Elodea in Yenisei River, Russia - [new section, we need to talk about this case study, very well scientifically researched and documented elodea because of the river's "issues", i.e. there are many tests and studies of the elodea as baseline data for radioactive contamination for example]

Elodea canadensis lives in the Yenisei River. —The Yenisei River rises in Mongolia and discharges to the Kara Sea. Also known by the name Yenisei-Angara River System, the catchment area ranks the Yenisei Basin as the fifth largest drainage area on Earth, at 2,580,000 square kilometers. Under a strong continental climatic influence, the basin is subject to very wide seasonal temperature variations, with some locations such as Krasnoyarsk subject to summer temperatures regularly exceeding 30 degrees Celsius and winter temperatures typically below minus 30 degrees Celsius (86°F Fahrenheit); moreover, northern portions of the catchment attain winter extremes below 60 degrees Celsius (139°F Fahrenheit), while southern reaches are frequently above 40 degrees Celsius (104°F Fahrenheit) in summer. The Siberian Arctic rivers are the most polluted Arctic inflows, discharging over one hundred times the pesticide and herbicide loads of North American and Scandinavian rivers. This trend was initiated with the communist regime and its program of centrally planned large scale military and industrial use of the Yenisei River. 31

Figure 16: Location and extent of the Yenisei River, Source: Encyclopedia of Earth

6.2 Alaskan Elodea's DNA Footprint & Common Hybridizing

A specimen from Chena Slough was sent to the University of Connecticut for DNA analysis. Researchers found that while the sample exhibited all the physical characteristics of Elodea canadensis, in fact, it was discovered the sample actually exhibits the overriding DNA characteristics of Elodea nuttalli. Further discussion and research on the matter reveals that Elodea canadensis and E. nuttalli frequently hybridize as Elodea is a plant that is easily cross-bred with other Elodea and is highly adaptive to its environment.

According to the Minutes of the January 31, 2013 meeting of a committee (Freshwater Aquatic Invasive Species committee of CNIPM) that has been formed out of the Non-Native Plants Industry with additional agency and District personnel from across the state, as well as a representative of the SeaLife Center in Seward, Dr. Les has informed the Fairbanks CWMA that he is "questioning native/invasive status because of the presence of both male and female plants in Chena Lake, which is uncommon in plant introduction scenario."

Also in the minutes from January 31, Dr. Les has confirmed both canadensis and nuttalli are present in Alaska, confirming the findings of the ASWCD. The group suggested to all members that from now on all DNA samples be sent to Cecil Rich at the USFWS for submission to experts, presumably also a control-point for analysis documentation on the return.

"Darcy reported that Dr. Don Les of University of Connecticut processed additional Alaska Elodea samples this fall. Though there is some confusion about the morphology of the samples, we now know both Elodea canadensis and Elodea nuttallii are present in Alaska. It also appears that the Chena Lake infestation is comprised of both male and female plants.

Dr. Les is also questioning the native/invasive status because of the presence of both male and female plants in Chena Lake, which is uncommon in plant introduction scenarios. Cecil pointed out that the pattern of discovery (urban areas and high plant density) and lack of identification in past Alaska vegetation surveys is good evidence toward its invasive status, but thinks we should leave definitions ambiguous until we have a more definitive answer.

Dr. Les has requested more Alaska Elodea samples this summer to sort out the morphological vs. genetic identification confusion, especially with flowers for identification purposes. Cecil offered to be central point of contact for samples that go to Dr. Les."

Part of this discussion is somewhat-intuitive in the thought that if two varieties have hybridized often enough that we're seeing the 'Alaskanized' Elodea that has adapted to its environment and evolved, the two varieties have likely been in close proximity for some amount of time, with the presence of both female and male plants.

Discussion regarding the presence of male AND female plants is of significance when discussing the hybridized version seen in Alaska. Male plants are necessary for
hybridization to occur. For example, it is widely reported that the United Kingdom’s Elodea population is unable to hybridize because for reasons science has not yet answered, there are no male plants present in the area.

Continued work with Dr. Les has revealed one of the Sand Lake samples submitted for DNA analysis revealed a unique DNA sequence not before seen in North America. Work with Dr. Les needs to continue, but has been postponed due to lack of funds.

Hybridizing of two closely related species is not uncommon in Alaskan conditions and there are many examples. Alaska’s Sitka spruce and white spruce cross-breed (hybridized) on the state’s Kenai Peninsula and other Southcentral Alaska locations, including southern forests of the Municipality of Anchorage. The hybrid, known as “Lutz” spruce, named after the research forester who identified it, has narrower crowns and wood that shows yellow and tan color variations; this color is variation between the more conventional white wood (from white spruce) and the yellower or brownish color of Sitka spruce.

Foresters generally identify the species by its location, first of all, and also by closer inspection of spruce cones. Cone scale margins on Lutz cones usually display a variation of smooth (similar to white spruce) to feathery or finely toothed margins (similar to Sitka spruce), all on the same cone. While research shows this hybridizing behavior to be rare to the southern boundary of natural spruce populations (one reported in Minnesota), it is commonly known to occur in Alaska.

The two species have been around Southcentral for at least 800 years, with the oldest known Sitka spruce in or near Kodiak from about 1570 – the Kenai Wildlife representatives note most of Alaska was glacier about 8,000 years ago, based on reasonably close-by core samples in the TAPS right of way (for example the Lodgepole Pine pollen present before last glaciation). The point being, Alaska is not new to hybridization, and it is in fact rather common in our climate as plants/vegetation strive to adapt for survival.

We have discovered that botanists in the United Kingdom have been unable to find any hybridization in their area as there are no male plants present - we have attempted to ascertain why this condition exists but have been unsuccessful. However, it is significant to note that one of the pieces of evidence in favor of a non-introduction scenario (native or naturalized) is the presence of both male and female plants, as discussed in this report.

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32 Leslie A. Vireck, Elbert L. Little, Jr., Alaska Trees and Shrubs, Second Edition
6.3 Summary of Position Regarding Native Status

We should start this section by correcting a mischaracterization that was assumed by some and perpetuated through gossip, unfortunately impacting the process for this project. The ASWCD did not agree to take on this project out of some ill-thought quest to take on the Non-Native Plants Industry, we took it on to fix a lake for the adjacent property owners and the entire community. When we took it on, same as every other project we do, we go through a process of deciding the best course of action with the best cost-efficiency possible and the longest-term results. As we are a credible entity who takes our fiduciary and public responsibilities very seriously, we also pay attention to proper public process, proper procurement process, risk management, and other issues such as legality.

While this project was presented to us as strictly a vegetation issue, the investigation broadened when our science team agreed that water quality is a contributing factor and vegetation issues will return unless lake health is addressed. In other words, we would be treating a symptom rather than the true disease itself. Several property owners immediately served us with verbal notice that if herbicide was put forward as the only alternative the ASWCD would be sued. Other property owner concerns were regarding the level of response necessary and wildlife and lake oxygen level concerns. It is because of this review and process with the property owners that we found we had to investigate whether the Division of Agriculture’s declaration of non-native was defensible, science-based, and would stand up in court. The answer was a resounding no from every angle we investigated and discussed, which caused us to slow down our process to ensure we were working from absolutely 100% accurate information and the most up to date information available.

In analysis and discussion of all the factors discussed in this report, a pattern has emerged from the science that says that Elodea may have been present in Alaska for at least several decades. Several legitimate questions remain that create enough reasonable doubt that the science needs to be completed before any government-based agency or entity can make a true declaration of non-native, before enormous amounts of funding are expended, before the agencies declare an emergency situation (sometimes with quarantine, as in the case of Stormy Lake and as has been suggested for Sand Lake) and before proceeding with herbicide applications without consideration of other less toxic alternatives that are just as effective, and much, much less in cost.

With the Division of Agriculture, State Parks and the Kenai Refuge submitting an application to DEC for permitting for the use of Diquat in Stormy Lake, and now a permit application for Fluridone®, we have an example of cost we can use, the figure being approximately $600,000, plus personnel costs for permitting and oversight, to apply Fluridone® Stormy Lake (403 acre lake on the Kenai Peninsula half owned by the federal government as Kenai National Wildlife Refuge, and half owned by the State). In comparison, a drawdown and freeze method would be a few thousand dollars, and completely kill the Elodea frozen in the drawdown zone. Removal of the sediment/muck
layer can be anywhere from $60,000-$200,000+ depending on whether focus is just within the canal or the entire lake, and the technique or combination of techniques chosen.

The Non-Native Plants Industry is fully aware of the cost comparison between their approach versus what we found in our investigation and analysis for this project, and they have been informed of the questions arising from the DNA work but have chosen to ignore the science and delegate Cecil Rich of the USFWS (who openly disagrees with the DNA science at the meeting), as the gatekeeper for all DNA sampling and analysis immediately upon being informed of the early results from the DNA experts. All DNA work after this date cannot be used because of chain of command and transfer issues that could create the perception of possible inappropriate handling or other issues that cause a decrease in our credibility with the property owners we serve. This is a huge detriment to the project.

Continuation of the DNA work and other necessary science, and to proceed with a couple of scientific tests regarding the muck layer and possible remedies, was not funded by the Legislature for FY13. The ASWCD was only appropriated funding to finish their investigation and draft report. Therefore, we are unable to give a clear, conclusive answer of native, naturalized, or non-native. Only around $15,000 in scientific research can answer that question and provide solid guidance on the issues.

As previously discussed, the ASWCD has secured cultural testimony and signed affidavits from property owners and water body users positively confirming Elodea's presence in Sand Lake in the 1960's. Similarly, the Elodea present in waterbodies in the Cordova area is confirmed to have been present at least 30 years ago and is listed by NRCS as native/naturalized.

Most surveys for Elodea have been only on the road system, only in certain lakes, and the methods used for the surveys were in some cases flawed, thereby making the datapoints and reports of negative presence virtually worthless. No comprehensive studies are available with reliable information, as confirmed populations are being discovered, it is being discovered as more plentiful as thought, in more than 15 waterbodies as of January 2014 with approximately 1% of the state surveyed to date. Only limnological studies can answer the question of how long Elodea has been in any part of the state, and responsible managers should be basing decisions on real data and not merely opinions and fear mongering.

It must also be noted that the proponents of millions of dollars in funding to address Alaska’s Elodea populations under the auspices of an emergency situation, fear tactics, propaganda, and through the use of whole-lake application of Alaska-untested herbicide with unknown consequences, are also in positions that benefit from any appropriations made, a clear conflict of interest. It is their payroll and project funds at stake. Further, at this point, if Elodea is proven to be native or naturalized to Alaska and a beneficial asset of our waterbodies (under normal population levels and healthy lakes), significant amounts of funds will have been wasted on the emergency situation and declaration, and the Non-

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33 NRCS Plants Database, 3/5/2013
Native Plants Industry will lose credibility and their funding. Clear reasons to actively work to avoid non-biased analysis or the completion of applicable science, whether or not it is being properly done within legal constraints and technicalities is immaterial; perception and law is pretty clear that even the possibility of it being an available avenue disqualifies one from being in this position.

It is only fair for us to tell you, the property owners, that the District is not currently popular in this group and they have been very vocal and manipulative with their quest to force herbicide use in Sand Lake. We have also been made aware of several discussions that have taken place between some members and property owners in which inaccurate, misleading, and alarmist information was given to the property owners, as well as a very narrow set of information when in fact, as you can see by the breadth of the necessary research and investigation this project has demanded, this is a more complicated issue than that. We also vary from the group in that we believe in, and practice on a daily basis, respect for property owners and their rights, including the right to know about anything that may affect their property and/or family.

The combination of all the indicators in this report gives question as to whether Elodea is truly non-native to Southcentral Alaska or whether, if introduced, when and how that introduction would have taken place prior to 1960. This also gives rise to the question: assuming Elodea is an introduced species 60-100 years ago and it has clearly naturalized, is eradication beneficial or necessary? Does Alaska’s climate, with healthy lake conditions, keep the Elodea’s population to moderate growth as in other cold weather climates? Is the decline in population and plant health in Sand Lake’s Elodea that we are currently witnessing a natural byproduct of the additional fertilizer added from the 2009 Rotenone® treatment now depleting? Will the decline in health and population continue? Is there too much Elodea present across Alaska so that eradication attempts at this point are futile, regardless of native vs. non-native?

The ASWCD is responsible for the area within our boundaries, a mirror image of the boundaries of the Municipality of Anchorage. The ASWCD is aware of, but not directly involved in, the work on Elodea in the Fairbanks area though we have said in meetings that the similarities in over abundance of nutrients, sedimentation, and lack of water flow would seem to confirm Sand Lake’s source of issues. In the Fairbanks SWCD 2013 Annual Report, they report they are currently working with the agencies involved to increase the flow through the Chena Slough to hopefully cause a ‘flush’ of some sediment material and lessen the habitat for Elodea.

The ASWCD is not in a position to declare Elodea native, non-native, naturalized, or any other official designation, but we are compelled to expect designations based on relevant scientific data and pertinent criteria.

Should science conclusively show that Elodea is non-native to Alaska, or some region(s) of Alaska, then the statewide goal may be to attempt complete eradication from those areas and what methods should be used in each specific case because of varying factors with each waterbody. If science shows it is native or naturalized, then the goal becomes
management/control and the recognition that lake health conditions are causing the current overpopulation of several species in this complex of lakes. If the best we can do is to say Elodea has been present for 60+ years, then there needs to be a statewide, science-based discussion wherein all parties involved need to make a judgment of whether the goal is eradication or control. This discussion must incorporate all available scientific and credible information and data and, with an open mind, we need to make a statewide judgment call following a rational discussion of cost effectiveness, financial ability, longest-term benefits, and control/eradication methods that will be safe to people and the environment. A better understanding of the current and past distribution of this plant should be considered critical to management decisions.
7 Management Options

The Aquatic Plant Management Society defines aquatic plant control as "techniques used alone or in combination that result in a timely, consistent, and substantial reduction of a target plant population to levels that alleviate an existing or potential impairment to the uses or functions of the water body." This definition became necessary to put in place because across the nation management of terrestrial plants was becoming intermixed with aquatic vegetation control, two drastically different situations and solutions. "Agricultural weed managers usually attempt to control a broad-spectrum of weeds in order to enhance one or more crop species in a fairly controlled environment with a specific function. Aquatic plant managers usually try to control one or two weeds (usually invasive exotic species) to conserve or enhance perhaps dozens of desirable plants as well as multiple uses of aquatic systems. In essence, an agricultural definition of "weed control" does not encompass many of the issues associated with aquatic plant management." Aquatic vegetation management is a complex subject that must be undertaken from a knowledge-based position, and on an entirely different basis than control or eradication of terrestrial plants.

This section discusses all options used worldwide for control and/or eradication of aquatic vegetation. From this menu of choices, we must select the appropriate method for the restoration of Sand Lake to a healthy state and/or control or eradication of Elodea. The action chosen may be a single option or a combination of multiple options from this list.

"There are direct and indirect environmental and economic costs associated with aquatic plant management activities. Responsible resource managers must understand these consequences and choose options that are proven effective and compatible with the current conditions at the site of interest. This information can be obtained through peer-reviewed literature, from direct experience, or through consulting with reliable sources with successful experiences controlling similar plant problems under similar conditions."35

Any option, or combination of options, chosen must:

- Be acceptable to all stakeholders
- Be legal and can be permitted
- Not negatively affect the Class A wetlands adjacent to and fed by Sand Lake
- Be sustainable for long-term viability/control
- Effectively accomplish short and long-term goals
- Be reasonable and practicable in implementation and cost

34 Michael D. Netherland (US Army Engineer Research and Development Center, Environmental Laboratory, Editor of the Journal of Aquatic Plant Management) and Jeffrey D. Schardt (Florida Fish and Wildlife Conservation Commission, Aquatic Plant Management Section), A Manager's Definition of Aquatic Plant Control, Undated
35 Michael D. Netherland (US Army Engineer Research and Development Center, Environmental Laboratory, Editor of the Journal of Aquatic Plant Management) and Jeffrey D. Schardt (Florida Fish and Wildlife Conservation Commission, Invasive Plant Management Section), A Manager's Definition of Aquatic Plant Control, Undated
36 Clarks Creek Elodea Task Force Meeting Minutes, Puyallup Washington, November 2012
It is important to note that application of herbicides to aquatic resources in the State of Alaska requires permitting from the Alaska Department of Environmental Conservation (AS 18 AAC 90.500). This statute was amended in March of 2013 to require development of an Integrated Pest Management Plan (IPMP) (JU2012200148), which requires that applicants “must establish a procedure for the use of one or more pesticides in a manner that poses the least possible hazard to people, property, and the environment, by using pesticides only after nonchemical practices, sanitation, and other preventive methods have failed or are impractical” (18 AAC 90.645: emphasis ours). DEC has adopted the policy that these Regulations are only applicable to terrestrial applications, however, the principle is directly comparable regardless of application location - Alaskans should be using the least toxic option possible. Development of an IPMP is an internationally accepted practice and one of the intentions is to force rational, holistic thinking into the process, and to make the thinking and justification for selection of particular management practices over others clear to stakeholders when considering managing pests.

Generally, an agency or entity would want to implement best management practices that are less toxic and expensive, and practices that may be reversible, before implementing chemical practices that are by definition toxic and arguably irreversible. It is in this spirit that we present the following management options for treatment of the overall health of Sand Lake. This section is not comprehensive, and due to time constraints some methods that came to our attention at a late date are not as thoroughly discussed as others.
7.1 No Change

The ‘No Change’ option is really not an option, something must be done to remedy the current situation. The project team agrees this really is not an option, including the ASWCD’s fisheries biologist who confirms by saying "Sand Lake appears to exhibit man-induced or cultural eutrophication in which the lake is aging at an accelerated rate by increased inputs of nutrients and sediments. Residential development, urban runoff, forest clearing, and waste water discharge will increase enrichment and primary production at faster rates offsetting natural lake productivity."

The results of the No Change option would be for the vegetation to continue to further overtake and degrade the lake, and the excess nutrients and sediment issues to compound over time. It is also thought by some to be possible for Elodea to be transferred from Sand Lake to other water bodies across the state by floatplanes, which may be a concern should it be proven that Elodea is non-native. Although, prior to instituting quarantines on floatplanes as has been suggested, the State should embark to scientifically prove this mode of transferability and the statistical odds of successful growth. Of note: we find it curious that the pilots of Sand Lake have been flying to Lake Hood (the shortest possible flight anywhere in the state) for refueling for many decades; however, the Alaska Department of Transportation, the manager of Lake Hood who does very inclusive, detailed vegetation management plans and projects on Lake Hood, report Elodea is not present in Lake Hood.

7.2 Restoration of Lake Health & Habitat Improvement

For this option to be successful two issues must be addressed: water quality and removal of the sediment/biomass layer in the lake.

Overabundant growth of elodea is a symptom of excessive nutrients (phosphorus and nitrogen) in the water. Control of overabundant aquatic plants is best accomplished by reducing or redirecting nutrient sources from the pond. This can be accomplished by reducing fertilizer applications near the pond, eliminating pet waste, maintaining septic systems properly, redirecting nutrient rich runoff away from the pond, and maintaining vegetative strips around the pond.37

The Elodea population is over-abundant in Sand Lake because of many contributing factors such as the alteration of the natural flow in the early 1990s, the inflow water quality and quantity, volcanic ash events, urban input, low oxygen, possible side-effects of the Rotenone® treatment to eradicate pike, the depth of biomass/sediment on the bottom of the lake, possible seepage from sewer/septic sources, and other less well known factors.

By restoring the lake’s health, and its sandy bottom, the lake will become considerably less desirable or uninhabitable by Elodea. This method will not harm fish, invertebrates, native vegetation, or other non-target species and will result in a re-balanced lake that will keep

37 Penn State College of Agricultural Sciences, School of Forest Resources, Pond Facts #18, Elodea (Common Waterweed), 2008
itself in-check. Elodea does not grow in sandy/rocky substrate, it cannot survive without the sediment layer discussed in this report.

Ultimately, this would be the best option because it addresses the issue long-term. Keeping the lake at a steady-state with a sand/rocky substrate could be challenging, but this has been done with high levels of success. The concept of a lake association or group to provide long-term maintenance would be necessary with this option.

After restoration to a healthy state, if small populations of elodea remain, they can be most likely eradicated with additional measures, and be contained to smaller areas/dosages, etc. with much more control to limit impacts to non-target species. Additional efforts would need to be put in place for this option to remain viable for the long-term. A reduction of nutrients entering the lake will be the largest and most important task. This can be accomplished with the installation and use of several best management practices such as natural vegetative buffers being installed between the lake and surrounding yards, the investigation and location of sources, and the elimination or decrease of those sources such as excess fertilizer used on yards, any issues with septic systems in proximity to the lake, and to address the storm drainage entering the lake, possibly finding a way to increase the volume of water that is sent to the lake.

There are literally hundreds of examples world-wide of successful water body restoration projects to return lakes to a healthy balance, with virtually the same conditions as Sand Lake is experiencing.
7.3 Drawdown, Freezing and/or Mechanical Removal

The lake's water level can be lowered, in this case approximately 6-feet, in September/October, exposing the shallow areas of the lake where Elodea has formed dense mats. The lowering of the level is then followed by mechanical removal of the majority of the vegetation/biomass to eliminate the possibility of adding to the sedimentation/biomass issue, and exposure of Elodea to freezing over the winter. Drawdown is an effective tool for controlling some aquatic weed species because it causes desiccation (drying out) of the plants and compaction of bottom mud. Freezing of the ground will also kill the roots and underground stems of certain aquatic plants.\(^{38}\) This method would drastically reduce or eradicate the overgrown patches of Elodea along the shoreline. It is also possible to apply herbicide selectively to the exposed patches.

The Elodea may not reestablish itself or the small populations that do reestablish can be much more easily addressed. The highest concern that comes to mind is the concern of how long it will take for the lake to fill back up to capacity. The only significant surges of water into/through Sand Lake is during the spring breakup and once the fall rainy season sets in, unless it is a high-rain summer like we’ve seen in recent memory. If Anchorage has a winter with significant snowfall, the lake could refill within one breakup season; if snowfall isn't significant enough it may take two years.

**Basic calculations for computation of water volume:**

- 50 acres = 2,178,000 sf
- Estimate 4’ drawdown = 8,712,000 cf
- 1 CF = 7.48 gallons

There are several elements that require discussion and care for a drawdown of a lake, including fisheries, wildlife habitat, public and/or private water supplies, dam or other control structures that can be utilized for the drawdown, bordering vegetation wetlands, flood control and storm damage prevention, and water quality.\(^{39}\)

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\(^{38}\) Land and Water Magazine Vol. 46 No. 1, Aquatic Plant Problems, 2012

\(^{39}\) Massachusetts Department of Environmental Protection, Bureau of Resource Protection, Wetlands/Waterways Program, Guidance for Aquatic Plan Management in Lakes and Ponds, April 2004
7.4 Tarping/Shading

An ongoing research project in the Fairbanks area is testing the use of submersed geotextile fabric to cover the lake floor; the fabric is weighted down with concrete blocks or other material. This method has been used worldwide with moderate to excellent success, depending on the application, location, material/weights used, and support from the community to keep the material in-place or to notify the project team when material becomes dislodged or needs attention.

Another method within this option is to cover the lake with the geotextile (similar to a swimming pool cover), but not submerge it (see the 'shading' section).

As mentioned, “Tarping” has previously been used worldwide with success in varying degrees. Keeping in mind that every lake basin, especially lake depth and benthic substrate differs from lake to lake. Sand Lake is approximately 73.5 surface acres. This is not a huge lake, but it is reasonably large in size for an urban area.

Geotextile and potential labor costs involved could be fairly expensive and a difficult task to completely cover the entire benthic zone, however, this method could be utilized in small areas with infestation, where it would not interfere with use of the lake.

Another option is to physically block sunlight from reaching the Elodea. There are several ways to accomplish this, from a floating fabric cover on areas of the lake with Elodea, to non-toxic additives. One additive that has good success is Aquashade, a non-toxic dye that is added to the waterbody that then blocks sunlight from reaching the vegetation, causing the vegetation to die from light starvation. While Aquashade is in the lake, the water is more blue than natural. However, Elodea is known to be somewhat tolerant to slightly low-light conditions, so the method of shading with Aquashade is questionable. A solid floating fabric cover would likely be more effective.

Shading, and the control and/or eradication of many aquatic plant species, can also be accomplished with the installation of trees, shrubs, or tall grasses next to the shallow areas of the lake where elodea overgrowth is of concern. Willows have been used quite successfully in efforts to control and eliminate Canary Reed Grass as they shade areas in which the grass would otherwise thrive. The same effect could be the case with Elodea.

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40 National Biological Information Infrastructure and Invasive Species Specialists Group (ISSG), March 2010
41 Ecological Engineering, Controlling Phalaris arundinacea (reed canary grass) with live willow stakes: A density-dependent response, 2006
A method common to commercial catfish farmers in the South is to fertilize ponds causing the production of algal blooms that shade out rooted vegetation and increases fish population. However, the addition of more nutrients can compound existing problems by stimulating additional noxious weed and algae growth.42

7.5  **Mechanical Removal, Hand-Pulling, Cutting, Raking, In-Lake Harvester**

Because of the massive volume of Elodea biomass, hand-pulling, cutting, or raking do not immediately seem efficient, also keeping in mind that a harvester can compound the problem by creating and releasing fragments which then grow a new plant, drastically increasing the numbers of plants. However, under good controls, the harvester may be a desirable start to the project, to remove as much biomass as possible before starting treatment(s), with containment at the lake’s outflow so as to not allow the transfer of small plant material to Campbell Lake. The removal of excess biomass is desirable so that it does not settle to the bottom of the lake and further add to the sedimentation/biomass problem.

Unless mechanical removal is done intensively, there will be no noticeable reduction of nutrient concentrations or sediment build-up.43

This option may also be used in combination with the lowering of the lake level. After the lake level has been lowered and before freeze, collection of the excess biomass from the infested areas would be much easier than without a drawdown of the lake level, and an improvement, to decrease the amount of biomass that is added to the lake’s problems.

7.6  **Biological Introductions**

In some areas biological controls have been introduced. These include herbivorous fish, insects with specific plant targets, and microbial populations to augment the biological ecosystem. Each of these have consequences, but some have benefits that outweigh the drawbacks.

In some areas of Europe the landowners or managers have introduced herbivorous fish such as Grass Carp or Rudd (native to Europe), which eat aquatic vegetation; introduced

42 Land and Water Magazine Vol. 46 No. 1, Aquatic Plant Problems, 2012
43 Land and Water Magazine Vol. 46 No. 1, Aquatic Plant Problems, 2012
microbial bio-augmentation to the ecosystem; and to attack some species non-indigenous insects have been introduced. Grass Carp are voracious eaters and can consume up to 200% of their body mass per day; however, they are not selective and will eat ALL aquatic vegetation. The introduction of a species such as Grass Carp may also bring other negative aspects such as increased densities of phytoplankton, due to fish metabolism causing the mobilization of nutrients.

The introduction of non-native species also poses several permitting and long term effects questions. All factors considered, introduction of another species is an unlikely solution to the issues associated and unknown factors, for example the unintended consequences of insect introduction and damage to non-target species.

7.7 Dredging - Large and Small-Scale Suction Dredging, With or Without Divers, and/or Heavy Equipment

Small-Scale Suction Dredging With Divers - We found many examples of areas that use suction dredging with divers, most commonly as yearly or bi-yearly maintenance on lakes under heavy management for aquatic plants, usually following significant herbicide applications. In these cases, divers are put in the lake with 2-4” hoses to selectively vacuum out the plant species unwanted. This is incredibly expensive and inefficient for the application needed for this project.

The Fairbanks group’s findings regarding selective suction dredging confirms our findings. In the Chena Elodea work, the Fairbanks group performed experiments with selective dredging and found it to be enormously expensive, especially when compared to the benefits received. The ASWCD contacted the Fairbanks representative and discussed the project, however, there was no documentation of the experiment produced. Because of this, the ASWCD is not privy to all information, contracting, or other elements of this work. In Anchorage, it may prove to be more cost effective, especially if able to use donated equipment and/or volunteers.

In subsequent years, as vegetation returns, in some situations, divers with suction dredges scour the lake floor and remove any unwanted species. In other areas it is simply done by hand, in yet other case studies, herbicides are used on a regular basis and the suction dredging is to remove all the dead material the herbicides cause.
**Without Divers (Large-Scale) and/or Heavy Equipment** - A much more cost effective method with much more successful results, that is applicable in Sand Lake is a large-scale suction dredge and to remove all sediment and plants together, non-selectively and without expensive and highly specialized certified divers.

Using large-scale suction dredging with a much bigger hose and suction attachment than experimented with in Fairbanks, removes all material down to the sand/gravel base, giving a 'ground-zero' condition to start from. We have had contact with commercial companies who would charge somewhere around $75,000; but we feel we can obtain the necessary equipment, and with volunteers (and post-microbe treatment to decrease the amount of biomass) the canal of Sand Lake can be dredged using this methodology for approximately $50,000 or less.

We find that the utilization of geotextile sludge bags/tubes are the best option to deal with the dewatering of the muck and avoiding sediment and plant fragment being reintroduced back into the canal. Basically, all material is pumped into these 50-100' long, 25-50' circumference tubes that then ONLY allow clean water to flow out of the geotextile fabric bag or tube. This also aids us in keeping the water level stabilized rather than all of that water being removed from the lake permanently.

**Heavy Equipment** - In other case studies, lakes have been drained and dredged with heavy equipment. This is a possible option to address the canal’s issues, possibly the whole lake’s shoreline as in several examples around the world. Should this be attempted in only areas of Elodea infestation rather than as part of a restoration strategy for the entire lake, and after the population of Elodea is better under control and/or contained to smaller areas, the costs also decrease significantly, though the results are also much different. Campbell Lake is a good example of heavy equipment to dredge, given the data available from this project, we can ascertain the potential cost of this, to just the canal of Sand Lake, would be about $100,000.

**Resulting material:** We find it best if a farm or other growing operation(s) can take the highly fertile muck for use in their operation(s). This muck is highly valuable in agriculture because of its level of fertility, physical characteristics, and the naturally present microbes and other materials that will decompose over time adding to the life and quality of the material.
7.8 Successful & Experimental Methods

During the research for this project we have discovered at least two interesting hypothesis that are viable for experimentation.

**Microbial removal of the muck layer** - The ASWCD has done extensive research into the practicality, effectiveness and costs of using microbes to remove the sediment/muck layer, thereby eliminating the Elodea's habitat leaving it without a place to grow, restore rather than further injure the ecosystem of the lake, and give the lake a huge kick-start to getting its ecosystem functioning well again. Once the lake is in improved condition the lake's natural ecosystem will be able to 'digest' the amount of biomass that is being added each year, mostly dead plant material, leaves, and everything in the stormwater runoff. Freshwater bacteria are at the hub of biogeochemical cycles and control water quality in lakes.\(^{44}\)

We are working with an amazing group of scientists that have done microbial bioremediation of lakes around the world. The microbes that are used in situations like Sand Lake are:

- *Arthrobacter globiformis*
- *Arthrobacter simplex*
- *Aspergillus oryzae*
- *Azotobacter chroococcum*
- *Azotobacter paspali*
- *Azospirillum lipoferum*
- *Bacillus macerans*
- *Bacillus pumilus*
- *Bacillus subtilis*
- *Bacillus polymyxa*
- *Myrothecium verrucaria*
- *Phanerochaete chrysosporium*
- *Pseudomonas fluorescens*
- *Rhizopus oryzae*
- *Streptomyces griseoflavus*
- *Trichoderma viride*

\(^{44}\) Guide to the Natural History of Freshwater Lake Bacteria
Figure x: Some ciliated protozoa found in lakes and rivers (naturally-present). Those placed towards the top left are typically found in the open water of lakes; those close to the centre at the base are all anaerobic. The remainder are generally found in sediments and detritus, and attached to submerged surfaces (e.g. aquatic animals and plants). All are drawn to scale (bar at the right-hand side = 1 mm). Source: P. Eigner

All microbes being proposed are completely naturally occurring (we are just boosting their prevalence in the lake to speed up the natural processes), microbes that thrive on the components in the muck of the lake. There are also microbes that thrive on ‘eating’ petroleum products, chemicals, etc. that are not being utilized in this project but are used on appropriate projects around the world. For example, microbes are being employed in the cleanup of the Deepwater Horizon / Gulf Coast Oil Spill.

The following text is from the District’s microbes contractor and does a very good job at describing the process we would be supporting:

**Restoring Balance to Lakes and Ponds:** Aquatic life forms are very much dependent on organic resources transferred from the terrestrial system. These inputs greatly exceed the organic matter produced within the lake through the photosynthetic activity of plant life. Organic compounds leached from leaves and other organic materials, are rapidly assimilated (mineralized) by microbial populations, and inorganic nutrients, i.e. nitrogen
and phosphates, are incorporated into and held within the microbial biomass.

The availability of the compounds found in the various surrounding substrates, and carbon dioxide and oxygen levels influence the types of micro and macro organisms present in a lake or pond.

The growth rate of these organisms and microorganisms are often restricted by the activities of man in the surrounding areas. Road construction, logging, industrial pollution, landscaping, fertilizer leaching and related runoff, the attraction of over-large bird populations and the accumulation of their droppings, the addition of large amounts of protein based bird and fish feed, and many other human-related activities directly contribute to the destruction of the natural microbial processes which balance and maintain the long term health of a lake or pond.

As turbidity increases, the penetration of light is reduced and the supporting photosynthetic organisms on the surface are limited in their function.

The temperature of a body of water directly affects the water’s oxygen-carrying capacity. As temperature increases, the oxygen level decreases and, consequently, microbial decomposition of sediment may slow due to the reduced oxygen level.

Application of a broad spectrum commercial microbe amendment to a lake or pond system can assist nature with the microbial balance needed to ease the pressure of excessive contamination. When the efficient natural systems begin to recover, microbe populations and natural distributions return to normal levels. As the nitrogen and phosphate levels normalize, the water body begins to clear and assimilation of the organic materials once again comes into balance.

Using microbes to remove the muck on the bottom of the lake will take away the Elodea’s habitat and restore the lake bottom to pre-1993 condition of sand and gravel, plant life in control, dramatically increased water quality - we may even be able to restore the ability to swim in the lake without swimmer’s itch and the other condition-related issues preventing full enjoyment of the lake currently.

We not only eradicate the problem plants or get the plants under control enough we can be selective in our treatment rather than the whole-lake herbicide method, but we do it as a restoration strategy so the funds spend don’t just treat the plants and compound the issues of the lake, but head toward restoration and get us further toward the goal of a healthy lake.
Even if the microbe treatment isn’t 100% successful and we only get a 50% reduction in biomass, that is 50% less biomass we have to deal with in suction dredging or other methods to remove the layer of muck, which is more expensive.

The microbes are introduced to the lake, they then eat and multiply, when they are out of food they die.

There is no negative effect to oxygen levels of the lake during this process as the oxygen levels are significantly increased with a related technology, resulting in elevated oxygen levels to support increased microbial activity (they live on oxygen) and the extra oxygen is a benefit to the fish population, macroinvertebrates, and food web.
Washington State, Before and After Microbe Treatment
punkt pomiarowy – grubość osadu przed oczyszczaniem
(Polish, Measuring point - the thickness of the sediment before treatment)

punkt pomiarowy – grubość osadu po oczyszczaniu
(Measuring point - the thickness of the sludge after treatment)
Poland
Cypress Sawmill Discovery & Hypothesis - In the research for this project, we found a study with potential application to Alaska, after exploration of the elements at play. Scientists were studying the Elodea present in a lake in the southern US, the lake being overtaken because of the warm climate of the area and other factors. However, the scientists discovered the lake directly adjacent to the study lake did not have these issues with Elodea. After investigation it was concluded that the second lake probably had no Elodea because of the lake’s closer proximity to a sawmill, which was processing Cypress. A hypothesis has been formed that either the sawdust blowing into the lake had deposited a thin layer on the bottom of the lake that was impeding the growth of the Elodea, or that the tannins created by the blown-in sawdust was pulling the heavy metals and other nutrients out, thereby making it less available to the Elodea. This hypothesis is easy and inexpensive to test, if tannins or other properties are able to accomplish this, hypothetically, one could "hang" bags of wood biomass from buoys in lakes and accomplish the same thing.

Barley Straw and Biochar - All over the world we find examples where barley straw in particular is used in much the same manner as discussed above. Biochar is also showing tremendous potential around the world in both water quality applications and forest improvement.

7.8 Herbicide / Chemical
There are many chemical/herbicide products for aquatic vegetation, though the ASWCD’s investigation has failed to find any that have been used anywhere in Alaska or that have undergone any testing applicable to Alaskan conditions. The herbicide/chemical option is also varied: it can either treat the entire lake or can treat only the specific areas that have heavy infestation.

Chemical/Herbicide options used for aquatic freshwater plants vary greatly, especially with application processes, plant absorption, and length of effective exposure, including the necessity of re-treatments. Following are the most common aquatic herbicides used for control/eradication of Elodea:

- Cutrine Plus/CuSO4®, Captain®, Navigate® (Copper compounds)
Herbicides fall into categories depicting the method of how they work. Contact herbicides, including the copper algicides, endothall and diquat, work very quickly by killing the plant tissue that they contact.

Translocated herbicides are herbicides that move into the plant through the leaf tissue and then move into and kill other plant parts, such as underground rhizomes and tubers. Some translocated herbicides, such as Fluridone®, cannot be used as a spot treatment because it may move away from the treated area before it can have an effect. Other translocated herbicides such as 2, 4-D, triclopyr, and glyphosate can be used for spot treatment, but work very slowly.

There is also evidence and information from manufacturers to suggest that herbicides do not affect aquatic plants when the water is too cold, discussing a minimum water temperature of for effectiveness. Also, with the exception of Fluridone, the target aquatic plant must be present at the time of treatment.45

It is important to recognize that all situations will be different and the weighing of options must be done on a case-by-case basis, using site-specific conditions as the basis to reach a decision. It is not possible or logical to apply only one treatment option to every instance statewide. Each case has different contributing factors, priorities to be recognized and implemented, considerations for land use and wildlife, permitting requirements, specific protection of non-target species, etc.

It is also important to recognize that the limited Alaskan-specific testing and real-life applications show that herbicides work differently in Alaska than in the laboratories, lands, and waters of the Lower 48, likely due to climate and environmental forces and conditions.

As an example of herbicides reacting and acting differently in Alaska in October of 2012 the ASWCD coordinated a roundtable discussion with all of Alaska’s SWCDs and others present, regarding a particular family of herbicides and the contamination the ASWCD is facing (an issue of contaminated land/compost/manure/hay across the state and in Anchorage). Since this roundtable, a training campaign has been undertaken by the Cooperative Extension Service to attempt to prevent future additions to this issue by educating on proper use of the herbicide and that property owners that choose to utilize these herbicides must not, by manufacturer and EPA restriction, allow organic material or hay to leave their farm. There is also Alaska-specific scientific experimentation and analysis currently underway on the Triclopyr® family of herbicides, which are being found to still

45 Purdue University Extension Service, Aquatic Plant Management, 2009
be present in organic matter more than five years after use (in Lower-48 conditions, the chemical is gone within 2-3 years). Curiously, the researchers have also shown that in the case of Triclopyr®-related herbicides reacting to the environmental influences present in Alaskan conditions, do not continue degradation during the winter months when frozen. Degradation stops, resuming again in the spring after thaw, but interestingly laboratory analysis also shows a higher detectable amount of Triclopyr® in the spring than in the previous fall before freezing, which is yet to be conclusively explained. Experiments are continuing.

If herbicide is chosen as a component of this project, or the sole treatment, it will be necessary to bid the work and award a contract to a qualified company/person experienced in the application of herbicides to lakes. Application of herbicide to water bodies in Alaska is a new territory in that we cannot locate a single instance of observed aquatic herbicide use in Alaska.

With all factors in consideration, liability for herbicide use is high both because of inherent risks and in terms of property owner support. Sand Lake has over 90 adjacent property owners with legal stake in whatever treatment option, or combination of options, is chosen, herbicide use being the highest concern in a discussion of potential liability. Sand Lake also has adjacent Class A wetlands and flows to other waterbodies, so whole-lake herbicide, in weighing all information, becomes an impossibility, if nothing but on financial considerations alone.

Whereas with an application to land we have the ability, if need be or if an error is made, to remove the earth that has been exposed and remove/remediate it - with aquatic applications, we do not have the ability to remove or control the herbicide once released. The herbicide is in the water and adjacent Class A wetlands and everyone is irrevocably and wholly committed.

### 7.9 Common Aquatic Herbicides

**Please note additional information is forthcoming regarding the herbicides that are more reasonable for use in Sand Lake's Alaska's conditions than Fluridone, and representatives and scientists will be available at a future meeting.**

#### Diquat with Copper Compounds

Investigation of Diquat and copper compounds reveals Diquat is a quick acting, non-selective contact herbicide, meaning it will work on most species, within reason, beginning almost immediately. Diquat however, only kills the exposed vegetation, not the roots into the sediment. Because Diquat does not kill the roots, Diquat is only used as an emergency measure to eliminate all exposed vegetation as quickly as possible, such as potato harvest on some farms where they use diquat to kill at vegetation of the potato plant, to make mechanical harvesting easier without the vegetation in the way.
The EPA lists as a 'moderately toxic' chemical, it may be fatal if swallowed, inhaled, or absorbed through the skin, and can be toxic to fish and waterfowl. Diquat and copper sulphate or chelates of copper can be used in stagnant water. When treating with Diquat, the addition of copper is reputed to improve control compared with Diquat alone and is also advantageous because algae are inhibited. However, copper is toxic to most crustacean species, affects fish reproduction and may impact the food web structure, e.g. by reducing zooplankton densities.

Diquat is applied by spraying to the water or plant, the Diquat then binds to suspended particles in the water which are then taken up by the plants, so degradation of Diquat is comparatively fast, in Lower 48 conditions. Diquat only kills vegetation that is exposed, not roots or tubers that are buried in sediment or lake bottom. The use of this method also compounds the sediment problem by making a mass of biomass at one time, thereby adding to the sediment and fertility of the sediment. Diquat should be considered a temporary treatment of the symptom.

**Endothall**

Research of Endothal-based products are in the dicarboxylic acid chemical class. It is a selective contact herbicide. The potassium and amine salts of Endothall are used as aquatic herbicides to control a variety of plants including plankton, pondweed, niad, coontail, milfoil, elodea, and algae in water bodies and rice fields. Endothall is also used to control annual grass and broadleaf weeds in sugar beets, spinach and turf. The EPA lists Endothall as 'moderately toxic' with a relatively fast half-life of 4-7 days in water. Endothall, in comparison to other herbicides, may be a 'more safe' option. Further, Endothall is available in granulated form and can easily be selectively applied as discussed in this report.

**Glyphosate**

Research of the Glyphosate-based products reveals Glyphosate is probably the herbicide most commonly used in Alaska, in the form of products such as RoundUp®. AquaMaster®, a water-based formulation of glyphosate, is being used by the Alaska Railroad in their ADEC-permitted project to address issues along the statewide railroad. Glyphosate is a broad-spectrum, non-selective systemic herbicide generally useful in control of all annual and perennial plants, including woody varieties. Glyphosate is only slightly toxic to wild birds. Interestingly, the Glyphosate preparation of RoundUp® is more toxic than Glyphosate itself due to a chemical added to RoundUp® as a surfactant. In water, glyphosate is strongly adsorbed by suspended organic and mineral matter and is broken...
down primarily by microorganisms. Its half-life in pond water ranges from 12 days to 10 weeks. Glyphosate may be extensively metabolized by some plants while remaining intact in others. Once in the plant tissue, the chemical is translocated throughout the plant, including to the roots.49

2, 4-D®

2, 4-D, a chlorinated phenoxy compound, functions as a systemic herbicide and is used to control many types of broadleaf weeds. Introduced to market in the 1940s as one of the first synthetic herbicides produced50, there are many forms or derivatives (esters, amines, salts) of 2, 4-D and these vary in solubility and volatility. The acid form of this compound is used in cultivated agriculture and in pasture and rangeland applications, forest management, home and garden situations and for the control of aquatic vegetation.

2, 4-D is the most commonly used herbicide in the non-agricultural sector, the sixth most common in the agricultural sector, with over 40 million pounds used annually in the U.S. in the 1990s. One of the more common 2, 4-D preparations is the 'Weed and Feed' line of products, under labels such as the commonly known Ortho Weed B Gone®. 2, 4-D products are selective herbicides, used to kill broadleaf plants while leaving grasses with little to no harm.

2, 4-D was a major component (about 50%) of the product Agent Orange, produced by Monsanto Corporation, used extensively throughout Vietnam. However most of the problems associated with the use of Agent Orange were associated with a contaminant (dioxin) in the 2, 4, 5-T component of the defoliant. The association of 2, 4-D with Agent Orange has prompted a vast amount of study on the herbicide. While the EPA listing of 2, 4-D suggests that it is only moderately toxic, the product carries the DANGER signal word on the label indicating that it is highly toxic. This is because 2, 4-D has produced serious eye and skin irritation among agricultural workers. Studies in Alaska and Canada failed to detect leaching in 22 weeks or from spring to fall, but 2, 4-D has been included on the EPA list of compounds that are likely to leach from soil.52

2, 4-D has also been in the news recently. Dow AgroSciences, a unit of Dow Chemical, is in the final stages of regulatory approval for a genetically modified corn (product name Enlist® corn). After the approval and introduction of Enlist® corn, Dow plans to produce Enlist® soybeans and cotton strains that are designed to work with their new Enlist® herbicide. These are genetically modified crops that are genetically altered to tolerate treatments of the Enlist® herbicide mixture, a combination of 2, 4-D and Glyphosate. These Enlist® crops are meant to replace Monsanto's RoundUp Ready® crops such as corn

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49 Extension Toxicology Network, Cornell University Cooperative Extension Offices, Michigan State University, Oregon State University, and University of California at Davis
50 Beyond Pesticides, chemicalWATCH Factsheet, 2,4-D, July 2004
51 Cornell University, Pesticides and Breast Cancer Risk: An Evaluation of 2,4-D,March 1998
52 Extension Toxicology Network, Cornell University Cooperative Extension Offices, Michigan State University, Oregon State University, and University of California at Davis