lake.

Weller (1975) showed the greater vulnerability of cattail in deeper water by demonstrating that the ratio of new shoots to stalks was inversely related to water depths for both *T. latifolia* and the hybrid *T.* x *glauca*. He found that new shoots of *T.* x *glauca* merely replaced old stalks in water depths of 38-51 cm (15-20 inches) while the shoot: stalk ratio (2.2:1) was much greater in water depths of 2.5-15 cm (1-6 inches).

Fluctuating water levels have been used to keep marshes attractive and

FIGURE 38. *Weedcutter cutting flooded cattails (Sinissippi, 7 August 1974).*

productive. In the past 10 years, Horicon, Theresa, Sinissippi, Beaver Dam Lake and Fox Lake have all undergone partial drawdowns, and in each case, a similar pattern of water bird response was recorded. Each of these wetlands attracted and maintained increased numbers of birds during the first year of reflooding. Populations were still noticeably above predrawdown levels in the second year of flooding. In subsequent years, however, each area seemed to become less attractive and populations apparently became more stable but at a lower level.

Muskrats

The deeper water areas of this zone will usually allow habitation by muskrats at all seasons while keeping the rootstocks of emerged plants exposed and available to these animals. Although many factors govern the thickness of marsh ice, the shallowest water areas are most like to freeze to the bottom and exclude muskrat activites for several months.

A study of muskrats on Horicon Marsh resulted in recommendations to insure the adequate, annual harvest of this animal (Mathiak 1966). If sufficient muskrats are not harvested, lower water levels in winter may be the only means of reducing populations and preventing an eventual eat-out of the emergent vegetation. During a muskrat population high, however, this would not be practical for runner muskrats would move into adjacent towns and countryside creating major public relations problems.

Mechanical Cattail Control

When sufficient cattail control cannot be obtained by manipulating water levels, other types of control are sometimes required. However, many of the control methods used in this study were not fully adaptable to the intermediate zone because the specialized wheel or track equipment was unable to function in the deep water sections and the floating weed cutters were excluded from the shallow portions.

A special marsh ditching machine, called the "cookie cutter," has been used to successfully cut ditches through overgrown cattails and other vegetation in several Canadian provinces (Ducks Unlimited 1977). The machine, which is actually a floating barge with rotary cutters, warrants testing in Wisconsin marshes.

Cutting Cattail Stems Below the Water

This method can also be used successfully in the intermediate zone. Martin et al. (1957) in Tennessee and Maryland, and Nelson and Dietz (1966) in Utah showed the value of cutting stems under water when at least 7 cm (3 inches) of water was retained over the stubble. The original stems were cut in July and resprouts were cut later when they were 60 cm (2 ft) high.

In Wisconsin, only one cut appeared necessary when the following guidelines were followed: (1) cut original stems after all leaf growth is completed (late July); (2) cut all stems, current or residual, as low to the ground as possible; and (3) retain at least several inches of surface water over the cut stubble throughout the next growing season. When these conditions were met on experimental plots, resprouts grew only within 30 cm (1 ft) of plot edges and were apparently produced by cattails situated outside of plot borders.

Cattails are apparently killed by this method because the air supply to the roots is shut off. Cutting cattail stems underwater appears effective throughout late summer and fall.

Cutting Cattail on Ice

Although this method was not tested in Wisconsin, it appears to be relatively inexpensive and effective and is worthy of greater trial when requirements can be met. Control is achieved in the same manner as cutting stems underwater which stops the passage of air to the roots.

Linde (1969) reported that a landowner in northeast Wisconsin successfully controlled cattail when he mowed them on winter ice after which spring floodwaters covered the stubble. An attempt by the same individual on another marsh area was unsuccessful the following year, but water levels were low and the stubble could not be covered. Weller (1975) found that this method was successful in Iowa when 18 cm (7 inches) of water was maintained over the cut stubble during the following spring and summer.

Cutting on ice appears to be especially adapted to marshes where water levels are easily manipulated and could be lowered in fall to anticipate these activities and then maintained at a higher level to cover the stubble.

Crushing

Crushing can be an important and successful method of cattail control in the intermediate zone if large specialized equipment is available. The alternative is crushing by more conventional equipment after a full or partial drawdown. In either case, the eventual success of this method will largely depend upon whether or not a cover of surface water can be maintained following the crushing.

Crushing should be timed to the period of lowest TNC storage whenever possible.

Herbicide Sprays

There are several problems attendant upon the use of herbicides in this zone. Power sprayers are feasible for small areas providing this equipment can be mounted on a vehicle capable of moving through the marsh.

Cattail stems killed by herbicides remain upright during the year after spraying, and dead rootstocks float and fill open water areas at Horicon. Crushing appears to be the better way of controlling cattail in this zone.

The Shallow Zone

The shallow zone, characterized by water depths of 2.5-30 cm, is a favorite nesting habitat for red-winged blackbirds and Virginia and sora rails. Dabbling ducks are attracted to this zone at all seasons providing it is free of restrictive emergent plants. However, it is not the nature of this zone to be without emergent plants and in southeastern Wisconsin, succession tends toward dense stands of cattail that restrict entry by most birds. Habitat of this kind can be made usable by creating and maintaining openings from the shoreline to the intermediate zone of the marsh. Openings, 20 m (66 ft) wide at the base, interspersed with 75-100 m (246-328 ft) strips of cattails, will provide food and nest sites for a large variety of waterfowl and marsh birds.

Cattail control efforts in this zone will be less permanent. Seeds of many plants, including cattail, are constantly ready to germinate at the shoreline or on other bare, exposed soils. Water depths are optimum for cattail growth and shoot production (Weller 1975) and muskrats are generally excluded from shallow areas that freeze to the bottom in winter. Water levels are less dependable in the shallow zone of most wetlands for use as an accessory control factor following mechanical control.

Advantages are that specialized equipment like the ATV can probably move freely throughout the zone at normal water depths and that more conventional equipment may be used when water levels are lowered.

Mechanical Control

Crushing or flattening the tops of adult cattail creates openings. If repeated annually, these openings can be maintained and the adult cattail eventually destroyed. Crushing alone may not cause physical injury to cattail rootstocks. Whenever possible, however, crushing should be timed to the low period of carbohydrate storage in cattail rhizomes for best control.

Action of this type disturbs the marsh soils and creates greater potential for seed germination. With the right kind of vehicle, crushing can be accomplished by the tracks or wheels of the machine without a special crushing device. This method is inexpensive and fast, and is suggested for further trial.

Herbicide Sprays

Herbicide sprays used in this zone have been effective for at least 3 years. To take full advantage of this period, however, the stems should be flattened soon after they are dead. When stems remain upright, although good nesting habitat is provided for small marsh birds, waterfowl use will be severely restricted for more than a year. Cattail seedlings were not a problem on sprayed plots covered by dead cattail debris.

Creating Permanent Openings

Deep water holes or ponds have been created in the shallow zone by explosives (Mathiak 1965, Nelson and Dietz 1966), peat burns, dredging and bulldozing (Linde 1969). These activities have created permanent openings in the cattails whenever water depths of 76 cm (30 inches) and over are maintained. Similar areas of permanent open water can be created in the shallow zone by removing soil from strips where openings are desired. Soil removal should begin at the marsh edge and proceed to the intermediate zone, creating a strip, 20 m (66 ft) wide at the base, with gently sloping sides and a maximum water depth of 122 cm (4 ft) (Fig. 39).

The arrangement would accomodate puddle ducks whose breeding pairs prefer marsh edges close to their upland nesting sites and whose broods frequent shallow edges populated by scattered emergents.The sloping edges, sure to be populated by emergent aquatics in varrying degrees, should provide potential nest sites for diving ducks, coots, rails and gallinules. If free of carp the deeper open water area should support submergent plants and invertebrates required by waterfowl broods. Permanent deep water would also insure the winter survival of muskrats in these areas, resulting in larger overall populations.

Present state law prevents the deposit of soils upon or within established wetlands. Excavated soils from creating deeper openings should be deposited in the most practical and legal way.

A late summer or fall drawdown of 30-60 cm (1-2 ft) would expedite the creation of openings by exposing soils and making digging easier. After soil surfaces have frozen solid, soils can be excavated by dragline and trucked to a site above the high water line. Excavated soils deposited on uplands should be spread evenly and seeded in spring to recommended grasses.

Other permanent openings can be dug along the marsh edge in the shallow zone. Here the dragline could deposit the excavated soils directly upon the uplands to spread and seed in the spring. In southeastern Wisconsin these openings would attract mainly puddle ducks that tend to nest on uplands close to water. Openings of this kind would be most productive when they are close to blocks of good upland nesting cover. They should not be placed adjacent to uplands that are used for agriculture.

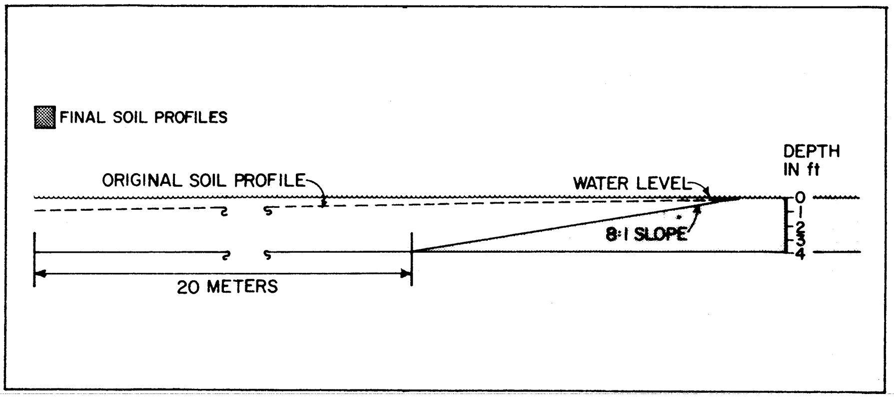

FIGURE 39. *Profile of permanent opening dug in the shallow zone.*

Contoured Bottoms of Projected Marshes

If an area is to be impounded for aquatic wildlife and is not yet flooded, bottom soils could be rearranged or contoured without violating existing laws. The end result could provide a natural interspersion of open water, cattails and other emergent plants that could be highly productive for many years with little additional management cost or effort.

An experimental approach to test bottom contouring at the 2 ft level would include the deepening of channels 10-20 m (33-66 ft) wide at their bases to 90-122 cm (3-4 ft) deep when flooded. Soils removed from these channels would be pushed to either side to form paralleling ridges of shallow water (15-30 cm; 6-12 inches) and the two would be connected by gently sloping sides (Fig. 40). Deepened channels should connect with the river system flowing through the marsh or end at the outlet structure so they can drain and fill freely when water levels are manipulated.

When flooded, the channels would remain as open water, and established cattail would dominate the higher ridges and the shallower portions of the slopes. Emergent plants would diminish in numbers as water depths on the slopes increased. Eventually, these plants would be controlled to a great extent by the muskrat population and annual harvests of these animals would be required to maintain the proper balance between the two.

Winter drawdowns should eliminate carp and, when necessary, reduce muskrat populations to protect existing emergent plants. Summer drawdowns would allow seedling germination and establishment of new crops of emergent plants whenever they were desired. Flooding above normal levels would expand the available muskrat habitat and allow greater access to existing emergent plants. These conditions could be reversed by holding water levels below normal depths. The extent, timing and duration of water level manipulations would depend upon the goals of the manager.

The example of contouring at the 60 cm (2 ft) level can be modified in many ways. It is also usable, with modifications, in the shallow and deep marsh zones to create edges and interspersion.

Contoured marsh bottoms are recommended for trial in southeastern Wisconsin to determine the degree of erosion that could take place as well as their potential to produce a variety of birds and mammals.

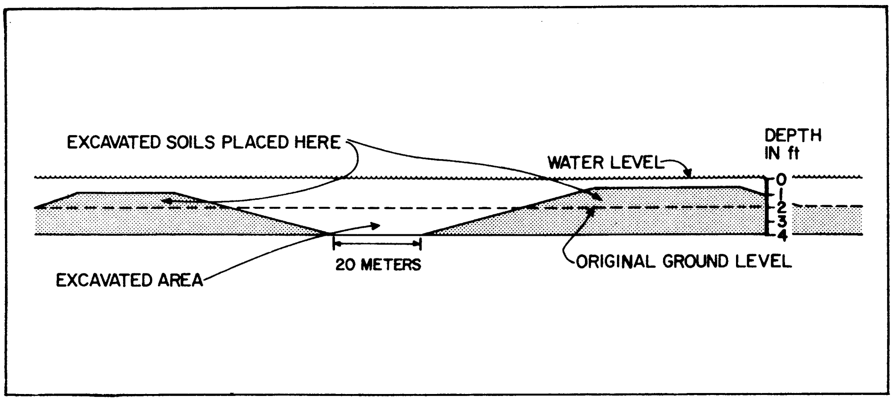

FIGURE 40. *Profile of contoured bottom in the intermediate zone.*

Equipment

Programs of marsh management have been severely limited in the past because specialized equipment adapted for working in this environment was not available. The lack of equipment also prevented the testing of many potential methods of cattail control. Nevertheless, large tracked or wheeled equipment that is used elsewhere and appears well adapted to work in Wisconsin marshes is manufactured by Quality Marsh Equipment Co., Inc., Thibodaux, Louisiana 70301 and Rolligon Corporation, Box 36265, Houston, Texas 77036. Equipment such as the "cookie cutter" (Ducks Unlimited 1977) also warrants additional testing.

Equipment of this kind could be invaluable to create and maintain the desired habitat in the problem marshes of southeastern Wisconsin.

Costs

Cost figures for control practices are not included, for cost accounting was not an objective of the study. Our main power source, the Busse ATV, is no longer being manufactured and will, therefore, not be available in the future. Much larger equipment will be necessary for practical programs of cattail control, and the proper equipment must be selected before costs can be figured.

Marsh managers should first determine the types of improvements that are desired and then determine costs by applying benefit/cost ratios.

Demonstration Areas

The next step in cattail managment is the establishment of experimental development sites. These should be evaluated and monitored for more widespread application.

SUMMARY

Factors that affect cattail status in Wisconsin include physical (water levels, wave action, ice action, bottom conditions, temperature, deposition of organic materials and silt), chemical and biological factors (plant associations, fish, insects, birds, mammals).

Management guidelines are directed toward controlling cattails with the ultimate goal of providing food and cover conditions for optimum production of marsh wildlife. In southeastern Wisconsin water manipulation is generally the most important management tool for cattail management available. The highly manageable marsh must have a dependable, all-season water supply, and be situated so that drainage is easily and quickly accomplished through an outlet structure.

Management guidelines for cattail control are presented for three zones of water depths: deep water (herbicides, cutting); intermediate (cutting stems below the water on ice, crushing); and shallow (crushing, applying herbicides, creating openings, bottom contouring).

LITERATURE CITED

ADDY, C. E. AND L. G. MACNAMARA
1948. Waterfowl management on small areas. Wildl. Manage. Inst., Washington, D. C. 80 pp.

BEDISH, J. W.
1967. Cattail moisture requirements and their significance to marsh management. Am. Midl. Nat. 78:288-300.

BEDFORD, BARBARA L., ELIZABETH H. ZIMMERMAN AND JAMES H. ZIMMERMAN
1974. The wetlands of Dane County, Wisconsin. Dep. Nat. Resour., Madison, Wis. 581 pp.

BELONGER, BRIAN J.
1969. Aquatic plant survey of major lakes in the Fox River (Illinois) Watershed. Wis. Dep. Nat. Resour. Res. Rep. No. 39. 62 pp.

BENT, A. C.
1948. Life histories of North American nuthatches, wrens, thrashers and their allies. Smithsonian Inst., Washington, D.C., U.S. Mus. Bull. 195.

CURTIS, J. T.
1959. The vegetation of Wisconsin. Univ. Wis. Press, Madison. 657 pp.

DUCKS UNLIMITED
1977. Construction 1976: A prediction come true. Ducks Unlimited 41(1):45.

GATES, JOHN M. AND JAMES B. HALE
1974. Seasonal movement, winter habitat use, and population distribution of an east central Wisconsin pheasant population. Wis. Dep. Nat. Resour. Tech. Bull. No. 76. 55 pp.

GUSTAFSON, T. D.
1976. Production, photosynthesis, and the storage and utilization of reserves in a natural stand of *Typha latifolia* L. PhD Thesis, Univ. Wis., Madison. 102 pp.

HEATH, R. G. AND C. R. LEWIS
1957. Aerial control of cattail with Radapon. The Dow Chemical Co., Midland, Mich. Down to Earth, Winter 1957.

HOTCHKISS, N., AND H. L. DOZIER
1949. Taxonomy and distribution of North American cattails. Am. Midl. Nat. 41:237-254.

JAHN, L. R. AND J. B. MOYLE
1964. Plants on parade. *In* Waterfowl tomorrow, U.S.D.I., Washington, D. C. pp. 293-304.

JESSEN, R. AND R. LOUND
1962. An evaluation of a survey technique for submerged aquatic plants. Minn. Dep. Conserv. Game Invest. Rep. No. 6.

KABAT, CYRIL
1972. A capsule history of Wisconsin wetlands, Wis. Dep. Nat. Resour. 6 pp.

KERNEN, L. T., R. J. POFF AND C. W. THREINEN
1965. Surface water resources of Dodge County. Wis. Dep. Nat. Resour., Madison, 63 pp.

KLOPATEC, J. M.
1974. Production of emergent macrophytes and their role in mineral cycling within a freshwater marsh. M. S. Thesis, Univ. Wis.-Milwaukee.

LINDE, A. F.
1963. Results of the 1962 Horicon marsh drawdown. Wetland Habitat Research, Ann. Prog. Rep. Job III B. Wis. Conserv. Dep., Madison.

1969. Techniques of wetland management, Wis. Dep. Nat. Resour. Res. Rep. 45. 156 pp.

LINDE, ARLYN F., THOMAS JANISCH AND DALE SMITH
1976. Cattail-the significance of its growth, phenology and carbohydrate storage to its control and management. Wis. Dep. Nat. Resour. Tech. Bull. No. 94. 27 pp.

MARTIN, A. C., R. C. ERICKSON AND J. H. STEENIS
1957. Improving duck marshes by weed control. U.S. Fish and Wildl. Serv. Circ. No. 19, 60 pp.

MATHIAK, H. A.
1965. Pothole blasting for wildlife. Publ. 352, Wis. Conserv. Dep., Pub. 352. 31 pp.

1966. Muskrat population studies at Horicon Marsh, Wisconsin. Wis. Conserv. Dep. Tech. Bull No. 36. 56 pp.

1971. Observations on changes in the status of cattails at Horicon Marsh, Wisconsin. Wis. Dep. Nat. Resour. Res. Rep. 66. 16 pp.

MC NAUGHTON, S. J.
1966. Ecotype function in the *Typha* community type. Ecol. Monog. 36:297-324.

MODLIN, RICHARD F.
1970. Aquatic plant survey of Milwaukee River Watershed Lakes. Wis. Dep. Nat. Resour. Res. Rep. 52. 45 pp.

NELSON, N. F. AND R. H. DIETZ
1966. Cattail control methods in Utah. Dep. Fish and Game. Pub. No. 66-2. 33 pp.

NISSON, JAMES
1976. Results of the 1976 mud-flat evaluation. U.S. Fish and Wildl. Serv. Unpub. rep. filed Horicon Nat. Wildl. Refuge. Horicon, Wis. 6 pp.

PETERSEN, L. R., J. COLE AND J. R. MARCH
1978. Documentation of recent wetland losses in the better waterfowl production regions of Wisconsin. Unpub. memo filed Wis. Dep. Nat. Resour., Madison, 6 pp.

POFF, RONALD
1961. Ionic composition of Wisconsin lake waters. Fish Manage. Div., Wis. Conserv. Dep. Misc. Rep. No. 4.

PRIEGEL, G. R.
1974. Warm water fish. *In* Evaluation of Rock River chemical reclamation program. Wis. Dep. Nat. Resour. (in prep.).

SIFTON, H. B.
1959. The germination of light sensitive seeds of *Typha latifolia.* Can. J. Bot. 37:719-739.

SMITH, S. G.
1962. Natural hybridization among five species of cattail. Am. J. Bot. 49:678.

STEENIS, J. H., L. P. SMITH, AND H. P. COFER
1959. Studies on cattail management in the Northeast. Trans. Northeast Wildl. Conf. 10:149-155.

WEBER, J. J., P. T. SCHULTZ, L. KERNEN AND C. W. THREINEN
1969. Surface water resources of Fond du Lac County. Wis. Dep. Nat. Resour., Madison, 85 pp.

WELLER, M. W.
1975. Studies of cattail in relation to management for marsh wildlife. Iowa State J. Res. 49(4):383-412.

TECHNICAL BULLETINS (1973-79)

No. 61 Overwinter drawdown: impact on the aquatic vegetation in Murphy Flowage, Wisconsin. (1973) Thomas D. Beard

No. 62* Eutrophication control: nutrient inactivation by chemical precipitation at Horseshoe Lake, Wisconsin. (1973) James O. Peterson, J. Peter Wall, Thomas L. Wirth and Stephen M. Born

No. 63 Drain oil disposal in Wisconsin. (1973) Ronald O. Ostrander and Stanton J. Kleinert

No. 64 The prairie chicken in Wisconsin. (1973) Frederick and Frances Hamerstrom

No. 65 Production, food and harvest of trout in Nebish Lake, Wisconsin. (1973) Oscar M. Brynildson and James Kempinger

No. 66 Dilutional pumping at Snake Lake, Wisconsin: a potential renewal technique for small eutrophic lakes. (1973) Stephen M. Born, Thomas L. Wirth, James O. Peterson, J. Peter Wall and David A. Stephenson

No. 67 Lake sturgeon management on the Menominee River. (1973) Gordon R. Priegel

No. 68 Breeding duck populations and habitat in Wisconsin. (1973) James R. March, Gerald F. Martz and Richard A. Hunt

No. 69 An experimental introduction of coho salmon into a landlocked lake in northern Wisconsin. (1973) Eddie L. Avery

No. 70 Gray partridge ecology in southeast-central Wisconsin. (1973) John M. Gates

No. 71* Restoring the recreational potential of small impoundments: the Marion Millpond experience. (1973) Stephen M. Born, Thomas L. Wirth, Edmund M. Brick and James O. Peterson

No. 72 Mortality of radio-tagged pheasants on the Waterloo Wildlife Area. (1973) Robert T. Dumke and Charles M. Pils

No. 73 Electrofishing boats: improved designs and operation guidelines to increase the effectiveness of boom shockers. (1973) Donald W. Novotny and Gordon R. Priegel

No. 74 Surveys of toxic metals in Wisconsin. (1974) John G. Konrad, Stanton J. Kleinert, Paul E. Degurse and J. Ruhland.

No. 75 Survey of lake rehabilitation techniques and experiences. (1974) Russell C. Dunst, Stephen M. Born, Paul D. Uttormark, Stephen A. Smith, Stanley A. Nichols, James O. Peterson, Douglas R. Knauer, Steven L. Serns, Donald R. Winter andd Thomas L. Wirth

No. 76 Seasonal movement, winter habitat use, and population distribution of an east central Wisconsin pheasant population. (1974) John M. Gates and James B. Hale

No. 77* Mechanical and habitat manipulation for aquatic plant management. (1974) Stanley A. Nichols

No. 78 Hydrogeologic evaluation of solid waste disposal in south central Wisconsin. (1974) Alexander Zaporozec

No. 79 Effects of stocking northern pike in Murphy Flowage. (1974) Howard E. Snow

No. 80 Impact of state land ownership on local economy in Wisconsin. (1974) Melville H. Cohee

No. 81 Influence of organic pollution on the density and production of trout in a Wisconsin stream. (1975) Oscar M. Brynildson and John W. Mason

No. 82 Annual production by brook trout in Lawrence Creek during eleven successive years. (1974) Robert L. Hunt

No. 83 Lake sturgeon harvest, growth, and recruitment in Lake Winnebago, Wisconsin. (1975) Gordon R. Priegel and Thomas L. Wirth

No. 84 Estimate of abundance, harvest and exploitation of the fish population of Escanaba Lake, Wisconsin, 1946-69. (1975) James J. Kempinger, Warren S. Churchill, Gordon R. Priegel and Lyle M. Christenson

No. 85 Reproduction of an east central Wisconsin pheasant population. (1975) John M. Gates and James B. Hale

No. 86 Characteristics of a northern pike spawning population. (1975) Gordon R. Priegel and David C. Krohn

No. 87 Aeration as a lake management technique. (1975) S. A. Smith, D. R. Knauer and T. L. Wirth

No. 88* Guidelines for the application of wastewater sludge to agricultural land in Wisconsin. (1975) Dennis R. Kenney, Kwang W. Lee and Leo M. Walsh

No. 89* Aquatic insects of Wisconsin. (1975) William L. Hilsenhoff

No. 90* The presettlement vegetation of Columbia County, Wisconsin in the 1830's. (1976) William Tans

No. 91 Wisconsin's participation in the river basin commissions. (1975) Rahim Oghalai and Mary Mullen

No. 92* Endangred and threatened vascular plants in Wisconsin. (1976) Robert H. Read

No. 93 Population and biomass estimates of fishes in Lake Wingra. (1976) Warren S. Churchill

No. 94 Cattail—the significance of its growth, phenology, and carbohydrate storage to its control and management. (1976) Arlyn F. Linde, Thomas Janisch and Dale Smith

No. 95 Recreational use of small streams in Wisconsin. (1976) Richard A. Kalnicky

No. 96 Northern pike production in managed spawning and rearing marshes. (1977) Don M. Fago

No. 97 Water quality effects of potential urban best management practices: a literature review. (1977) Gary L. Oberts

No. 98 Effects of hydraulic dredging on the ecology of native trout populations in Wisconsin spring ponds. (1977) Robert F. Carline and Oscar M. Brynildson

No. 99 Effectsof destratification and aeration of a lake on the distribution of planktonic Crustacea, yellow perch, and trout. (1977) Oscar M. Brynildson and Steven L. Serns

No. 100 Use of arthropods to evaluate water quality of streams. (1977) William L. Hilsenhoff

No. 101 Impact upon local property taxes of acquisitions within the St. Croix River State Forest in Burnett and Polk Counties. (1977) Monroe H. Rosner

No. 102 Scientific Areas in Wisconsin. (1977) Clifford E. Germain, William E. Tans, and Robert H. Read

No. 103 A 15-year study of the harvest, exploitation, and mortality of fishes in Murphy Flowage, Wisconsin. (1978) Howard E. Snow

No. 104 Changes in population density, growth and harvest of northern pike in Escanaba Lake after implementation of a 22-inch size limit. (1978) James J. Kempinger and Robert F. Carline

No. 105 Population dynamics, predator-prey relationships and management of the red fox in Wisconsin. (1978) Charles M. Pils and Mark A. Martin

No. 106 Mallard population and harvest dynamics in Wisconsin. (1978) James R. March and Richard A. Hunt

No. 107 Lake Sturgeon Populations, Growth and Exploitation. (1978) Gordon R. Priegel and Thomas L. Wirth

No. 108 Brood Characteristics and Summer Habitats of Ruffed Grouse in Central Wisconsin. (1978) John F. Kubisiak

No. 109 Seston characterization of major Wisconsin rivers (slime survey). (1978) Joseph R. Ball and David W. Marshall

No. 110 The influence of chemical reclamation on a small brown trout stream in southwestern Wisconsin. (1978) Eddie L. Avery

No. 111 Ecology of great horned owls and red-tailed hawks in southeastern Wisconsin. (1979) LeRoy Peterson

---

*Out of print—Loan copies available upon request from Mrs. Sandra Farr, Bureau of Research, Department of Natural Resources, Box 7921, Madison, Wisconsin 53707. (608) 266-7012.

Complete list of all technical bulletins in the series available from the Department of Natural Resources, Box 7921, Madison, Wisconsin 53707.

About the Author

John Beule has been a research biologist for DNR from March 1968 until his retirement in May 1978. His work concentrated on developing techniques to control cattail and establish upland duck nesting cover on state-owned wildlife management areas.

Acknowledgments

The completion of this study represents the efforts and cooperation of many people for many years.

The original study design and techniques were conceived by Arlyn F. Linde and focussed on determining the best techniques for controlling cattail. He directed all operations until July, 1972 when he left the project. The scope of the project was later broadened to include other aspects of marsh management involving cattails.

Thomas Janisch was an outstanding project assistant from 1972 through 1975. His replacement, Lawrence E. Vine, capably assisted during the last year of the study. Much of the credit for the success of this study must also be shared with the numerous seasonal assistants and summer interns who assisted with the various field investigations. I am particularly indebted to Joseph Haug, the late Gary Scharf, John Christian, John Lacenski, Gary Zimmer, Robert Trudeau, Gary Miller, Richard Kahl, Blaise Chanson, Jan Salick, Scott Christe, Norman Weiland and Stanley Skutek who contributed long hours of field work. Their enthusiasm was a continuous source of pleasure.

Wildlife managers James Bell, Armin Schwengel, Jerome Rieckhoff and Gary Jolin and their assistants, Duane Ketter, Walter Eickstedt and Duane Behn furnished needed equipment and never failed to include physical assistance whenever it was requested.

I am especially grateful to James Hale and Richard Hunt for their support and supervision of this study, and to C. Kabat, James March and Donald Thompson for their critical review of this manuscript. William Wheeler and James March provided suggestions during the course of the work that improved the collection and handling of data.

This study was financed by the Wisconsin Department of Natural Resources through the Federal Aid to Wildlife Restoration Act under Pittman-Robertson Project W-141-R.

Cover sketch by Doris Rusch, from "Wisconsin Wetlands", University of Wisconsin-Extension.

PRODUCTION CREDITS

Ruth L. Hine, Editor
Sheryl S. Smith and Anne G. Chacon, Copy Editors
Richard G. Burton, Graphic Artist

2500—3J03003—79