OVERWINTER DRAWDOWN

Impact on the Aquatic Vegetation in Murphy Flowage, Wisconsin

Technical Bulletin No. 61
DEPARTMENT OF NATURAL RESOURCES
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ABSTRACT

A lowering of the water level on Murphy Flowage during the winters of 1967-68 and 1968-69 resulted in a significant reduction in the relative abundance and acreage of aquatic vegetation. Before the drawdown approximately 75 acres (42% of the flowage) were covered by plants to the extent that fishing was almost impossible in these areas from June through the summer. After two overwinter drawdowns 60 of the 75 acres was still open to fishing.

Five of the six species in greatest dominance before the drawdown were most affected, and these five species showed a reduction of 187.3 acres after two drawdowns.

The last section deals with items that should be considered by management personnel in the use of an overwinter drawdown to control aquatic vegetation.

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By

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INTRODUCTION

Dense growths of aquatic plants are a problem in many shallow flowages and natural lakes in northern Wisconsin. In some waters the growth of vegetation hinders fishing, swimming, boating and other forms of public recreation.

A number of control methods for aquatic plants are now being practiced throughout the country, the most common being the use of aquatic herbicides. Lueschow (1972) discusses the use of four aquatic herbicides, 2,4-D, Silvex, Diquat and Aquathol, and their effectiveness in controlling certain species of aquatic vegetation. Mechanical control of aquatic vegetation is becoming more practical with the development of more efficient commercial cutting equipment. But, both of these methods are an expensive and temporary cure for control of aquatic plants and must be repeated periodically for complete control.

Biological control has been proposed by a number of authors: Mathis (1966) found that Israeli carp, along with an overwinter drawdown, were successful in controlling *Elodea, Ceratophyllum, Polygonum, Nitella* and *Chara;* Avault (1965) used the grass carp to control *Najas guadalupensis, Potamogeton diversifolius, Elodea densa, Chara* spp., *Spirodela polyrhiza, Eleocharis acicularis* and *Vallisneria americana* in experimental plastic-lined pools; Avault et al (1968) found that the common carp controlled filamentous algae and *Eleocharis acicularis* when stocked at 124 per ha and that *Tilapia melanopleura* controlled filamentous algae and a variety of higher plants when stocked at 2,470 to 4,940 per ha. Dean (1969) found that the crayfish *Orconectes causeyi* controlled several species of *Potamogeton, Myriophyllum, Elodea, Ceratophyllum, Ranunculus, Chara* and filamentous algae in a number of shallow ponds in the Southwest. The problem with biological control is that the species introduced into a lake is usually foreign to the ecosystem and thus may have the potential to create a problem greater than the one it was introduced to solve.

A few studies have shown that aquatic vegetation may be controlled by fluctuating water levels. McDonald (1955) found that increased water levels in marshes along Lake Erie caused a die-off of the following emergent plants: *Typha angustifolia, T. glauca, Scirpus fluviatilis, S. acutus, S. validus* var. *creber, Carex stricta* and *Phragmites communis* var. *berlandieri.* Robel's (1962) study in Utah showed that submerged aquatic vegetation increased by 32 percent in the shallow areas but decreased by 35 percent in the deeper areas when water levels were increased. Mathis (1966) found a complete absence of *Elodea* spp., *Ceratophyllum demersum* and *Polygonum* spp. after a fall and winter drawdown in Lake Catherine, Arkansas. Lantz et al. (1967) reported that a summer drawdown on Anacoco Lake, Louisiana definitely restricted the growth of *Potamogeton* spp. and *Nuphar* spp., with a total reduction of 90 percent in vegetation over a three-year period. Only Robel's (1962) study provided any quantitative data to support the findings and his study was concerned with the effects of increased water depths on submerged vegetation.

In the initial study of the effects of an overwinter drawdown on aquatic vegetation in Murphy Flowage, Beard (1969) found that the drawdown released approximately 60 acres from thick vegetation cover. *Potamogeton robbinsii, Potamogeton amplifolius, Ceratophyllum demersum, Myriophyllum* spp. and *Nuphar* spp. showed the greatest decrease in abundance after the drawdown. The present paper is an extension of this study to determine the reinvasion of certain species into the flowage and to discuss various management implications of an overwinter drawdown.

The study was conducted at 180-acre Murphy Flowage in Rusk County, Wisconsin. Maximum depth was 14 feet, but 70 percent of the flowage was less than 10 feet deep. The mean annual alkalinity was 38 parts per million. According to Moyle (1945) the natural separation between hard and soft waters seems to be at a total alkalinity of about 40 ppm, with 30 ppm being the lower limit of the hard water species and 50 ppm being the upper tolerance of most soft water species. The vegetation in Murphy Flowage included both hard and soft water plants.

Murphy Flowage was formed at its present level in 1937 and an intensive study of the fish population has been conducted on the flowage by the Wisconsin Department of Natural Resources since 1955. Observations by Department personnel have indicated a gradual increase in the total acreage covered by the aquatic vegetation since 1955. The first quantitative and qualitative study made on the aquatic plants was begun in 1967.

METHODS

Murphy Flowage was divided into 210 quadrats (Fig. 1). These quadrats were used originally for determining random net sets for making fish population estimates. Each quadrat was 225 feet square with a total area of 1.16 acres. Since each quadrat did not lie completely within the flowage, the approximate area which was under water was calculated so that the total acreage covered by each species could be determined.

The aquatic plants were identified in each quadrat and a visual ranking as to abundant, common, present and rare was made. If a species covered 75 percent of a quadrat it was marked abundant; 50 percent, common; 25 percent, present; and below 25 percent, rare.

In deeper areas where visual obser-

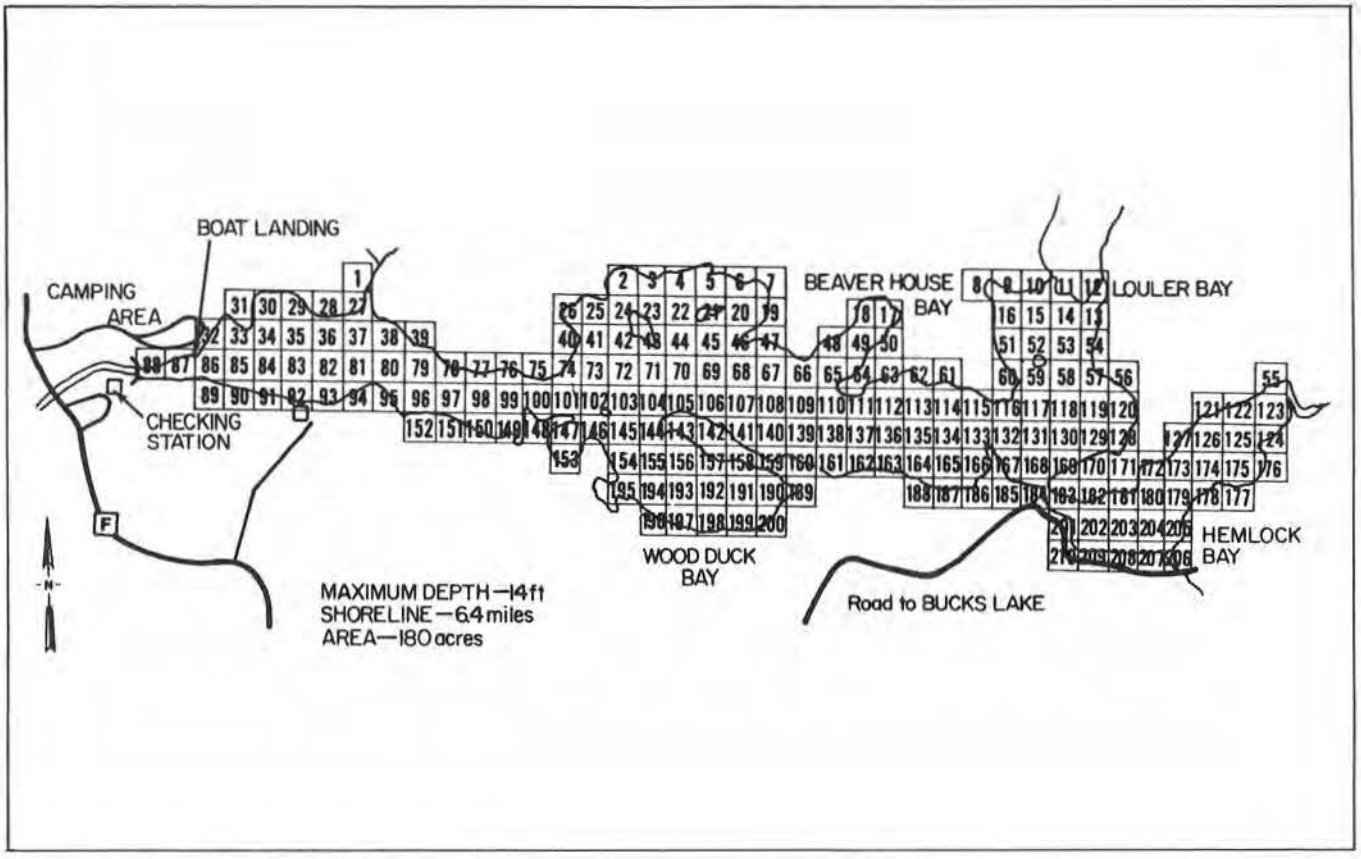


FIGURE 1. The distribution of the 210 quadrats at Murphy Flowage, Wisconsin.

vations were limited, a garden rake was used to determine the presence of aquatic plants. In no case was any vegetation found below visual observation range. Jessen and Loud (1962) used rake recoveries at selected sample sites to determine density of aquatic vegetation as well as visual observation of density at the same sample sites. They found that no significant differences existed between visual observation and rake determinations.

Between mid-October and mid-November, 1967 and 1968 the level of Murphy Flowage was lowered 5 feet. The low level was maintained until March, after which the water was gradually raised to the former level by April 1. During the entire winter the area of the flowage was reduced by 45 percent and the total volume by 70 percent. Each year observations on the abundance of vegetation were made in the last two weeks of August, and aerial photographs of the flowage were taken in the first week of September.

Area in Louler Bay in Nobember, 1967, showing the large mats of vegetation left on the bottom after the drawdown.

RESULTS

Before the drawdown, in 1967, there were 24 species of aquatic plants present in the flowage. After the first drawdown, in 1968, there were 20 species found, including 18 of the pre-drawdown species and two new species. The two new ones were: *Vallisneria americana* and *Scirpus americanus* (Table 1). In 1969, there were 23 species of aquatic plants in the flowage, none of which were new species to the flowage. In 1967, 202 quadrats had aquatic vegetation, while in 1968 and 1969, only 163 and 156 quadrats, respectively, had plants.

Before Initial Drawdown

Six species of aquatic vegetation comprised the major portion of plants found in the flowage. *Potamogeton robbinsii* was the most abundant species in the flowage before the initial drawdown (Table 2). It was found in 84 percent of the quadrats in the flowage and was abundant in 62 percent of the quadrats. *Nuphar* spp. was the next most abundant plant, being found in 69 percent of the quadrats. It was abundant or common in 22 percent. *Myriophyllum* spp. occurred in 53 percent of the quadrats. Although this species was only abundant and common in 6 percent of the quadrats, it was recorded present and rare in 47 percent. *Ceratophyllum demersum* and *Potamogeton amplifolius* were recorded in 40 and 32 percent of the quadrats respectively. *Ceratophyllum demersum* was abundant in 4 and common in 11 percent, while *Potamogeton amplifolius* was never recorded abundant or common but only as present in 8 and rare in 24 percent of the quadrats. *Potamogeton natans* was found in 26 percent of the quadrats and was abundant or common in 16 percent.

After Drawdowns

There was a drastic change in the abundance of aquatic vegetation in 1968 and 1969 after the drawdowns. *Potamogeton robbinsii,* the most abundant species prior to drawdown, was recorded in 42 percent of the quadrats in 1968 and was not abundant or common in any of these; in 1969 it was found in only 17 percent of the quadrats (Tables 3 and 4). *Nuphar* spp. was found in 53 percent of the quadrats in 1968 and 46 percent in 1969 but was recorded abundant or common in less than 3 percent of the quadrats in both years. *Myriophyllum* spp., the third most abundant species in 1967, was found in only 5 percent and 13 percent of the quadrats in 1968 and 1969, respectively. *Ceratophyllum demersum* was absent from

TABLE 1. Species of Aquatic Plants Identified in Murphy Flowage, Wisconsin in August, 1967, 1968 and 1969

Species	Common Name	Present in 1967	Present in 1968	Present in 1969
Potamogeton robbinsii	Robbins' pondweed	X	X	X
Potamogeton natans	Floating-leaf pondweed	X	X	X
Potamogeton richardsonii	Clasping-leaf pondweed	X	X	X
Potamogeton epihydrus	Leafy pondweed	X	X	X
Potamogeton zosteriformis	Flat-stemmed pondweed	X	-	X
Potamogeton amplifolius	Large-leaf pondweed	X	-	-
Potamogeton diversifolius	Waterthread pondweed	X	-	X
Spirodela polyrhiza	Big duckweed	X	X	X
Lemna spp.	Duckweed	X	X	X
Myriophyllum spp.	Water milfoil	X	X	X
Ceratophyllum demersum	Coontail	X	-	X
Utricularia vulgaris	Bladderwort	X	X	X
Megalodonta beckii	Water marigold	X	X	X
Najas flexilis	Bushy pondweed	X	X	X
Ranunculus trichophyllus	Water crowfoot	X	X	X
Anacharis canadensis	Waterweed	X	-	-
Vallisneria americana	Wild celery	-	X	X
Nuphar spp.	Yellow water lily	X	X	X
Polygonum coccineum	Smartweed	X	X	X
Sparganium chlorocarpum	Burreed	X	X	X
Sagittaria latifolia	Arrowhead	X	X	X
Typha latifolia	Common cattail	X	X	X
Brasenia schreberi	Water shield	X	X	X
Eleocharis acicularis	Needle rush	X	-	-
Acorus calamus	Sweet flag	X	X	X
Scirpus americanus	Three-square bulrush	-	X	X

TABLE 2. Percentage Occurrence and Relative Abundance of Each Species in 210 Quadrats Before Overwinter Drawdown at Murphy Flowage, August, 1967

Species	Occurrence		Relative Abundance (Percent)			
	No.	Percent	Abundant	Common	Present	Rare
Potamogeton robbinsii	176	84	62	6	9	6
Nuphar spp.	145	69	7	15	20	27
Myriophyllum spp.	112	53	0.9	5	14	33
Ceratophyllum demersum	85	40	4	11	11	14
Potamogeton amplifolius	67	32	-	-	8	24
Potamogeton natans	54	26	5	11	6	3
Megalodonta beckii	49	23	-	0.5	4	18
Spirodela polyrhiza	49	23	-	-	13	10
Lemna spp.	49	23	-	-	13	10
Utricularia vulgaris	32	15	0.9	4	4	7
Polygonum coccineum	29	14	-	-	3	10
Potamogeton epihydrus	21	10	0	1	2	7
Potamogeton diversifolius	18	8	-	-	-	8
Typha latifolia	16	8	-	0.5	2	5
Brasenia schreberi	18	8	0.9	-	-	8
Acorus calamus	17	8	0.5	-	1	6
Potamogeton zosteriformis	12	6	-	-	-	6
Potamogeton richardsonii	10	5	0	0.5	1	3
Ranunculus trichophyllus	7	3	-	-	0.5	3
Anacharis canadensis	7	3	-	-	-	3
Sagittaria latifolia	6	3	-	-	1	1
Najas flexilis	4	2	-	-	0.5	12
Sparganium chlorocarpum	3	1	-	-	-	1
Eleocharis acicularis	3	1	-	-	-	1

TABLE 3. Percentage Occurrence and Relative Abundance of Each Species in 210 Quadrats After Overwinter Drawdown at Murphy Flowage, August, 1968

Species	Occurrence		Relative Abundance (Percent)			
	No.	Percent	Abundant	Common	Present	Rare
Nuphar spp.	111	53	0.9	0.5	8	43
Potamogeton robbinsii	89	42	-	-	3	40
Potamogeton natans	64	30	2	12	5	11
Utricularia vulgaris	40	19	3	2	10	4
Polygonum coccineum	27	13	-	-	0.9	12
Megalodonta beckii	25	12	0.5	2	3	6
Potamogeton epihydrus	15	7	-	-	2	5
Spirodela polyrhiza	16	7	-	-	0.5	7
Lemna spp.	16	7	-	-	0.5	7
Potamogeton richardsonii	12	6	0.5	0.5	0.5	4
Typha latifolia	14	6	-	-	1	5
Myriophyllum spp.	11	5	-	-	0.5	5
Sagittaria latifolia	8	4	-	-	-	4
Najas flexilis	5	2	-	-	0.5	2
Sparganium chlorocarpum	5	2	-	-	-	2
Acorus calamus	5	2	-	-	-	2
Vallisneria americana	2	0.9	-	-	-	0.9
Ranunculus trichophyllus	1	0.5	-	-	-	0.5
Brasenia schreberi	1	0.5	-	-	0.5	-
Scirpus americanus	1	0.5	-	-	-	0.5
Potamogeton zosteriformis	0	0	-	-	-	-
Potamogeton amplifolius	0	0	-	-	-	-
Potamogeton diversifolius	0	0	-	-	-	-
Ceratophyllum demersum	0	0	-	-	-	-
Anacharis canadensis	0	0	-	-	-	-
Eleocharis acicularis	0	0	-	-	-	-

TABLE 4. Percentage Occurrence and Relative Abundance of Each Species in 210 Quadrats After Overwinter Drawdown at Murphy Flowage, August, 1969

Species	Occurrence		Relative Abundance (Percent)			
	No.	Percent	Abundant	Common	Present	Rare
Nuphar spp.	97	46	0.5	2	3	41
Potamogeton diversifolius	85	41	-	2	8	31
Najas flexilis	84	40	3	1	7	29
Potamogeton natans	69	33	9	6	7	11
Megalodonta beckii	49	23	4	7	5	7
Potamogeton epihydrus	41	20	-	-	2	18
Potamogeton robbinsii	35	17	-	-	-	17
Myriophyllum spp.	28	13	-	-	-	13
Polygonum coccineum	23	11	-	-	-	11
Scirpus americanus	19	9	-	-	0.5	8
Spirodela polyrhiza	17	8	-	0.5	2	6
Lemna spp.	17	8	-	0.5	2	6
Typha latifolia	14	7	-	-	0.5	6
Potamogeton richardsonii	9	5	1	-	0.5	3
Brasenia schreberi	7	3	-	-	-	3
Potamogeton zosteriformis	5	2	-	-	-	2
Sparganium chlorocarpum	3	1	-	-	0.5	0.5
Ceratophyllum demersum	2	1	-	-	-	1
Vallisneria americana	2	1	-	-	-	1
Utricularia vulgaris	2	1	-	-	-	1
Acorus Calamus	2	1	-	-	-	1
Ranunculus trichophyllus	1	0.5	-	-	-	0.5
Eleocharis acicularis	0	0	-	-	-	-
Anacharis canadensis	0	0	-	-	-	-

the flowage in 1968 and occurred in only one percent of the quadrats in 1969. *Potamogeton amplifolius* showed the greatest change, being absent in the flowage in 1968 and 1969. The overwinter drawdown seemed to have very little effect on *Potamogeton natans* which was found in about the same number of quadrats before and after the drawdowns.

The effects of an overwinter drawdown on the six most abundant species before and after the drawdowns are shown in Figure 2. The ranking was based on the percent abundant, common, present and rare within the 210 quadrats covering the entire flowage.

Acreage Changes

To provide a more quantitative description of the change in vegetation due to the drawdowns, the approximate acres covered by each major species was calculated. The aquatic vegetation was divided into three categories, those species showing greatest decrease, slight decrease or increase, and greatest increase.

Greatest Decrease. Five of the six most abundant species in 1967 showed the most drastic acreage decreases in 1968 and 1969 (Table 5). *Potamogeton robbinsii* covered 104.4 acres in 1967; in 1968 and 1969 it covered only 8.0 and 3.1 acres, respectively. This represents a total reduction in acreage of 101.3 acres from 1967 through 1969. *Nuphar* spp. was reduced 32.9 acres from 1967 through 1969 with the greatest reduction (30.1 acres) occurring after the first drawdown. After the first drawdown *Myriophyllum* spp. was reduced from 19.8 acres to 0.9 acres and after the second drawdown it increased slightly in abundance to 2.9 acres. In 1967, *Ceratophyllum demersum* covered 26.1 acres and by 1969 it covered only 0.1 acres for a total reduction of 26.0 acres. *Potamogeton amplifolius* covered 10.2 acres before the drawdown and was eliminated from the flowage after the first drawdown and has not returned.

Potamogeton robbinsii, Nuphar spp. and *Potamogeton amplifolius* decreased in abundance after each drawdown. *Ceratophyllum demersum* and *Myriophyllum* spp. showed slight increases in abundance after the second drawdown but these increases were so slight that they could have been due to sampling error. The five species showed a total reduction from 203.6 acres to 16.3 acres after two drawdowns, which was a decrease in acreage of 187.3 acres. Of the 187.3 acres decrease after the two drawdowns, 181.7 acres occurred after the first drawdown. The acreage covered by the major species was more than the total acreage of the flowage since more than one species could be ranked abundant in the same quadrat.

Slight Decrease or Increase. The largest number of species showed a slight decrease, but only one plant of

TABLE 5. Approximate Acreage Covered by Aquatic Vegetation Before (1967) and Two Years After Overwinter Drawdowns on Murphy Flowage

Species	1967 No. Quadrats	1967 Total Acres	1968 No. Quadrats	1968 Total Acres	1969 No. Quadrats	1969 Total Acres
GREATEST DECREASE						
Potamogeton robbinsii	176	104.4	89	8.0	35	3.1
Nuphar spp.	145	43.1	111	13.0	97	10.2
Ceratophyllum demersum	85	26.1	0	-	2	0.1
Myriophyllum spp.	112	19.8	11	0.9	28	2.9
Potamogeton amplifolius	67	10.2	0	-	0	-
Totals		203.6		21.9		16.3
SLIGHT DECREASE OR INCREASE						
Potamogeton natans	54	21.5	64	18.8	69	21.2
Utricularia vulgaris	32	10.0	40	13.6	2	0.2
Spirodela polyrhiza	49	7.5	16	1.5	17	2.0
Lemna spp.	49	7.5	16	1.5	17	2.0
Polygonum coccineum	29	6.0	27	3.8	23	2.7
Potamogeton epihydrus	21	3.4	15	1.8	41	3.8
Acorus calamus	17	2.7	5	0.5	2	0.3
Brasenia schreberi	18	2.4	1	0.1	7	0.7
Typha latifolia	16	2.2	14	1.9	14	1.4
Potamogeton richardsonii	10	1.6	12	2.1	9	2.0
Sagittaria latifolia	6	1.2	8	0.7	13	1.0
Potamogeton zosteriformis	12	1.1	0	-	5	0.5
Ranunculus trichophyllus	7	1.0	1	0.1	1	0.1
Anacharis canadensis	7	0.9	0	-	0	-
Sparganium chlorocarpum	3	0.4	5	0.5	3	0.7
Eleocharis acicularis	3	0.2	0	-	0	-
Vallisneria americana	0	-	2	0.2	2	0.3
Scirpus americanus	0	-	2	0.2	19	1.3
Totals		69.6		47.3		40.2
GREATEST INCREASE						
Megalodonta beckii	49	7.4	25	6.2	49	18.5
Potamogeton diversifolius	18	1.7	0	-	85	11.7
Najas flexilis	4	0.6	5	0.6	84	12.7
Totals		9.7		6.8		42.9

major importance was in this category (Table 5). This species was *Potamogeton natans* which covered 21.5 acres in 1967 and 18.8 and 21.2 acres in 1968 and 1969, respectively. This represents a reduction of only 0.3 acres after two drawdowns. *Utricularia vulgaris* increased after the first drawdown from 10.0 acres to 13.6 acres but after the second drawdown it decreased to 0.2 acres. *Potamogeton richardsonii* showed a slight increase after the first drawdown but decreased slightly after the second drawdown. *Sparganium chlorocarpum* increased slightly after each drawdown from 0.4 acres in 1967 to 0.7 acres in 1969. In total, the species in this category decreased from 69.6 to 40.2 acres for a reduction of 29.4 acres.

Greatest Increase. Three species of aquatic plants were not affected by the overwinter drawdown and by 1969, along with *Potamogeton natans,* were the dominant plants in the flowage. Unlike *Potamogeton natans,* none of these species were present in any abundance before the drawdown. *Megalodonta beckii* covered 7.4 acres in 1967 and 6.2 acres after the first drawdown, but after the second drawdown it had increased to 18.5 acres. *Najas flexilis* increased from 0.6 acres in 1967 to 12.7 acres after the second drawdown. In 1967, *Potamogeton diversifolius* covered 1.7 acres; in 1968, it was not found in the flowage; but by 1969 it covered 11.7 acres. These three species combined had increased from 9.7 acres before the drawdown to 42.9 acres in 1969.

In 1967, approximately 75 acres (42% of the flowage) were covered by plants to the extent that fishing was almost impossible in these areas from late spring through the summer. The first drawdown released approximately 65 of the 75 acres for fishing. Even after the increase in abundance of three species of plants in 1969 there were still 60 acres of the 65 acres open to fishing after the second drawdown.

Distribution Changes

The distribution of the major species of aquatic plants before and after the drawdowns is shown in Figure 3. The distribution includes only the areas in which the species were abundant, common and present. Before the drawdown, *Potamogeton robbinsii* was found mostly in depths of 10 feet or less. The major concentration of *Nuphar* spp. was in Louler and Hemlock Bays and some of the other shallow areas of the flowage. *Ceratophyllum demersum* was found exclusively in Louler and Hemlock Bays where the average water depth was less than 3 feet. *Myriophyllum* spp. and *Potamogeton amplifolius* were not concentrated at a certain depth or area but were evenly distributed throughout the flowage. *Potamogeton natans* was found in Louler, Hemlock and Beaver House Bays in water less than 3 feet in depth.

After the first drawdown the distribution of *Potamogeton robbinsii* was reduced to a few areas around the shore and *Nuphar* spp. was found in only a few shallow bays. *Potamogeton natans* was still found in the same areas of Louler, Hemlock and Beaver House Bays.

After the second drawdown *Potamogeton robbinsii* was not concentrated in any areas of the flowage. *Nuphar* spp. was found in about the same areas as after the first drawdown. The major concentration of *Potamogeton natans* was the same as before the drawdowns. *Megalodonta beckii* began to invade the shallow areas of Louler and Hemlock Bays and *Najas flexilis* and *Potamogeton diversifolius* started to invade the shoreline along the deeper part of the flowage.

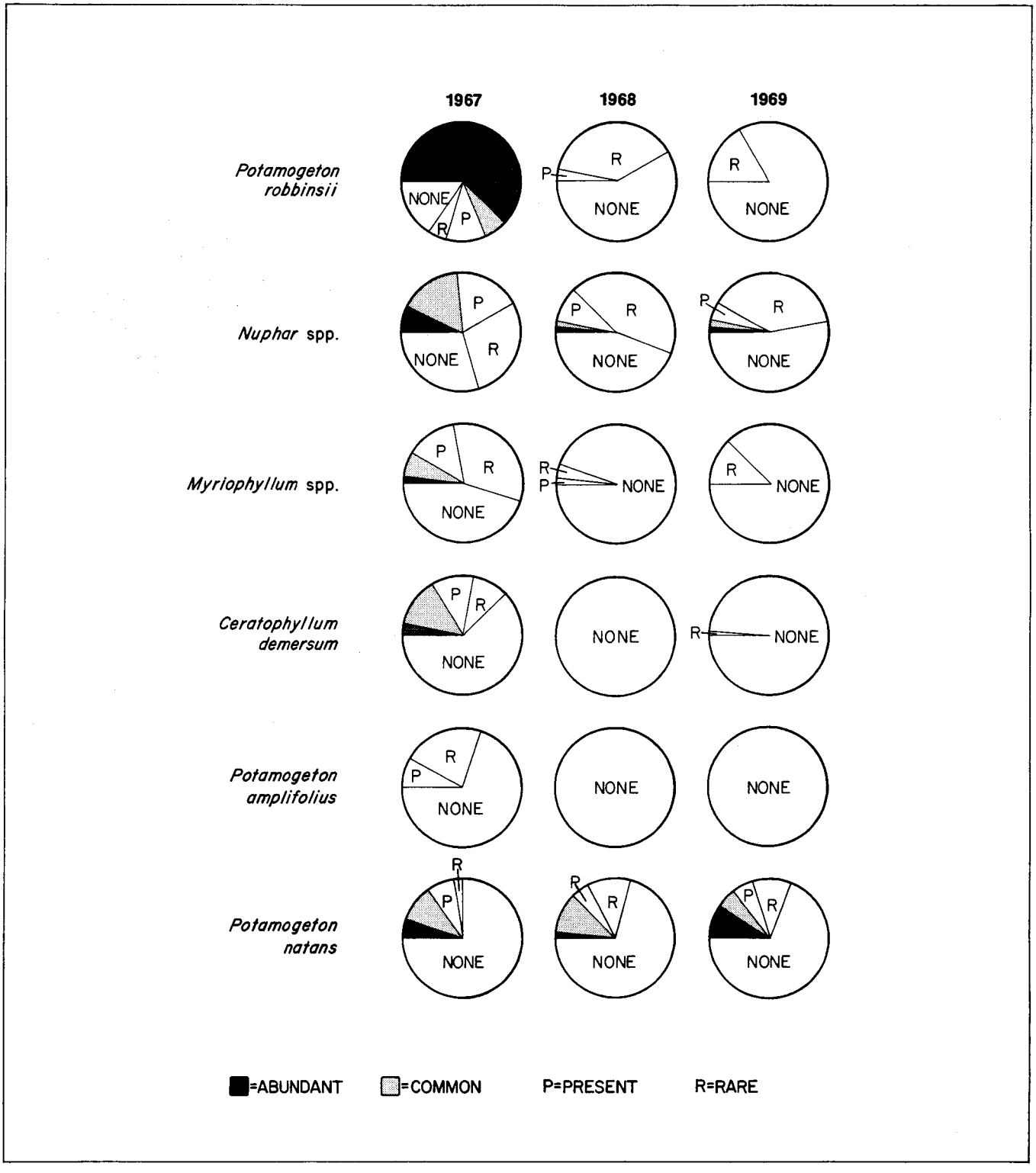
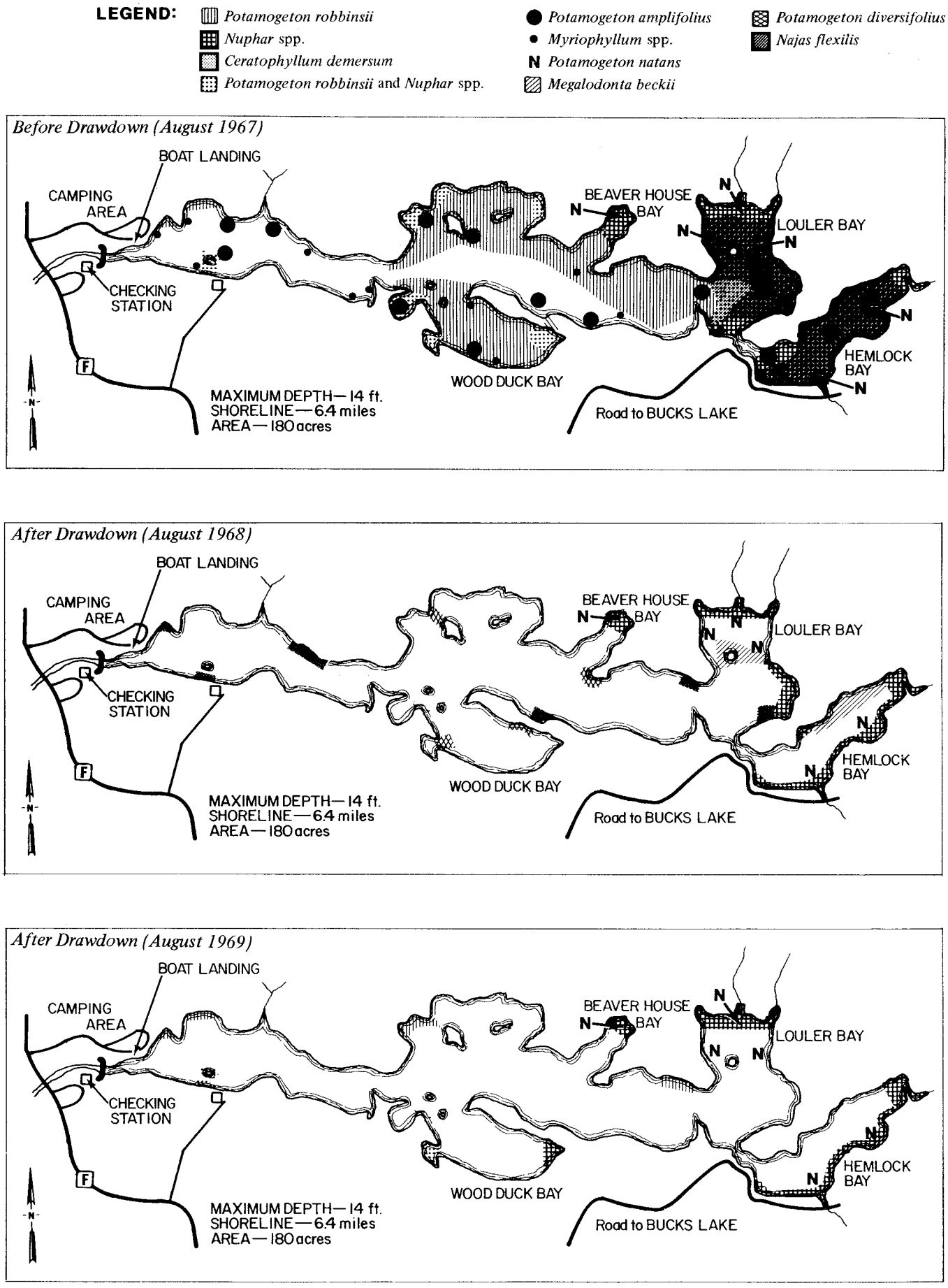


FIGURE 2. *Abundance of aquatic plants before and two years after an overwinter drawdown at Murphy Flowage, Wisconsin. (Ranking was based on the percentage within the 210 quadrats, covering the entire flowage.)*

FIGURE 3. Distribution of the major species of aquatic plants in Murphy Flowage, Wisconsin before and after overwinter drawdowns. (The distribution includes only the areas in which the species were abundant, common and present.)



DISCUSSION

The drastic reduction of *Ceratophyllum demersum* recorded in Murphy Flowage has also been found by Lantz et al. (1967) and Mathis (1966) when the water level was lowered. The stress due to the low water level probably destroyed the vegetative reproductive structures. The reduction of *Myriophyllum* spp. was probably due to the same factor.

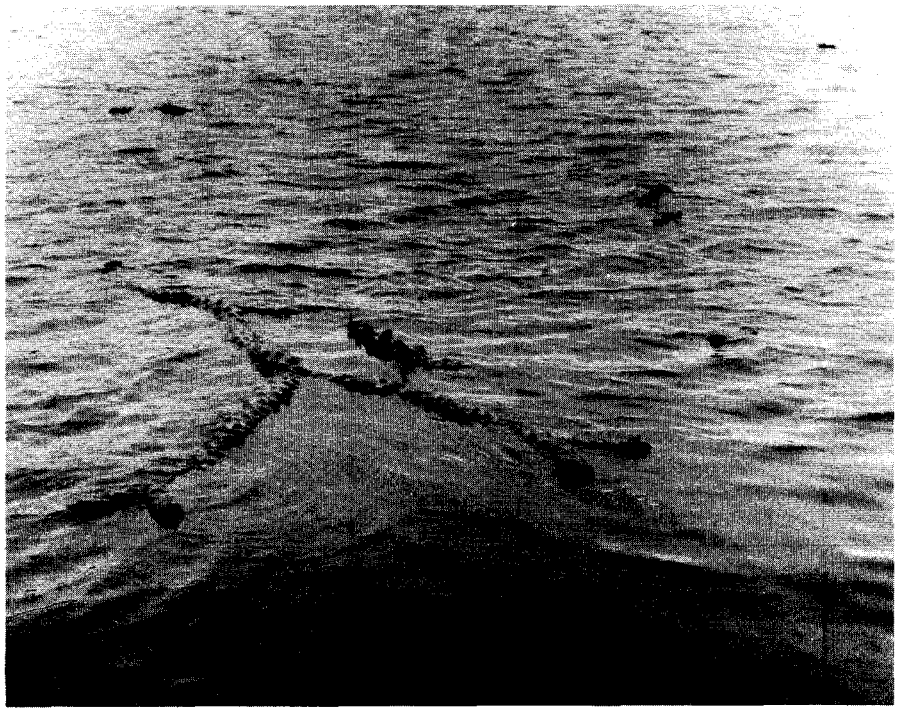
Most Potamogeton species reproduce vegetatively by either tubers, winter buds or creeping rootstocks and if any fruiting does occur it is usually in the fall (Muenscher, 1936). *Potamogeton robbinsii*, apparently matures fruit only very rarely but reproduces vegetatively from winter buds. The overwinter drawdown probably destroyed most of the winter buds and the few plants that did survive, survived from seeds produced in the fall or from winter buds in unexposed areas. The elimination of *Potamogeton amplifolius* could also be due to the reduction of the plant's capacity to reproduce vegetatively.

The main mode of reproduction of *Nuphar* spp. was by vegetative means from underwater rhizomes. In the shallow area where *Nuphar* spp. was abundant the rhizomes were exposed over the winter, and in the spring and throughout the summer large numbers of these rhizomes were found floating on the flowage. Also, much of the *Nuphar* spp. sprouting from the remaining rhizomes in the spring turned yellow and died after a short period of development. This was probably due to the lack of food reserve in the rhizomes because of the stress during the low water level period.

Potamogeton natans showed very little change after the drawdowns. One reason for this may be that a large number of these plants had produced fruiting bodies in the summer of 1967 before the drawdown, and could have dispersed seeds before the drawdown. *Polygonum coccineum* also did not show a drastic change after the drawdown. Most of these plants produced mature fruiting bodies before the drawdown, and most of the reproduction of this species in 1968 and 1969 was by seeds produced in the fall of 1967 before the drawdown.

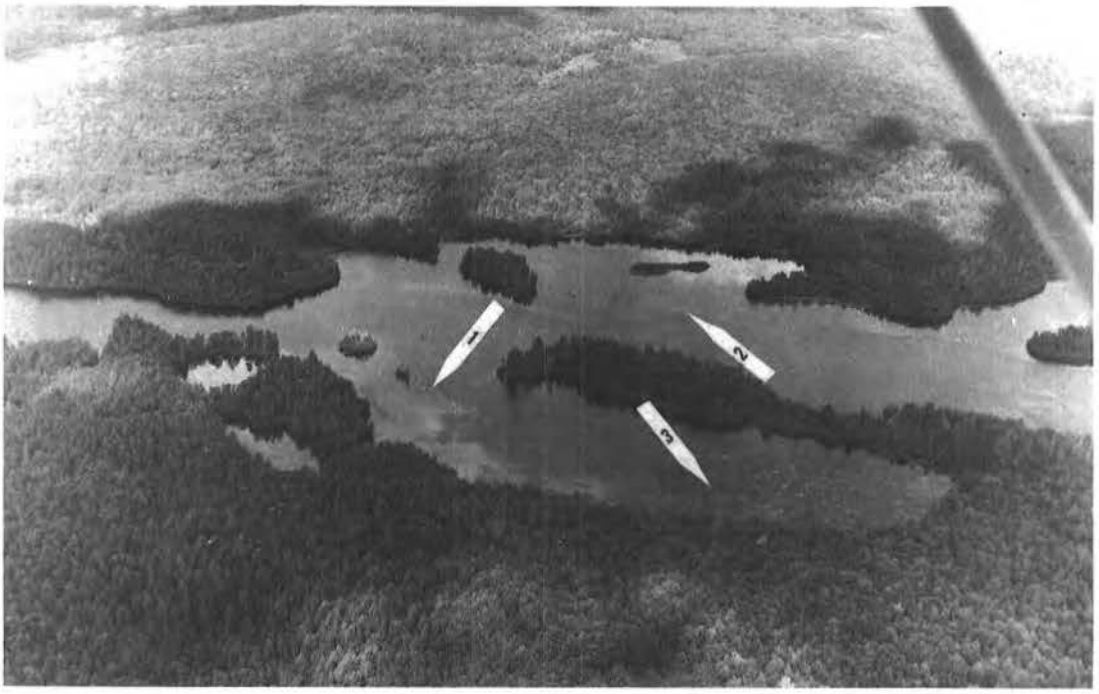
Winter freezing conditions were probably one of the factors responsible for the reduction in the vegetation, but evidence from other studies suggests that they were not the only ones involved. For example, Lantz (1967) obtained a reduction of *Ceratophyllum demersum* and *Potamogeton* spp. with a summer drawdown in Louisiana and Mathis (1966) observed a reduction of *Ceratophyllum demersum* with a winter drawdown in Arkansas, where the winters are not as severe as in northern Wisconsin. One exception, however, was *Nuphar* spp. During the first winter drawdown there was very little snow and deep frost in the ground. When the flowage was raised in March the bottom of the flowage in many places lifted, ripping the *Nuphar* spp. rhizomes from the bottom. In the spring and summer many rhizomes were seen floating in the flowage.

The primary factors responsible for the reductions observed in 1968 and 1969 appeared to be related to the effect of lowered water levels on reproduction. The main mode of reproduction for the major plant species in the flowage is by vegetative means. When these species were subjected to low water levels the plants may not have had time to develop mature fruit and most of the vegetative parts were destroyed. Also, lower water levels may modify various other factors such as temperature, light intensity, rate of photosynthesis and growth, any of which could cause a change in the vegetation.



Nuphar *rhizomes which were found floating on the flowage during the spring and summer of 1968.*

The overwinter drawdowns on Murphy Flowage did result in a marked reduction of aquatic vegetation. Re-invasion by three species of aquatic plants was beginning after the second drawdown. How long it would take the plants to occupy the flowage to the extent they did before the drawdown was one of the questions left unanswered when the flowage was destroyed by a flood which washed out the dam in the spring of 1970.



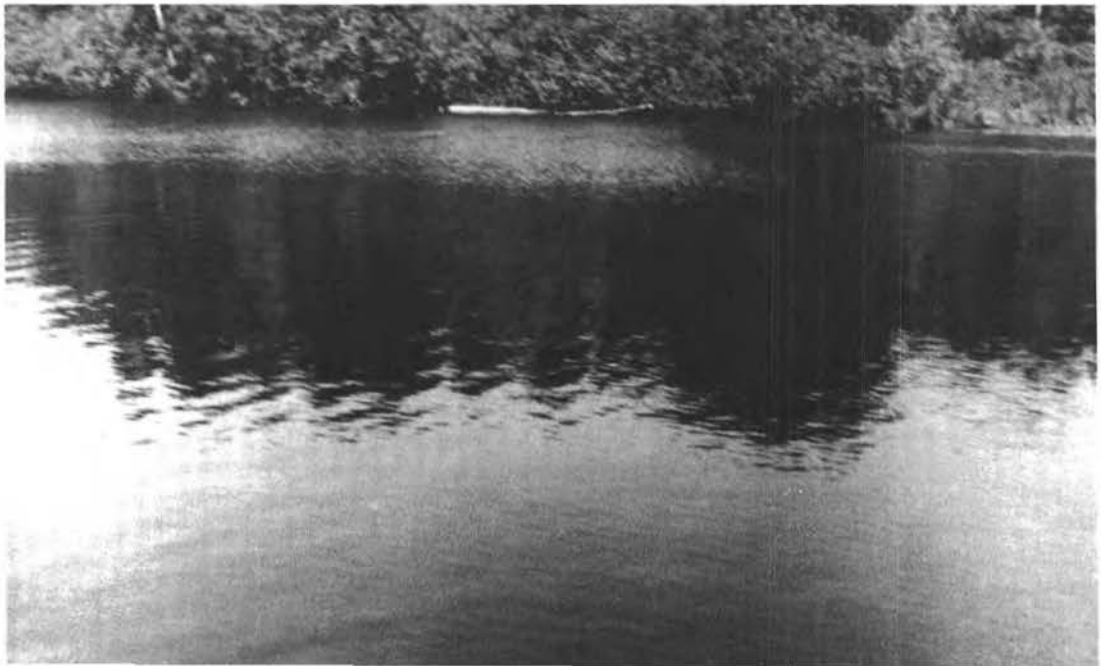
Aerial photograph of Wood Duck Bay looking north across the flowage in September, 1967 before the drawdown. The white area at the tip of Arrows 1 and 2 shows the relative abundance of submergent vegetation. Arrow 3 shows the scattered stands of **Nuphar**.

September, 1968. Notice the complete absence of submergent vegetation and the reduction of **Nuphar** *(Arrow).*

September, 1969. Still no encroachment of submergent vegetation into the bay.

Shallow area in Hemlock Bay choked with **Nuphar** *before the drawdown, August, 1967.*

The same area after the first drawdown, August, 1968.



The same area after the second drawdown, August, 1969.

MANAGEMENT CONSIDERATIONS

There are a number of considerations that management personnel should be aware of when using an overwinter drawdown to control aquatic vegetation.

Type of Vegetation

An overwinter drawdown does not kill all types of vegetation. Some species seem to be resistant to this type of control. From the data from Murphy Flowage, contact with department personnel, and information from the Yellow River Flowage, Washburn County, Wisconsin which was drawn down over two winters, I have found these results:

Resistant Vegetation:
Thin-leaved Potamogetons
Potamogeton natans
Meglodonta beckii
Najas flexilis

Non-Resistant Vegetation:
Ceratophyllum demersum
Myriophyllum spp.
Potamogeton robbinsii
Potamogeton amplifolius

Thus, if the dominant species in a flowage are *Ceratophyllum demersum* and *Myriophyllum* spp., there should be a reduction from the drawdown. If the dominant species are *Najas flexilis* and *Potamogeton natans,* there may not be a reduction. The reduction of *Nuphar* spp. may depend on the type of winter. In Murphy Flowage a combination of light snow, deep frost and the lifting of the bottom when the flowage was flooded apparently caused the reduction of this species. Depending on the species in a flowage, it may be possible to get a change in the species composition but no reduction in the amount of vegetation. Also, it is possible that in a number of flowages more adaptive species are the dominant plants and a drawdown would not cause a reduction in the aquatic plants.

Invasion of Aquatic Vegetation After the Drawdown

Certain resistant vegetation will come back. In Murphy Flowage three species of plants were beginning to reinvade the flowage after the second drawdown. How long it would have taken these species to reinvade the flowage to the level of abundance at the time of the drawdown was one of the big questions left unanswered after the dam washed out. After resistant species reinvade a flowage, overwinter drawdowns may no longer solve the problem.

Phytoplankton Bloom

In any flowage there is a source of nutrients coming in and if these nutrients are not used by rooted aquatic plants, they will be utilized by the phytoplankton. One year after the reduction in vegetation in Murphy Flowage there was a pea soup phytoplankton bloom for about three weeks in August. There was no indication in Murphy Flowage that the overwinter drawdowns had any visible effect on the algae.

Wells

There was one landowner on the flowage with a shallow well (20 feet). The well went dry approximately one month after the flowage was completely down. Complete drawdown of Murphy Flowage was 5 feet or a water volume reduction of 70 percent. However, the Yellow River Flowage was drained completely over two winters and none of the residents on the flowage complained of their wells going dry. The manager should be aware that wells could go dry based on the depth of the wells, the depth of the water table around the flowage and the amount of water removed during the drawdown.

Amount of Drawdown

It is best to draw the flowage down to a point where most of the vegetation areas are dry, although at Murphy Flowage there was a reduction of vegetation in areas which were still water-covered and frozen to the bottom during the winter.

Timing and Number of Drawdowns

A number of authors have had success controlling certain species of aquatic plants with summer drawdowns. It is quite possible that *Ceratophyllum demersum* can be controlled by short exposure to drawdowns in the summer.

In Murphy Flowage the drawdowns were started in October and the flowage was filled by the first of April. It was important to start filling the flowage in March to catch the spring runoff and also to insure that the northern pike spawning areas in the flowage would be full before spawning started.

In Murphy Flowage the first drawdown had the greatest effect on the plants, causing a total reduction of 206.9 acres and after the second drawdown the vegetation increased over the amount present after the first drawdown. In the Yellow River Flowage, it took two drawdowns to produce a noticeable effect on the vegetation. The number of drawdowns to be used probably depends on the species composition in the flowage.

Winterkill

At Murphy Flowage we had no problems with winterkill of fish with a water volume reduction of 70 percent. On the contrary we got a slight increase in the dissolved oxygen during the winter. The reason for the slight increase was as follows: One factor that determined the oxygen content in the flowage was the interchange of oxygen between the stream channel and the surrounding water. By reducing the volume of the flowage by 70 percent the water remaining was concentrated around the stream channel causing a faster interchange. Under normal conditions there would not be a rapid interchange because of the dilution factor.

Fishing Pressure

The residents on the flowage were concerned about increased fishing pressure, overexploiting the fishery during the drawdown period when the fish are concentrated into a smaller area. At Murphy Flowage the number of northern pike caught per 100 hours fishing averaged 6.6 for three winters before the drawdown and 3.6 during the three winters of the drawdown. Largemouth bass were not taken in

any numbers before or during the drawdown. The number of panfish (bluegills, yellow perch, pumpkinseeds, rock bass and black crappie) caught averaged 4.9 fish per hour for three winters before the drawdown and 4.5 fish per hour for the three winters during the drawdown. Thus, by concentrating the fish there was no increase in catch rate. The catch rate for northern pike actually decreased.

The number of largemouth bass caught during the first summer after drawdown was the highest taken from the flowage since 1958. Snow (1971) attributed this to two things: (1) The reduction of vegetation released many acres of water to the angler that could not be fished before this time. (2) The decrease after the drawdown in the number of crayfish, the major food item of bass before the drawdown, could have made the bass more vulnerable to the angler.

Other Uses

It is very important that contacts be made with other agencies or interests before a drawdown is started. For example, the benefits of reducing the weeds has to be weighed against the usage of the flowage by waterfowl for feeding and nesting purposes. Also, an overwinter drawdown has an adverse effect on muskrats and quite possibly on beaver. The ramifications of an overwinter drawdown for control of aquatic vegetation must be considered in light of other organisms that use and live in the aquatic community.

SUMMARY

1. There was a drastic change in abundance of aquatic vegetation after the drawdowns in Murphy Flowage. Five of the six major species before the drawdowns were the ones most affected. *Potamogeton robbinsii* was the most abundant plant in the flowage in 1967, covering 104.4 acres. It was reduced to 8.0 acres in 1968 and 3.1 acres in 1969. *Nuphar* spp. was reduced from 43.1 acres in 1967 to 10.2 acres in 1969; and *Myriophyllum* spp. was reduced from 19.8 acres in 1967 to 2.9 acres in 1969. *Ceratophyllum demersum* was absent from the flowage in 1968 and covered only 0.1 acre after the second drawdown. *Potamogeton amplifolius* was eliminated from the flowage. Of the six major species of vegetation in the flowage, only *Potamogeton natans* was resistant to the drawdowns, covering 21.5 acres in 1967 and 18.8 and 21.2 acres in 1968 and 1969, respectively. The five species most affected by the drawdown showed an approximate acreage reduction after the drawdowns of 187.3 acres.

2. Re-invasion by *Najas flexilis, Megalodonta beckii* and *Potamogeton diversifolius* was beginning to take place after the second drawdown.

3. The drawdown released approximately 65 acres for fishing in 1968 and 60 acres were still open by 1969 after the second drawdown.

4. Interference with reproduction due to the low water levels was probably the major factor involved in the reduction of the aquatic vegetation. One exception, however, was *Nuphar* spp. which was controlled by the deep frost and severe winter of northern Wisconsin.

5. Type of vegetation in a flowage, invasion of resistant species after drawdown, phytoplankton bloom, timing and number of drawdowns, winterkill, fishing pressure and other uses of the flowage are factors which management personnel should consider before an overwinter drawdown is used to control aquatic vegetation.

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