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Long-term Effects of Mechanical Harvesting on Eurasian Watermilfoil

D. SCOTT PAINTER

ABSTRACT

The long-term efficacy of mechanical harvesting of Eurasian watermilfoil (*Myriophyllum spicatum* L.) was examined over a four year period. The harvesting strategy chosen was a double cut performed in June and September of each year. Milfoil biomass, shoot weight and plant density were reduced; however, plant height continued to reach the water's surface in the fourth year of the study. Smaller root masses were observed in the harvested area. A linear relationship between shoot weight and root weight was determined suggesting that harvesting of shoot material would result in some root die-back. Tissue phosphorus concentrations were at all times above growth-limiting levels, nor were any trends discernible that would explain the impact of harvesting on milfoil biomass. Carbohydrate concentrations were reduced in the spring, but any differences between harvested and control plants were eliminated by mid-summer. The effect of harvesting on biomass did not appear to be related to shoot or root carbohydrate concentration trends. Sediment biologically-available phosphorus concentrations were reduced in the last two years of the study; however, since tissue concentrations were not limiting, the effect of harvesing would not appear to be related to changes in sediment phosphorus.

Key words: Myriophyllum spicatum, carbohydrates, phosphorus, sediment phosphorus, nutrition, plant biomass.

INTRODUCTION

Mechanical harvesting is commonly employed to control the nuisance aquatic plant, Eurasian watermilfoil (*Myriophyllum spicatum* L.). The ability of harvesting to achieve long-term control is desirable but questionable. Perkins and Sytsma (1982) reported that no long-term control of biomass was achieved in their harvesting experiments in Union Bay, Lake Washington. Kimbel and Carpenter (1979) reviewed several research harvesting projects and observed that harvesting had an impact on regrowth in the second year in 12 of 13 reported projects. Painter and Waltho (1985) observed that if a fall harvest

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was conducted biomass was reduced in the second year but not plant height.

Tissue chemistry, particularily total non-structural carbohydrates (TNC), has been examined in an attempt to explain the effects of harvesting on regrowth. Harvesting would remove photosynthetic tissues which would otherwise be producing storage carbohydrates possibly necessary for over-winter survival. Harvesting would also remove tissue nutrients and further growth and uptake of nutrients from the sediment could possibly deplete the sediment nutrient pool if the harvesting program was maintained over a long period. Both Perkins and Sytsma (1982) and Painter and Waltho (1985) observed declines in tissue carbohydrates as a result of harvesting. The effect of harvesting was most pronounced on root TNC which was reduced 36.3% in the harvested plants. Lower root TNC was observed in 18 of 19 harvested plots in June of the subsequent year. Painter and Waltho (1985) also observed minor effects on tissue phosphorus, nitrogen and carbon.

The possibility of long-term control of Eurasian watermilfoil was examined by harvesting a 2 hectare plot in Buckhorn Lake for 4 years. A harvesting scenario was chosen that Painter and Waltho (1985) had observed would have the most impact on the subsequent year's biomass and tissue chemistry.

METHODS

One experimental and one control plot were located in 1.5 to 2.5 meters of water on the west side of Nichol Island in Buckhorn Lake, Ontario. The 2 hectare plots were created by dividing a bay in half length-wise. Painter and Waltho (1985) had previously used the bay to examine the short-term impact of 19 harvesting strategies, therefore, two years of pre-treatment data were available for most of the parameters sampled. Eurasian watermilfoil was the dominant aquatic plant present in the area and its biomass was extremely dense and uniform. A single cut was performed in the fall of 1980 and June and September cuts were performed from 1981 to 1984. The milfoil was cut at approximately 50 cm from the sediment surface. Sampling of both the control and harvested areas was conducted monthly from April to November of each year.

Milfoil shoot weight was determined by obtaining 25 random samples of milfoil plants from each area and weighing the shoot material. Mean Plant weight was calculated with a standard error of ± 12.7% of the mean. Plant density was determined using the Point-Centered Quarter Method as described in Mueller-Dombois and Ellenberg (1974). The closest individual method and the Point-Centered Quarter method were tested with two samplers and compared with 1 m^2 quadrat density measurements and the Point-Centered Quarter method was more reliable between sampling periods and between observers (standard error of the mean was ± 10.2%). A plotless, non-destructive sampling method was chosen to minimize the damage to the plots. Biomass was determined from shoot weight and plant density. Estimates of biomass using this technique had a standard error of 23%.

The 25 milfoil shoot and root samples were combined and analyzed for % water, % organic content, total non-structural carbohydrates, and total phosphorus. Standard error for the tissue analysis was 8.5%. Five sediment samples were obtained from each area by Ekman grab and analyzed for biologically available phosphorus and spring sediment samples were analyzed for CDB and NaOH-extractable phosphorus, Apatite phosphorus, total inorganic and total phosphorus. Standard error for the sediment analysis was 13.7%. Total phosphorus of the plant material and the various sediment phosphorus fractions were determined as described in Mayer and Williams (1981). Bioloically-available phosphorus was determined on the sediments using a 0.1 N NaOH extraction (Williams et al. 1980).

Plant material was dried for 16 hours at 75 C for determination of dry weight. Loss on ignition (% organic content) was determined on dried plant material which was ignited in a muffle furnace at 550 C for two hours. Total non-structural carbohydrates were determined by enzymatic extraction with amyloglucosidase for conversion of starches to glucose and glucose analysis using the phenol-sulphuric acid colorimetric method (Smith, 1969). The loss on ignition values were used to correct the chemical analyses, initially expressed on a dry weight basis (DW), to an ash-free dry weight basis (AFDW).

TABLE 1. PLANT DENSITY (PLANTS/m^2) IN THE CONTROL AND HARVESTED AREAS FROM 1981 TO 1984. 1 S.E. = 10.2%.

Date	Control	Harvested
1981	10.3	10.3
1982	12.5	9.4
1983	26.4	5.1
1984	15.0	7.0

RESULTS AND DISCUSSION

The biomass of Eurasian watermilfoil was reduced by the double harvesting treatments performed (Fig 1). The milfoil biomass in the control plot fluctuated during the six years sampled. The cause for the dramatic drop in the biomass in 1982 in the control plot cannot be ascribed to climatic conditions in either the previous winter or that growing season and remains unknown. Shoot weight of the harvested plants was also reduced compared to the control plants (Fig 2). Plant density in the harvested area was significantly reduced in the last two years compared to the control. The density increased in the control area in 1983 and was probably a response to the drop in shoot weight in 1982. In 1982, the shoot weight and size was much smaller than the previous year, therefore, allowing more light penetration to the sediment surface and increased chances for shoot fragments to root and establish. The shoot weight in the harvested area naturally decreased as a result of the harvesting but the plant density decreased rather than increased as would have been expected. One possible hypothesis is that the harvesting affected the sediment chemistry in such a way as to reduce shoot fragment establishment.

Plant height was not measured rigorously but visual observations were recorded. The biomass in the harvested

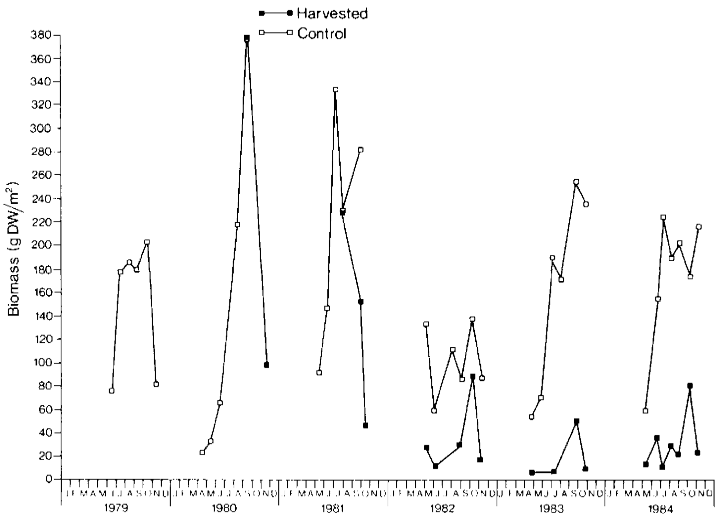

Figure 1. Eurasian watermilfoil biomass (gDW/m²) in the control and harvested areas from 1979 to 1984. 1 S.E. = 23%.

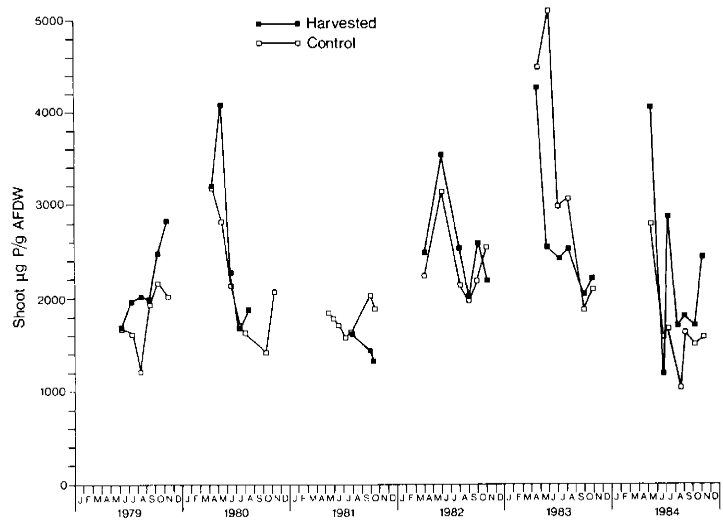

Figure 3. Eurasian watermilfoil shoot phosphorus (μg P/gAFDW) in the control and harvested areas from 1979 to 1984. 1 S.E. = 8.5%.

area in 1983 had been affected to such an extent that harvesting throughout the season would not have been necessary to maintain boating access. In 1984, however, plant height had increased so that the stems were reaching the water's surface and restricting access. The plant density and shoot weight were affected by the harvesting, but the milfoil stems were capable of reaching the water's surface in 1.5-2.5 meters of water after four years of harvesting. Boating access was easier in the harvested area than the control area, but frequent stops to clean the propeller were still necessary. Painter and Waltho (1985) also observed in an earlier study on short-term harvesting effects that milfoil biomass was affected in the year following harvesting but that plant height was not.

During the last year of the experiment, the root masses of the harvested plants visually appeared to be smaller than those of the control plants, so for several months the root weights of the 25 plant samples from both the harvested and control areas were measured. Root weights in the harvested area were smaller. The root to shoot percents for both areas were similar so the observed smaller root mass in the harvested area was due to the smaller shoot size. Root weight was linearly related to shoot weight ($RW = 0.778 + 0.194*SW$, $r = 0.69$, $df = 123$, $p < 0.001$). Therefore, root/shoot percents were inversely related to shoot weight. For mature plants which had the stems removed by harvesting, the root/shoot percent approached 100% and for large uncut plants the root/shoot percent approached 20%. Harvesting resulted in smaller shoot weights which then resulted in some root death, since the remaining milfoil shoots could not support the total root mass.

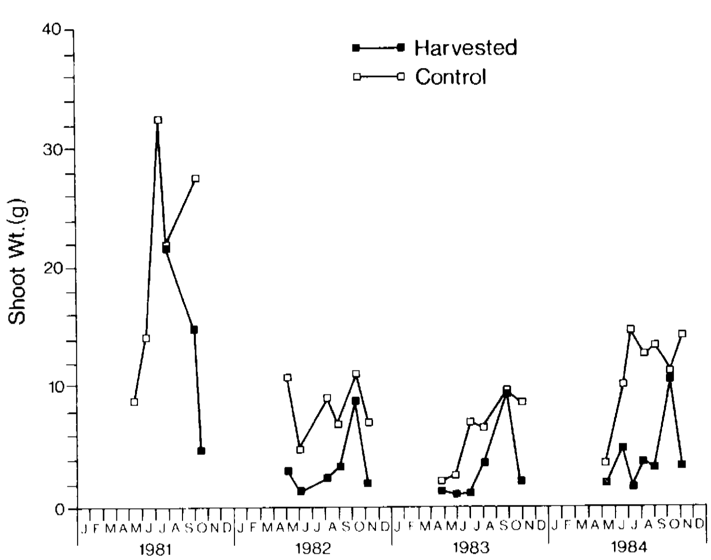

Figure 2. Eurasian watermilfoil shoot weight (g) in the control and harvested areas from 1981 to 1984. 1 S.E. = 13%.

Shoot phosphorus concentrations increased after harvesting in 1982 and 1984 and decreased after harvesting in 1981 and 1983 (figure 3). Painter and Waltho (1985) previously observed increases in shoot phosphorus after harvesting (1979 and 1980 in figure 3). Root phosphorus concentrations are generally similar between harvested and control plants (figure 4). Regardless of the effect that harvesting may have had on tissue phosphorus, tissue concentrations would appear to be high enough not to limit growth. Schmitt and Adams (1981) determined that photosynthesis would approach maximum rates at tissue phosphorus concentrations of 0.3% or 3000 μg/g DW (approx. 3333 μg/g AFDW). No trends in the shoot or root phosphorus concentrations were discernible over the four years of the harvesting experiment that would explain the drop in biomass as a result of harvesting or the poor growth in 1982.

Shoot and root total non-structural carbohydrate concentrations (Figures 5 & 6) were similar or higher than previously reported observations (Perkins and Sytsma, 1982; Titus and Adams, 1979). The predominate impact of harvesting on shoot and root carbohydrates was a reduction in the spring tissue concentraions. A reduction in the spring TNC concentrations as a result of a fall harvest has been previously reported (Painter and Waltho, 1985). The

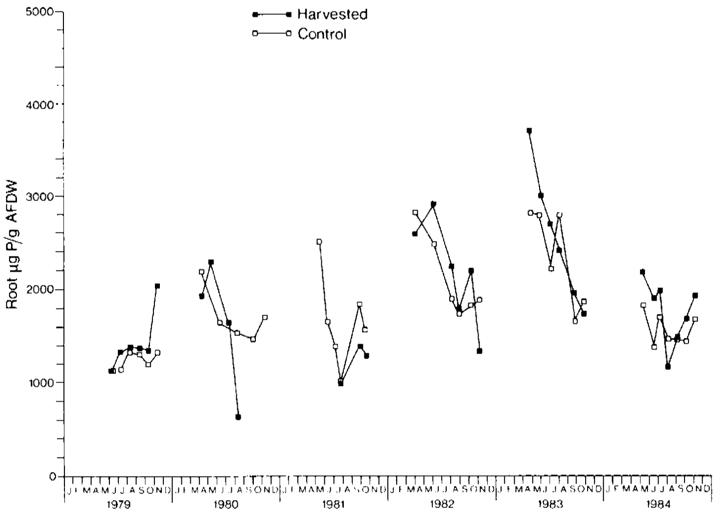

Figure 4. Eurasian watermilfoil root phosphorus (µg P/gAFDW) in the control and harvested areas from 1979 to 1984. 1 S.E. = 8.5%.

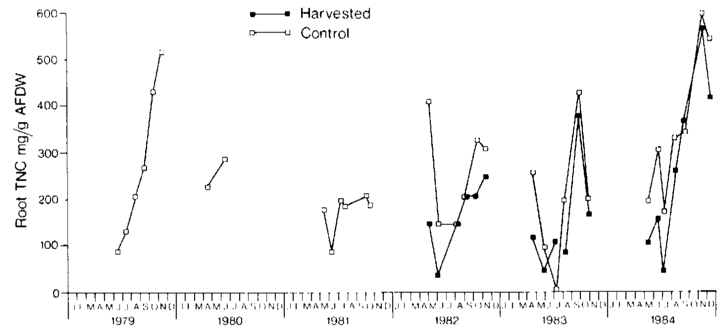

Figure 6. Eurasian watermilfoil root total non-structural carbohydrates (mg TNC/gAFDW) in the control and harvested areas from 1979 to 1984. 1 S.E. = 8.5%.

spring differences in shoot and root TNC concentrations between control and harvested plants were eliminated by mid-summer. The effect of harvesting on biomass did not appear to be related to shoot or root TNC trends during the four years.

Sediment biologically-available phosphorus concentrations were reduced only in the spring in the last two years in the harvested area compared to the control area (Figure 7). Phosphorus fractionation analysis of the surficial sediment from the spring period during the six years confirmed that the BAP and total inorganic phosphorus concentrations were reduced in the last two years and the CDB phosphorus fraction was reduced in the last year in the harvested area (Table 2). The total phosphorus concentration averaged 1373 µg P/g over the six year period. This concentration was twice as high as was observed in L. Wingra (Prentki, 1979) but was similar to the Great Lakes (Mayer and Williams, 1981). Prentki reported that L. Wingra sediments were roughly 50% organic and 50% inorganic phosphorus, whereas, Buckhorn Lake sediments are roughly 70% organic and 30% inorganic phosphorus. The total inorganic phosphorus concentrations in the two lakes were similar (400 µg P/g) but in L. Wingra more than half of the inorganic phosphorus was residual (apatite) phosphorus. In Buckhorn Lake only 25% of the inorganic phosphorus was residual, leaving 75% as potentially available for uptake. Since the shoot and root phosphorus concentrations did not appear growth-limiting throughout the study, the concentrations of phosphorus in the sediments of both the harvested and control areas also does not appear to be growth-limiting. Harvesting appears to have had an effect on the readily available sediment phosphorus fractions in the last two years of the four year harvesting experiment but the reduction in sediment phosphorus did not appear to translate into a reduction in tissue phosphorus concentrations. Therefore, the reduction in the sediment phosphorus fractions cannot explain the impact of harvesting on the biomass of milfoil.

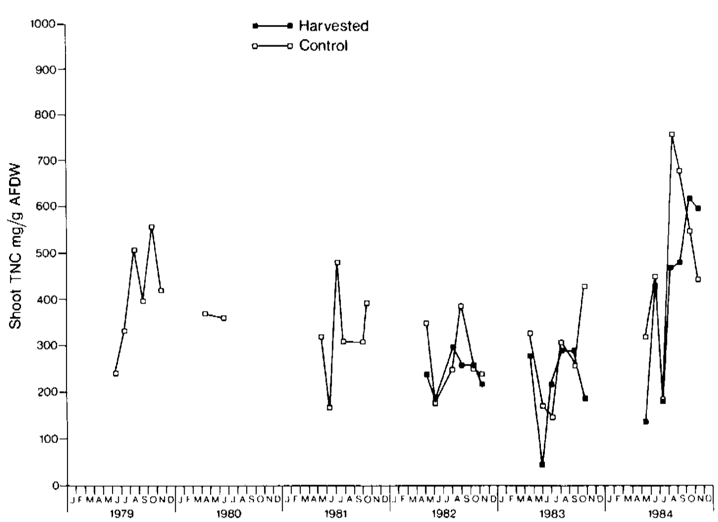

Figure 5. Eurasian watermilfoil shoot total non-structural carbohydrates (mg TNC/gAFDW) in the control and harvested areas from 1979 to 1984. 1 S.E. = 8.5%.

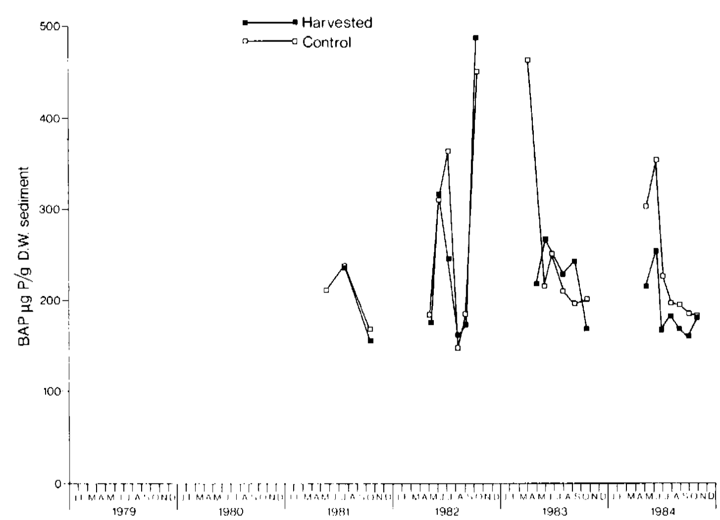

Figure 7. Biologically available phosphorus (µg P/g DW) in the surficial sediment in the control and harvested areas from 1981 to 1984. 1 S.E. = 13.7%.

TABLE 2. SURFICIAL SEDIMENT PHOSPHORUS FRACTIONS FOR THE CONTROL AREA (C) AND HARVESTED AREA (H) FROM 1979 TO 1984. PHOSPHORUS CONCENTRATIONS ARE IN µg/gDW. CDB-P IS CITRATE-DITHIONATE-BICARBONATE EXTRACTABLE PHOSPHORUS. NaOH-P IS 1 N SODIUM HYDROXIDE EXTRACTABLE PHOSPHORUS. TOTAL P IS 1 N HCl EXTRACTABLE PHOSPHORUS ON AN ASHED SAMPLE. TIP IS TOTAL INORGANIC PHOSPHORUS. BAP IS BIOLOGICALLY-AVAILABLE PHOSPHORUS EXTRACTED WITH 0.1 N NaOH. 1 S.E. = 13.7%.

	CDB-P		NaOH-P		Apatite-P		Total P		TIP		BAP	
	C	H	C	H	C	H	C	H	C	H	C	H
79	90	—	23	—	140	—	1113	—	415	—	—	—
80	49	—	78	—	105	—	1176	—	381	—	—	—
81	318	—	85	—	103	—	1581	—	489	—	212	—
82	178	298	81	61	110	76	1543	1528	395	477	183	175
83	95	111	74	71	75	92	1586	1307	422	289	453	219
84	330	181	90	70	105	105	1262	1136	431	260	303	218

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Residues and Efficacy of Two Formulations of 2,4-D on Aquatic Macrophytes in Buckhorn Lake, Ontario

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ABSTRACT

Efficacy studies and monitoring of 2,4-D residues in sediments, water and plants in Buckhorn Lake, Peterborough County, Ontario, (1977-79) indicated no significant differences in the effectiveness of the use of BEE 2,4-D or DMA 2,4-D. Early season treatments with either herbicide, seemed to offer slightly better control of aquatic macrophytes than treatments later in the season. Herbicide treatments coupled with harvesting (1977 only) did not show significant differences to treatments without the harvesting carried out at the same time. Residues persisted throughout the summer months in all of the plots tested. The problems of unauthorized use of 2,4-D prior to treatment and/or the effects of land drainage were indicated. Lateral movement or dilution of the chemical through the water was established.

Key words: Aquatic weeds, harvesting, lateral movement, persistence, 2,4-D amine, Myriophyllum, Potamogeton.

INTRODUCTION

Throughout the mid to late 1970's, aquatic macrophyte growth in the Kawartha Lakes district of Central Ontario was extremely high, covering an estimated 80% to 90% of the surface area of these highly used recreational bodies of water. Extensive aquatic macrophyte growth creates problems for shoreline residents and transient boaters over most of the Kawartha Lakes district in the Province of Ontario. The exotic macrophyte, Eurasian Water Milfoil (*Myriophyllum spicatum* L.), hereafter called milfoil, is of increasing concern.

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