The basic member of Aquamarine's Aqua-Trio is the H-650 Harvester. It cuts a swath eight feet wide and five feet deep. Live bed hold packs weeds automatically, unloads automatically.

Effects and Costs

Aquatic Weed Harvesting

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SINCE the first weed harvesting attempts in the early 1900s, there have been many unanswered questions about the effects of weed harvesting. Even if harvesting is proved beneficial, perhaps an overriding question yet to be answered is that of the cost of harvesting.

It is the purpose of this article to show there are more benefits by harvesting than just the short term removal of the weeds and, secondly, to offer some definitive costs on the removal of submerged aquatics, using the latest harvesting systems.

Since a prime cause of today's weed problems is an over-abundance of nutrients in our waters, it would seem logical that a cutoff of nutrient input would effectively retard weed growth through nutrient starvation.

This weed-algae-nutrient relationship is being recognized. Massive expenditures on better sewage treatment, effluent diversion projects, separation of storm and sanitary sewer systems, and community sewage systems instead of septic tanks are a few of the positive efforts in this direction.

These efforts seem to be a losing battle, with population pressures building faster than our capabilities to cope. To compound our problems, the fertilizer industry has grown exponentially, nearly paralleling the seriousness of the weed problem.

A measure of the scope of the nutrient problem is the fact that 32 states reported production of 20 million tons of fertilizer from July, 1967, to June, 1968. Because of rising demand for wood and paper, the forestry industry is presently planning large scale forest fertilizing to promote "instant trees." A side effect will again be enriched water runoffs into lakes and streams! So, for the foreseeable future, nutrients will be entering our waters at an increasing rate, and weed crops will ever increase—nearly as a direct function of the nutrients present.

Mechanically or Chemically

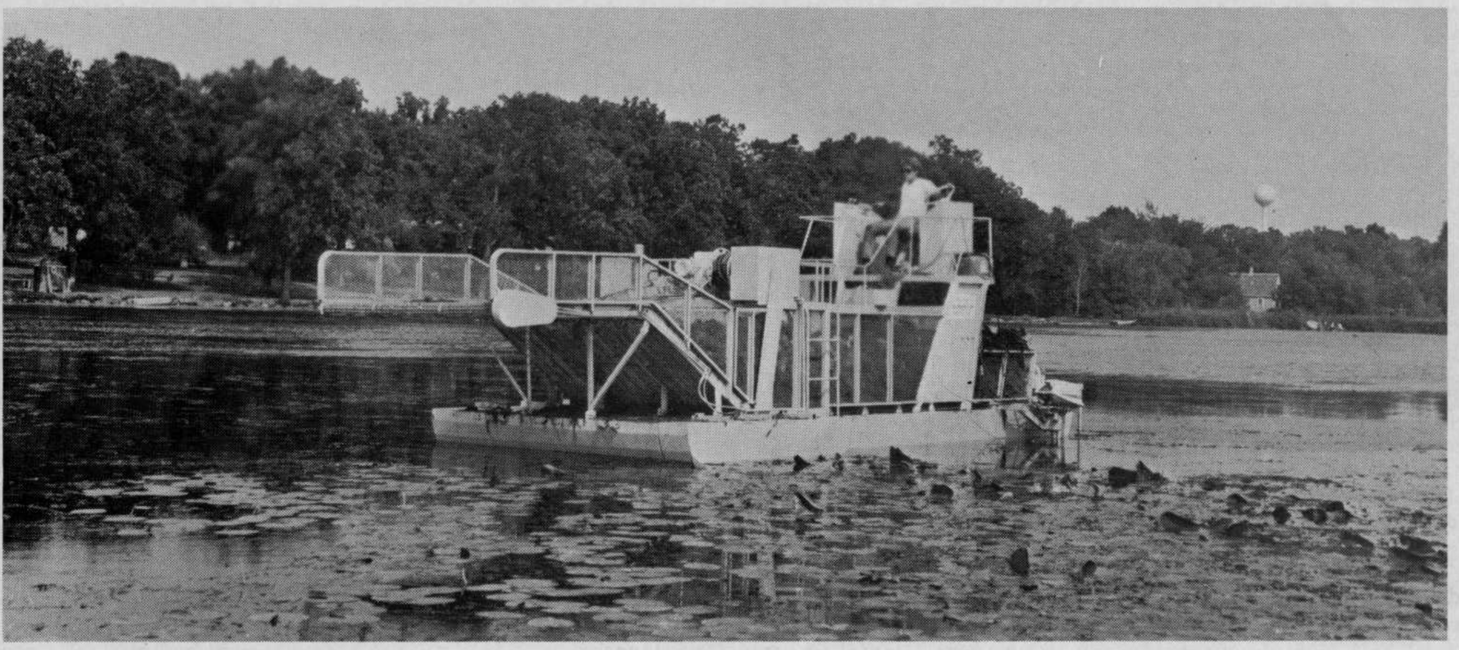
It then is evident that every person in a position of responsibility for weed control eventually has the choice of attacking cause or effect, i.e. nutrients or weeds.

The usual two choices commercially available to people with weed problems are mechanical weed harvesting or chemical herbicides: One attacks the nutrient problem (cause), and one attacks the weeds (effect). Very little has been documented about the former, leaving the field wide open for the latter—and the vacuum is being understandably filled by herbicide manufacturers, because herbicides **do** make weeds disappear.

Lack of documentation on the effects of extracting weeds from the water, plus the thin information available on costs of harvesting, are probably the two most damaging roadblocks to its universal acceptance. However, there seems to be a stirring of curiosity within the "anti-pollution community" to find out what harvesting does do to a lake now that some sophisticated harvesting equipment is being produced.

Weed-Harvesting Research

The Wisconsin Water Resources Center in Madison, Wisc., is presently backing a weed-harvesting research project in Lake Mendota. Professor Grant Cottam, of the Botany



Weeds are transferred from the Harvester automatically to the T-650 Transport, which in turn unloads automatically into the Shore Conveyor (next page).

Department of the University of Wisconsin, is in the third year of a project to analyze the effects of harvesting Eurasion Watermilfoil *(Myriophyllum exalbescens)*.

Monthly samples are cut from each of three one-hundred-squaremeter areas in University Bay. Comparisons are then tabulated against three unharvested control areas as regards density (stems/acre), stem length, and dry weight. Regrowth has been averaging less than 20 cm. per month and, most promising, "harvesting also produces an initial reduction of density since all the cut stems do not resprout in a month's time."

Since 99% of milfoil revegetation is through resprouting, removal of the weeds from the lake after cutting is a critical and necessary prerequisite. This is one reason why it is a Wisconsin state law that all weed-cutting programs must incorporate coincidental weed removal.

Although milfoil shows significant growth retardation after harvesting and a cut stem does not resprout in a month's time, what of other species? What if each cut end sprouts six new branches, as it has been said happens with elodea? One of two things (or a combination of both) can happen: If each sprig grows at the same rate as before harvesting, weed tonnage will be produced at six times the former rate in the same area, greatly reducing per-ton harvesting costs the second time around and accelerating nutrient removal. More likely the growth rate of each sprig will slow somewhat due to natural retardant effects of shading, crowding, and nutrient removal. However, net weed tonnage grown will still be largely proportional to the nutrients present.

M. E. Grinwald, who has been harvesting weeds for 20 years in Pewaukee Lake in Wisconsin, reports, "A 2000-foot channel, mechanically harvested for four years of heavy weed growth to open a public access to the lake, did **not** require harvesting a fifth year, while the weed growth on either side of the channel was as dense as ever.

A similar situation seems to have occurred in Rib Lake, Wisc., where after two years of harvesting, practically none was required the third year. Water clarity and fishing con-

Attachable wheels connect easily to the H-650 Harvester, making it quickly mobile. It's easily towed with a minimum loss of cutting time.

ditions have reportedly improved considerably."

Using Herbivore Not Feasible

The nutrients in our waters show up visibly in the form of weeds and algae. A great deal of research is being done to locate some herbivore with a yen for aquatic weeds or a water flea with a voracious appetite for algae. But does this not beg the question?

The successful location and transplanting of this manatee, flea, snail, or whatever, only removes the weeds from sight and transforms them into another form of nutrient on the bottom of the lake, or in solution, ready for another weed growth cycle. It might be argued that this is a better alternative than a solid, floating surface of hyacinth. But if we are successful in controlling the hyacinth without controlling the nutrients, nature will immediately fill the vacuum with elodea, milfoil, or worse.

In consideration of the nutrient problem, Professor A. D. Hasler, Director of the University of Wisconsin Limnology Department, ventured the following in "Natural History" magazine in November, 1968:

"The best that can be said for spraying chemical poisons on lakes in the grip of algae and weeds is that it is usually a futile undertaking. Treating a lake with copper sulfate or other toxic chemicals is no more effective than taking aspirin for a brain tumor. It offers only temporary relief, masking the symptoms of cultural eutrophication. In the long run it makes a lake sicker. Poisoning algae and weeds simply accelerates the natural process of growth, death, and decay, thereby freeing nutrients for another cycle of plant production."

Perhaps the weed problem is so staggeringly massive that we must close our eyes to accelerated cultural eutrophication in exchange for making the weeds go away for awhile. Lacking a potential alternate solution might justify shunting the eutrophication problem into the laps of our children and grandchildren. But harvesting of weeds on a big scale can potentially let us eat our cake and have it, too: Weed control plus nutrient removal.

Detroit Lakes Program

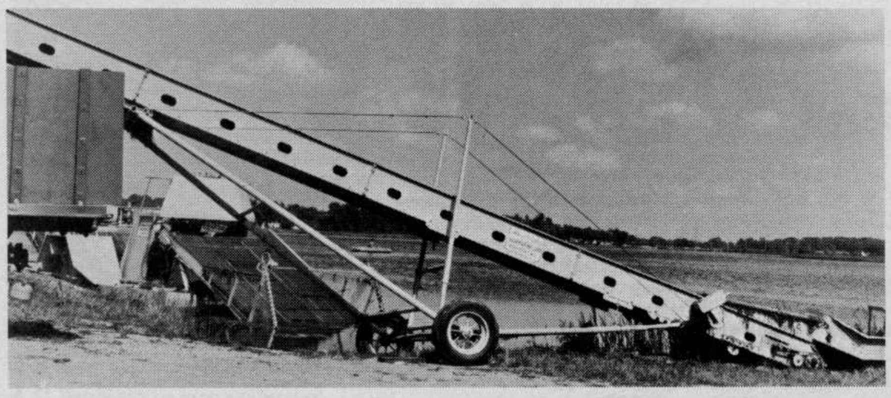
A three-year program to prove such a double benefit is presently under way at Detroit Lakes, Minn. Funded by $140,000, a joint venture of local groups, city and county governments, the Department of Interior, and the Minnesota Conservation Department, has purchased a harvester and is harvesting weeds in Lakes Sallie and Melissa, downstream from the Detroit Lakes sewage plant. It is their hope to remove more nutrients in the form of weeds in the summer months than flow into the lake in a year.

Harvesting Costs

In November of 1968, the City of Maitland, Fla., contracted with Aquamarine Corporation to harvest 20 acres of Florida Elodea as a demonstration of the new AQUA-TRIO system:

Conditions:

1. One 20-acre solid mat of Florida Elodea *(Hydrilla Verticillata)* 2 feet to 4 feet thick on surface of lake (acreage determined from scaled map of lake).
2. Density of freshly harvested weeds, compacted by their own weight in a 3-foot deep pile. 10 lbs./cu. feet.
3. Harvesting system used: AQUA-TRIO manufactured by Aquamarine Corporation, Waukesha, Wis., consisting of one H-650 Harvester, one T-650 Transport, and one S-650 Shore Conveyor, and one dump truck. Note that paddle wheels were furnished on the T-650 Transport instead of outboard motors shown.
4. Average run for transport



The S-650 Shore Conveyor loads weeds automatically into truck. Remote controls allow conveyor and transport to be operated from one position.

Steering mechanism is part of tow bar assembly and makes handling of Harvester easier.

barge—800 feet.

5. Average run for dump truck—1200 feet.

6. Manpower used: One harvester operator, one transport operator, one truck driver.

7. Harvester capacity of 650 cu. ft. loaded to 500 cu. ft., or 5000-lb./load.

Results are shown in Table I.

Conclusions

Before extrapolating these costs into any other waters or weed infestations, adjustments must be made to allow for changes in labor rates, weight of harvested weed, average weight of unharvested weeds per acre of lake, distance of weeds to shore conveyor site, dump truck haul distance, and design of harvesting equipment.

Significant cost reductions could be expected if Figure 1 is studied closely. Note that peek production was hit after the operators became experienced in the capabilities of the system. On Nov. 23, a rate of 9.3 tons per crew hour was achieved or $1.69 per ton cost. The balance of the harvesting was largely clean-up work, reflecting lower production figures and higher costs.

TABLE 1. Mechanical Harvesting Demonstration, Maitland, Fla.

Date 1968	Transport Loads Harvested	Crew Harvesting Hours **	Loads Per Hour	Tons Per Crew Hour
11/13	9.5	5	1.9	4.8
11/14	11	6	1.8	4.5
11/15	16	7	2.3	5.8
11/16	4	1	2.9	7.3
11/18	12	4.5	2.7	6.8
11/19	4	1.5	2.7	6.8
11/20	6	3	2.0	5.0
11/21	11.5	6	1.9	4.8
11/22	15	6	2.5	6.3
11/23	22	6	3.7	9.3
11/25	2	2	1.0	2.5
11/26	3	2	1.5	3.8
11/27	9	7	1.3	3.3
	Total 123	Total 57	2.2 Average	5.5 Average

* Loads and times independently tabulated by K. Downey, City of Maitland.

** Adjusted to account for down time, weather and demonstration delays.

Harvesting Rates:

1. Tonnage harvested: 123 loads at 2½ tons each = 307.5 tons.
2. Weed concentration per acre, average 307.5 ÷ 20 = 15.4 T/acre.
3. Man-hours expended in actual harvesting: 57 × 3 = 171 man hours.
4. Tons harvested, transported, and trucked away per man hour 307.5 ÷ 171 = 1.8 T/man hour.

Costs:

Equipment:	AQUA-TRIO	$44,000.00	
	Dump Truck	3,500.00	
		$47,500.00	
	Weekly depreciation on a 10-year basis		$100.00
Interest: $47,500.00 @ 10% =			100.00
Labor: 40 hours at $8.00/crew hour =			320.00
Maintenance and running costs (estimate)			100.00
	Weekly Cost		$620.00

Tons harvested, transported, and trucked away per 40-hour week:
40 hrs. × 3 men × 1.8 Ton/man hour = 216 Tons/week.
Cost per ton (Lake Maitland) = $620/wk. ÷ 216 Ton/wk. = $2.87/Ton
Cost per acre (Lake Maitland) = 15.4 Ton/acre × 2.87/Ton = $44.20/acre