FROM: pmaleady0786@charter.net
SUBJECT: Lessons Learned harvesting Water Chestnut and other aquatic vegetation.
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I'm writing this in response to comments during a CRC Zoom conference on Wednesday, 3Nov21.

Harvesting Water Chestnut (Trapa natans)(WC) and other aquatic weeds is hard, wet, dirty work. Records of doing so go back thousands of years. But you have to be willing to search literature in Chinese, Russian, Greek, Latin and various other languages to access them. There were notable pioneers in Eastern Massachusetts who were pulling WC almost fifty years ago. I have learned very little in the past that they did not document. It is all available on the internet. You have to be willing to do your homework. Unfortunately, we seem to live in an illiterate society.

I am an Operations Research/Systems Analyst, a biologist, linguist and retired Special Forces US Army Special Forces Officer. I consider myself a scientist, I observe things and ask and test why they are as they are. What follows is a list of Lessons Learned (LL).

LL1: You must remove what you harvest from the watershed. 100 feet in from the water line doesn't work. It must be disposed of where nutrients cannot drain back into the water body.

LL2: Kayaks don't work except to ferret out vegetation inaccessible to other vessels. Even when equipped with saddlebag or panier style weed baskets (consult G. Boetner) they can rarely carry more than fifty pounds of drained vegetation. They are far more effective if frequently relieved of their accumulated vegetation by a circulating power boat which transfers the vegetation to a shore collection point.

LL3: Canoe teams are better, especially if one member can Stand Up Paddle (SUP), look down into the water to detect the target vegetation, point her/his assistant to it or harvest it with a paddle fork. Polarized sunglasses may help you pick out the targeted vegetation. Canoes can also carry hundreds of pounds of drained vegetation. They can collect vegetation from kayaks and transfer it to powered weed transports.

LL4: A PaddleFork is a nylon manure fork I mounted on a shaft with a canoe paddle on the other end. It allows a crew to paddle to the targeted weeds, lift them up, drain them somewhat and dump them into a boat without having to switch back and forth from paddle to harvest fork. (consult me).

LL5: A weed transport is typically a large canoe or small boat with a team aboard powered by a small outboard engine or trolling motor. It can typically carry over a thousand pounds of weed and safely and easily transfer it to the shore. I've used a 17' Grumman Bob Tail Canoe for this, an aluminium speedboat, 1436 and 1336 jon boats with mud motors and an 18' airboat as weed transfer boats.

LL6: A plastic collection bag should have its bottom corners cut off so that it drains. Do this before you hand them out.

LL7: A laundry basket with a strong, defined rim will hold a collection bag open making it easier to dump harvested weed into it.

LL8: Weed collection bags will drain into your boat. Eventually a lot of water can collect in a boat. No kayak, canoe or other boat should go out without a bailer. I made a rechargeable, battery powered, bilge pump contained in an ammunition can that does an excellent job pumping out a larger boat.

LL9: The most suitable boat for harvesting aquatic vegetation is a jon boat. The flat hull form is stable if you aren't too stupid about how far you lean out. Avoid those who frequently fall out of their boats! Jon boats are categorized by their length and bottom width. A 1232 is 12' long and 32" wide. That's smaller than your average canoe; too small. A 1436 is 14' long by 36" wide. It makes an excellent harvest boat that virtually anyone can handle when powered by a small outboard engine or trolling motor. It has about the same capacity as a 16' long, 32" wide canoe but is much more stable and draws less water in the shallows. It is much safer and easier to nose onto shore and unload. A 1636 jon boat is a handful for a less than skilled pilot. Think of trying to turn an 18' canoe in a stiff breeze.

LL10: Electric trolling motors suck. The require heavy batteries which eat up cargo capacity and are extremely prone to weed clogging their propellers. They require constant stopping and untangling. They are ubiquitous and inexpensive but you must add the cost of batteries and chargers to them. They are quiet unless operated at full throttle when they whine and overheat.

LL11: Outboard engines suck. They are prone to weeding up and need to be constantly stopped, untangled and restarted. Most are water cooled and the cooling ports become clogged with vegetation fragments causing the engine to overheat. That condition is difficult to clean out when out on a river drifting towards a power station dam. An outboard engine, properly throttled is no louder than a lawn mower. Unfortunately they can be very annoying at full throttle and tend to disturb the bottom.

LL12: Mud motors are good. They are specifically designed to operate in shallow, vegetation clogged waters. A 6.5hp mud motor costs more than an outboard but will last, with proper care, for many years. They are air cooled and are easy to muffle and because they run on the surface, disturb the bottom less.

LL13: Airboats are cool. Properly handled, they can be quite stealthy and they do not disturb fragile bottom ecologies. The drive does take up a lot of room in a boat and they require excellent piloting to be safe around a harvesting crew.

LL14: Pontoons are perhaps the most effective harvest boats because they allow the crew to observe the operation of tools in the water. I can also build a 12' long pontoon boat for a fraction of the cost of other hulls. (Consult me about AVCH.)

LL15: Harvest early and often rather than late. The seems so obvious. You need to understand the reproductive biology of the aquatic vegetation you are harvesting. You need to short circuit it and harvest the vegetation before it has a chance to develop reproductive stems, seeds, turions, tubers or rhizomes. The biomass of your harvest is not a meaningful measurement. It is the number of reproductively capable plant parts relative to the mass that is meaningful. A ration which changes throughout the reproductive season. Yes, you should weigh your harvest on a good scale but you also need to count the number of plants relative to the weight. Why did it take me years to convince people of this?

LL16: Let's discuss fragmentation. The plant is already in the water. 100% of its reproductive mechanisms are in place. Anything you harvest reduces that percentage. If your harvesting produces reproductively capable fragments you obviously should capture them. However, you should also understand that fragmentation is only a problem when you create more reproductive units than originally existed. What is a viable reproductive unit? It is a mature seed, a mature turion, a sufficiently long stem to not die back, it is a fragment with roots (a miniature plant). A WC fragment, to be viable, must contain at least three leaf/root nodes. The stem will die back to the two extreme nodes. The center node, depending how it is stimulated, can grow into a new plant. Hence your harvester must be able to capture WC fragments about 3-4" long. The same is true of other aquatic vegetation. Your Hydrilla harvester must be able to capture any mature turions.

LL17: Aquatic mowers are good only as much as you use them. Mowers make viable fragments by definition because they don't remove growing root systems. So you need to cut them back down throughout the season. You have to mow your water body the way you mow your lawn. But a single person in the properly equipped boat can manage WC in a large water body in a fraction of the time it takes with current methods of hand harvesting. (Consult me about AVCH.)

LL18: Razor cutters are effective but extremely dangerous. Too dangerous to be used by non-professionals or otherwise unsafe personnel. It is fun to buzz through the weeds magically parting them but then you have to go back and harvest them up.

LL19: The hydraulic trash pump harvesters I use will effectively harvest the essentially rootless Coontail (Ceratophyllum dimersum) I designed it for. It will harvest immature WC, Elodea, Milfoils, Hydrilla, etc. Mature, tough stemmed plants may require cutting first. The harvested vegetation is typically about a centimeter long piece of shredded vegetation.

LL20: HydroRakes by any name are dredges, indiscriminate bottom ecology destroyers.

LL21: I am currently working on a conveyor harvester. It is basically a miniature Weedoo Aquaharvester. It may be effective against thick surface vegetation such as is found in Log Cove in Holyoke.

LL22: One of the fundamental mistakes made by harvest managers is to tie up expensive equipment while transporting harvested vegetation to the shore. A large project requires a variety of appropriate tools. So if you are lucky enough to have a Weedoo or Conte Harvester, you need a small fleet of half a dozen weed transport boats and a shore crew with ATVs and dump trailers to support it. The last thing you want is an expensive piece of equipment idling because it has nowhere to offload. You don't just need equipment and tools, you need teamwork.

LL23: Drawdowns do not work effectively against WC. You can desiccate mature water chestnuts, seeds, for sixty days, rehydrate them and freeze them solid for three months and they will germinate at 78%. The only thing I know that kills them are rodents eating the exposed nuts. Yes, North American rodent species do eat Central Eurasian WC!

LL24: WC is a surface plant. It shades the water under it. If you remove it, more sunlight will penetrate deeper into the water. The water will warm. SAV will receive more energizing sunlight and grow more vigorously. It may reach the point where it saturates it's niche and exhausts the O2 level of the water. Unless there is good circulation the water may become anoxic. What grows in anoxic water? Cyanobacteria. The explosion of Cyano blooms is clearly related to warming. And, by wholesale removal of WC, we are exposing our waters to warming.

LL25: What will replace the plant you are removing. If you remove WC what will grow in its place. In my experience, generally SAVs. You may get lucky and other invasives like Nymphia (European White Water Lily), Nuphar (Yellow Water Lily), Brasenia (Watershield), might move in in time. But most likely you'll get SAVs like Hydrilla.

I call this the Dandelion Parable: if you kick a dandelion out of your lawn, what will grow there next? Probably another dandelion. Or maybe crab grass, stinging nettles, thistles or wild rose bushes! The only way you'll get grass is if you plant it.

So suppose you fostered and deliberately planted the vegetation you want to replace the WC you are removing. Might you not have a healthier, more diverse water body?

LL26: Brasenia schreberi (Watershield) exhibits allelopathy and phytotoxicity. It may outcompete WC. There is rarely WC in the presence of Brasenia. It is the perfect native invasive surface plant with which to supplant WC.

LL27: Don't get giddy after three or four years of success against WC. The seeds last from seven to twelve years and can still germinate. But suppose you get to the thirteen year mark and can't find any WC. Is it over? Not while a goose can fly in with a WC seed caught on its feathers. Face it, WC is endemic. It may well be naturalized. It's still invasive but it's not so alien.

LL28: WC has a peculiar relationship to SAV. I became aware of this when I was comparing the growth rates of WC and Nymphia. In the absence of SAVs, Nymphia, propelled by its biochemical rhizomaceous batteries, out raced the WC to the surface and crowded out subsequent WC growth. But in the presence of SAVs, the WC won out. I had to snorkel down into the very cold Spring water to see what was happening. WC nuts were hooking onto the SAV. As it grew, the SAV raised the WC nuts into warmer water and greater sunlight. They germinated earlier and reached the surface before the collocated Nymphia did. I call this my Elevator Hypothesis.

This may somewhat explain the propensity to find WC collocated with SAVs like Hydrilla.

LL29: What to do with the harvested vegetation. I take it home and compost it for ornamentals.

LL30: WC can be identified from satellite photos because of its characteristic growth patterns and IR reflectivity. Drone surveys are useful and would be more so if they were integrated into a WC scouting program. A crew can survey a water body in minutes instead of hours and specifically target infestations using GPS coordinates. The coordinates can then be forwarded to a central facility and harvest crews dispatched as required.

LL31: Envoi: La plus ca change, la plus c'est le meme chose. Who is going to bother reading and learning from this?