The State of Maryland requires that permits be issued for the applications of toxic materials to waters of the state for aquatic plant control. Such permits were obtained for the application of 2,4-D during 1967, 1968, and 1969. The state became aware of the application of diquat during 1968 after a visit to the installation in 1969. The installation was informed by the state that a permit was required for this type of work and requested that in the future, applications for permits be made.

SUMMARY

Currently there is no problem with Eurasian watermilfoil in the Bush River on the eastern side of the Edgewood Arsenal installation. There still is considerable Eurasion watermilfoil infestations in the Gunpowder River on the western side of this installation. There is speculation that a disease organism has eliminated the Eurasian watermilfoil from the Susquehanna Flats and the Bush River; however, it is not known if this has been confirmed. Since there is no longer a problem in the Bush River and this aquatic plant in the Gunpowder River appears to be contained and not spreading, no recent control measures have been taken. The installation has also been reluctant to enter into discussions with the state relative to who has jurisdiction over water areas within the installation boundaries and the necessity for obtaining permits for treating these waters.

In noxious aquatic weed control, our objectives and those of this society are most certainly the same. We extend to you the offer of complete cooperation in future endeavors.

Control Of Watermilfoil In Large Wisconsin Lakes[1]

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ABSTRACT

Studies conducted in Dane and Marinette Counties indicate that mechanical harvesting offers the most attractive means for large scale control of watermilfoil (*Myriophyllum* spp.). in Wisconsin lakes.

These studies examined chemical control, biological control, and habitat alteration as possible alternatives to mechanical harvesting. The reasons for the attractiveness of mechanical harvesting include the facts that this method is target specific, removes problem biomass from the ecosystem, leaves root systems intact, can actually improve fishing if planned intelligently, and is attractive from a political point of view. Estimates based on information supplied by the Wisconsin Department of Natural Resources and observations of the Dane County harvesting operation during the summer of 1970 place mechanical harvesting at one-half to one-third less than the least expensive acceptable chemical alternative, provided at least 200 acres of problem plant growth are involved. Updated estimates on rates of harvesting, and costs of harvesting, labor and maintenance suggest that these original calculations may have been too high. Some operational problems encountered in carrying out mechanical control of aquatic plants are discussed. Despite the attractiveness of mechanical harvesting, on a long term basis only enlightened shoreland management will solve the problem of watermilfoil in Wisconsin.

INTRODUCTION

Among the symptoms of accelerated eutrophication perhaps the most obvious is the proliferation of aquatic macrophytes. In our studies, Eurasian watermilfoil (*Myriophyllum spicatum* L.) and the variable watermilfoil (*M. heterophyllum* Michx.) have been identified as particularly offensive nuisances. These plants, which thrive in fine-grained sediments and muck bottoms in 1 to 4 m of water, are extremely aggressive competitors, capable of crowding out more desirable plant species and of growing as monocultures (16). Although there are differences in the ecological requirements and the life histories of the two species, both reproduce rapidly by means of four-seeded fruits and fragmentation. Variable watermilfoil also appears to be capable of producing winter buds, or turions, in the late fall (4). Both plants reach densities in excess of 3 kg/m^2 (wet weight). This dense growth provides excessive shelter for small fish which leads to stunting of larger predator species. Thick growth interferes with recreation by entangling both swimmers and

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outboard motors. Also, the esthetic appreciation of affected lakes is undermined by masses of decaying vegetation that wash ashore in autumn. On the positive side, the root systems of watermilfoil stabilize loose organic sediments, and the upright stems reduce turbulence and wave action. The net effect is improved water clarity. Such an increase in clarity was observed in Lake Noquebay in Northeastern Wisconsin where Secchi disc visibility was 1.4 m in 1942 and had improved to 3.4 m in 1971, coincident with the development of a heavy infestation of variable watermilfoil. Watermilfoil may also play a role in inhibiting the growth of filamentous algae (9, 14, 16). Watermilfoil, if present in low densities, provides shade and shelter for young fish and supplies a low grade waterfowl food source (8).

Generally, three alternatives are available for aquatic weed management. Decision makers may take no action, may initiate "cosmetic" programs, or may attempt to control human activities which aggreviate eutrophication problems while also attacking the symptoms of the malady. The third alternative involves comprehensive shoreland management and sound watershed planning (4).

The first alternative might appear desirable from a short-range viewpoint, for the other two will involve heavy expenditures of funds and time, and inevitably some political consequences. However, over a longer time period this alternative is vastly more expensive than any other, judged on either economic or political criteria. To illustrate, our estimates place the value of Lake Noquebay to the Marinette County, Wisconsin economy at around $1,000,000 annually (to the best of our knowledge, no one has the courage to estimate the dollar value of Madison's five lakes but a summary of their situation was reported by Hasler and Ingersoll in 1968). Our data further indicate that the weed problem on Lake Noquebay is growing worse each year, and survey results reveal that riparian owners and tourists are contemplating moving their activities (and their money) to greener pastures —or, in the case of lakes, to pastures not so green! This will inevitably result in a decline in the tourist industry, in property values, and in tax base which is sure to intensify existing political pressures. Finally, experience reveals that the longer a rational program is delayed, the more difficult and expensive aquatic weed management becomes (11).

BIOLOGICAL CONTROL

Biological control appears highly desirable for control of some problem species. Among other organisms, the crayfish (*Orconectes causeyi* Jester) has been successfully employed in the elimination of macrophytic vegetation in New Mexico (7). The slender spikerush (*Eleocharis acicularis* (L.) R. and S.), which forms a dense, short carpet, has shown the ability to outcompete less desirable macrophytes in California (16). The white amur (*Ctenopharyngodon idellus* Val.), a herbivorous fish, appears promising in experiments in Arkansas (1). Eurasian watermilfoil in the Chesapeake watershed has been controlled naturally, apparently by two unknown diseases (2). However, the introduction of a new species into an ecosystem may bring unexpected side effects. For example, turbidity increased two-fold after the crayfish controlled macrophytes in the Southwest (7). Also, introduced species may attack a broad variety of aquatic plants rather than a single nuisance species. Therefore, management agencies have been understandably slow in granting permission for the introduction of exotic species into lakes.

HABITAT MANIPULATION

Habitat manipulation in Wisconsin has generally involved either winter drawdown or dredging. While winter drawdown appears promising for inexpensive control of shallow-water plants in certain lakes (3), watermilfoil's relatively deep water habitat and its ability to produce "landforms"[2] render this technique ineffective in watermilfoil control. Dredging would doubtless be effective in controlling watermilfoil (17), especially variable watermilfoil which requires finegrained organic sediments.[3] However, dredging is extremely expensive. A minimum estimate for the employment of this technique in Lake Noquebay is $1,016,400 exclusive of trucking and onshore disposal costs. Also, dredging would result in significantly increased turbidity, accompanied, perhaps, by a shift in primary production favoring the phytoplankton (13).

CHEMICAL CONTROL

Two alternatives offer hope for controlling watermilfoil in Wisconsin in the immediate future. The first involves the employment of chemical herbicides, which traditionally has been considered the least expensive of available control methods (18). It does, however, possess certain drawbacks. First, chemical destruction of weed beds, by failing to remove plant material from the lake, adversely affects water quality. As the weeds decay in place, bacteria consume oxygen essential to fish life. Conservative estimates of the quantity of plant material constituting a problem in Lake Noquebay lie between 1,300 and 2,070 tons. The decay of such immense quantities of organic matter would without a doubt involve fish kills resulting from oxygen deficits as well as aesthetic problems when decaying masses of dead plants drift inshore (6). Second, the employment of toxic chemicals on such a large scale could damage game fish directly and would certainly threaten the food chain upon which the sport fishery is dependent (15). Finally, recent evidence indicates that successful chemical control of large quantities of rooted aquatics can lead to increased levels of nitrogen and phosphorous in the water column and favor phytoplankton blooms (6). Politically, chemical control is also unattractive at this time because of the newly awakened environmental awareness of the public. An ordinance already exists prohibiting the employment of chemical pesticides in the Madison lakes. We further seriously doubt that it would be possible to obtain approval from the Wisconsin Department of Natural Resources for treat-

[2]Stanley, R. A., 1971, personal communication.
[3]Steenis, J. H., 1970, personal communication.

ment of areas as large as many Northern Wisconsin lakes require.[4] Moreover, should such approval be forthcoming, treatment of the beds in Lake Noquebay with the granular form of the potassium salt of 2-(2,4,5-trichlorophenoxy) propionic acid (silvex), the least expensive state-approved chemical we feel could do an effective job, would cost at least $30,548 annually including labor, supervision and equipment. This figure is based upon an average cost per acre-foot of $18, and water depth averaging 8 ft (2.5 m). The cost per acre-foot was computed by the Wisconsin Department of Natural Resources from manufacturers specifications and the average of manufacturers recommended retail price.[4] During the period the chemical is being applied both swimming and fishing would have to be prohibited; swimming for 1 day and fishing for 3 days following treatment (19). Treatment would require 1 to 2 weeks depending on the weather. The implications of such a program for the tourist trade are obvious.

MECHANICAL CONTROL

A final method for controlling aquatic vegetation is mechanical harvesting. Mechanical harvesting leaves root systems intact and, in our experience, does not produce significantly increased turbidity. Since vegetable material is removed from the lake, the problems of oxygen stress, phytoplankton blooms, and the accumulation of unsightly masses of decaying vegetation are avoided. Because no toxic materials are employed, dangers of fish kills or damage to sport fishing are not present. In fact our observations lead us to believe that fishing is improved by opening channels through the weed beds. Politically the procedure is also attractive. Invariably drawing a crowd wherever they are employed, weed harvesters provide a constant reminder of action taken to improve the environment. A recent survey conducted by the Dane County Administrator at the County Junior Fair queried taxpayers concerning the mechanical harvesting program. Of 1,370 replies 1,139 felt that the service should be extended, 179 suggested that present levels of spending should be continued, and only 52 felt that the program should be cut back. Those who are familiar with County government consider this an overwhelming indication of political support for the program.

COSTS OF MECHANICAL CONTROL

On the basis of Dane County's experience the costs of mechanical harvesting appear to have been overestimated in the past. We used cost data collected on the Madison area lakes during the summer of 1971 to calculate expenses involved in complete control for all areas of problem growth in Lake Noquebay where 210 acres of variable watermilfoil were causing problems. These expenses, according to our computations, would amount to $22,190 per year including labor, and trucking and amortizing equipment costs ($51,000 for the most expensive system available today) over a 5-year period. This averaged out to slightly over $100 per acre.

However, during the summer of 1971, Dane County, with an equipment acquisition budget of $39,482 and an operations (labor, maintenance, trucking) budget of $35,337 was able to harvest a total of 3,500 acres. This indicates that Dane County was able to control watermilfoil for a total cost of $21.38 per acre or an operational cost of $10.10, significantly less than the data from the preceding year had led us to anticipate.

A combination of factors was responsible for Dane County's success in 1971. Probably the major factor was increased experience in weed harvesting operations—the program, inherited from the city of Madison, entered its second year during the summer of 1971. Another major factor was improved equipment. During the second summer Dane County operated two relatively new systems (a Grinwald-Thomas GT 501 harvester with GT 471 Craneveyor and 2 transport barges manufactured in 1968, and a 1970 Aquamarine H650 harvester with T 650 transporter), as well as two very old systems which had been used by the city of Madison—a 1963 Aquatic Controls harvester and a Hockney Shoreline cutter of indeterminate age (valued at $100).

UNSOLVED PROBLEMS

While mechanical harvesting appears to be a viable alternative at present, there are still considerable areas requiring improvement in the system and the operation. Among these areas perhaps the most serious is the necessity of hauling aquatic plant material (which is 90% water) to a land fill site sometimes many miles distant from the lake. During the summer of 1972 a system developed for reducing the volume and weight of harvested weeds (12) was tested operationally with considerable success. Further, chopped, dewatered watermilfoil met with initial public acceptance as a soil conditioner in conjunction with these tests, and as a result, we expect that trucking costs can be significantly reduced during the summer of 1973.

Additional problems lie in the relatively slow harvesting rate (approximately 1 mile per hour) of the present generation machinery. This slow harvesting rate means that on large lakes an entire summer is consumed in the weed control operation. Lesser problems involve the relatively easily damaged cutter bar particularly in lakes filled with underwater obstacles and the necessity of clearing the cutter bar when it becomes clogged with filamentous algae. The operation tends to be strongly weather dependent and thunderstorms or winds in excess of 5 miles per hr cause problems. Many of these problems should be solved with a newer and simpler generation of machines which will render handling of harvested weeds an easier task and reduce the need for extensive mechanical support (12). In our opinion the present generation equipment is equivalent to the early automobile—still somewhat expensive and with considerable room for improvement. Given the continued growth of problems with rooted aquatics, we feel confident that these improvements are forthcoming.

THE REQUIREMENT FOR WATERSHED MANAGEMENT

Although mechanical harvesting appears to offer the

[4]Karl, G. 1971, personal communication.

best alternative for milfoil control in Wisconsin in the immediate future, it alone cannot slow the eutrophication process materially nor can it eliminate the causes of accelerated eutrophication. Only the control of nutrient and sediment inputs from the surrounding drainage basin will materially alter the course of accelerated lake ageing (5). Such activities as filling and dredging, wet-land development, septic tank placement, storm water control, and agricultural practice must be carefully manipulated if cultural impacts are not to produce additional intensification of watermilfoil and related problems. This control can only be achieved by a coordinated effort on the part of a variety of governmental entities ranging from the township level all the way to federal regional commissions and political and economic support from individual citizens. Citizen support will not be forthcoming until the general public achieves a far better understanding of the intimate linkages that exist between such problems as the excessive growth of watermilfoil and societal activities in the drainage basin. Our experience in Dane County indicates that this understanding comes naturally as eutrophication reaches intolerable levels, but unless it is to arrive too late to benefit Wisconsin's recreational lakes, a concerted educational effort must be initiated. The University Extension appears to us to be the agency best equipped to undertake this effort, though an expansion of its capabilities in the area of lake management either through new staffing or through close coordination with academic institutions possessing this expertise will be necessary.

CONCLUSION

Solving the watermilfoil problem on large Wisconsin lakes will require a two-fold attack. Weed control, demanded by the public, seems best effected for the immediate future by mechanical harvesting; a relatively inexpensive technique which is target specific, effective, and produces minimal ecological side effects. On a long term basis only enlightened watershed management, the result of the activities of an educated citizenry will save the lakes which are the foundation for the State's expanding recreation industry.

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