Reflection Lake Vegetation Restoration Report and Recommendations

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The Gonzaga University Environmental Studies and Sciences department has partnered with the Reflection Lake Community Association (RCLA) to create restoration projects assessing the Reflection Lake ecosystem. The Symposium in Environmental Science Course is aimed to give students real experiences working with community partners, fostering skills in communication and problem-solving through environmental work. For the Reflection Lake Project, two teams of four students addressed aquatic vegetation restoration and invasive grass carp management, as per the request of the RLCA.

This project is meant to address the restoration of vegetation in Reflection Lake in light of the importance of vegetation to overall ecosystem health in Reflection Lake. Aquatic plant species are vital due to the filtering qualities that they possess as well as their role as a lower trophic level that is consumed by a variety of wildlife which inhabit the lake and land surrounding it (Srivastava et al., 2008). Additionally, the lake is important to the close-knit community of stakeholders who are invested in the health of the water. This project aims to assess the general water quality, potential nutrient pollution or contamination in the water, and vegetation that is currently colonizing the lake. This information will be used to inform a recommendation to the RLCA of what steps can be taken to restore the submerged and shoreline vegetation present in Reflection Lake. This will address the community's continued issues and concerns over the health of the ecosystem while also maintaining a body of water that is conducive and aesthetically appealing to use for recreation like swimming and fishing.

Specific Questions to be Addressed:

1) How are water quality and nutrient pollution impacting biological life in the Reflection Lake ecosystem?
2) How does a large grass carp population impact the Reflection Lake ecosystem, particularly the submerged aquatic vegetation?
4) What plants exist within Reflection Lake's seed banks? Are these native species?
3) What are methods of restoring native vegetation to Reflection Lake and what types of vegetation are best to grow in light of recent issues of excessive growth and grass carp invasion?

Project Summary

I. Water Quality Report

II. Current Plant Assessment

III. Seed Bank Assessment

IV. Restoration Recommendations

V. Resources

Reflection Lake Water Quality Testing Report

Date of Sample Collection: October 13, 2024
Collection of samples and tests conducted by Gonzaga University undergraduates.

Report includes background information, methods, results of major ions and other parameters, as well as recommendations for future work in regards to water quality testing.

Background information

Table 1. Recommended freshwater concentrations to protect biological life. *Chronic criteria are listed where available. ***Total phosphorus concentrations are shown. Levels as low as 0.025 mg/L may trigger algal blooms in lakes.*

Major Ion	Concentration (mg/L)
Nitrate*	8
Phosphorus**	0.025
Sulfate	250
Chloride*	230

Nitrate is one of many forms of nitrogen that occurs in lakes; ammonium and nitrite being others. Acceptable levels of nitrate vary in freshwater systems, and levels may change depending on acute/chronic concentrations, as well as the biological organisms of concern. The upper limit for acute nitrate exposure is 60 mg/L N:NO_3. To best protect aquatic life in cool/warm lakes, concentrations should not exceed 8 mg/L N:NO_3.[1] Chronic concentrations of chloride in freshwater lakes occur above 230 mg/L.[2] Acceptable levels of sulfate vary widely across freshwater surface waters, with natural ranges falling between 0 and 230 mg/L SO_4^{2-}. Elevated sulfate levels can impact biogeochemical processes and have adverse effects on biological organisms within the lake.[3] For Reflection Lake, phosphorus may be the more critical nutrient, with small increases in total phosphorus concentrations harming biological life and triggering algal blooms.[4]

A natural range of alkalinity, the buffering capacity of the lake or its ability to maintain the pH, is anywhere from 20 to 200 mg/L $CaCO_3$.[5] The pH can range from 6.5-9 in freshwater lakes, but

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1 Philip Monson. (2022). *Aquatic Life Water Quality Standards Draft Technical Support Document for Nitrate.* Minnesota Pollution Control Agency. https://www.pca.state.mn.us/sites/default/files/wq-s6-13.pdf

2 Water Quality Program, WADOE. (2025, April). *Water Quality Standards for Surface Waters of the State of Washington, Chapter 173-201A WAC* (p. 41). https://apps.ecology.wa.gov/publications/documents/0610091.pdf

3 Zak, D., Hupfer, M., Cabezas, A., Jurasinski, G., Audet, J., Kleeberg, A., McInnes, R., Kristiansen, S. M., Petersen, R. J., Liu, H., & Goldhammer, T. (2021). Sulphate in freshwater ecosystems: A review of sources, biogeochemical cycles, ecotoxicological effects and bioremediation. *Earth-Science Reviews*, *212*, 103446. https://doi.org/10.1016/j.earscirev.2020.103446

4 Washington State Department of Ecology: Water Quality Program. (2025). *Water Quality Standards for Surface Waters of the State of Washington Chapter 173-201A WAC* (p. 27). https://apps.ecology.wa.gov/publications/documents/0610091.pdf

5 US EPA, O. (2015, September 3). *National Recommended Water Quality Criteria—Aquatic Life Criteria Table* [Data and Tools]. https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table

can vary with depth and by seasons, as well as with the biological life present in the lake.[6] For biological life, especially fish, a dissolved oxygen concentration above 6.5 mg/L should be maintained.[7] Concentrations of DO can vary by season and temperature.

Methods

Water samples were collected at the water surface at six sampling locations around the lake. Locations were chosen for ease of access at docks, open water samples were collected on a kayak. Water samples were filtered on site using a 60ml syringe attached to a 0.45µm syringe filter. Samples were then stored in a refrigerator until analyzed. Major ions (chloride, phosphate, nitrate, and sulfate) were quantified using Ion Chromatography against standards ranging from 0.5-30.0 mg/L. Alkalinity was determined by titrating a water sample from the lake with HCl and reported as mg/L of $CaCO_3$. Water clarity, or turbidity, was measured using a Secchi disk. Other measurements were taken on site using Vernier Go Direct probes. All probe measurements were collected at the water surface.

Results

Table 2. Ion Concentrations as various sampling locations around Reflection Lake

Phosphate levels were below the limit of detection (LOD=0.5 mg/L). Concentrations of chloride, nitrate, and sulfate were all detected at higher levels in the spring that flows in near the plant pen.

Site	Chloride (mg/L)	Phosphate (mg/L)	Nitrate (mg/L)	Sulfate (mg/L)
S. Open Water	2.726	<LOD	1.556	5.477
N. Open Water	2.759	<LOD	1.5935	5.4845
Turtle Dock	2.610	<LOD	1.500	5.4875
Bings Landing Dock	2.805	<LOD	1.5915	5.5115
Outflow	2.784	<LOD	1.588	5.5655
Spring near plant pen	5.802	<LOD	6.960	7.842

Table 3. Other water quality parameters results. Turbidity is reported as depth of clarity using a Secchi Disk. Note: Averages are displayed for some results, as results were relatively consistent throughout the lake.

Water Quality Parameters	
DO (mg/L)	9.61
Conductivity (µS/cm)	208
pH	8.41
Alkalinity (mg/L $CaCO_3$)	98
Turbidity (m)	3.53

[6] Water Quality Program, WADOE. (2025, April). *Water Quality Standards for Surface Waters of the State of Washington, Chapter 173-201A WAC* (p. 17). https://apps.ecology.wa.gov/publications/documents/0610091.pdf

[7] Water Quality Program, WADOE. (2025, April). *Water Quality Standards for Surface Waters of the State of Washington, Chapter 173-201A WAC* (p. 13). https://apps.ecology.wa.gov/publications/documents/0610091.pdf

Summary:
Overall, none of the concentrations of the major ions or other water quality parameters measured were of major concern, and all were within acceptable levels in regards to supporting biological life. Phosphate was likely below detectable limits in the water column because it may be predominantly bound to sediment particles rather than dissolved in the water.[8] Additionally, our ion chromatography method's lowest standard (0.5 mg/L) may have been insufficient to detect the potentially lower phosphate concentrations present in the lake. Results of major ion testing showed elevated concentrations of chloride, nitrate, and sulfide in the stream that inflows near the plant pen. This is not of major concern as groundwater inflows and stream inlets can contain higher dissolved ion concentrations, which are rapidly diluted upon entering larger water bodies.

These results can inform us of the chemical make-up of the lake and the aquatic life that will most likely flourish. It can also inform us of how the current make-up of aquatic life may be influencing these physicochemical parameters as well. For more information on water quality and the physicochemical parameters of lakes the EPA and the Washington Department of Ecology websites are excellent resources.

Future work:
Future testing should look at other forms of nitrogen in the lake, including nitrite and ammonium. Total phosphorus and other phosphate testing should also be done, as this study was unable to provide results on that. Other parameters to test for include total dissolved solids, total suspended solids, and heavy metal testing. Future studies should also collect samples from different points in the water column as well as the sediment for nutrient testing. Sediment sampling is a key component that we were unable to complete - in Newman Lake, much of the phosphorus is bound to sediment, and sediment movement was actually a major source of nutrient input.[9] Expanding our sampling methods can better fully access the state of the Lake. For this study we only looked at parameters that could be found in filtered lake water. Future testing may require acidifying water samples on site or other more involved methods.

Timing of sampling should also be considered and expanded upon. Sampling in early fall prior to mixing (ideally early September) and late spring (late May) would be ideal to capture nutrient loading, as nitrates and phosphorus typically sink to lower levels when the lake is stratified.

Identifying the sources and locations of nutrient pollution and phosphorus loading within the lake is essential for reducing excessive nutrient inputs and provides a foundation for effective restoration efforts. Extensive work has previously been done on Newman Lake to identify sources of nutrient pollution, including from fertilizer run-off and septic leakage. Methods of detection that were used at Newman Lake could potentially be applied to Reflection Lake to identify sources of nutrient input.

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[8] Illinois EPA & Northeastern Illinois Planning Commission. (1998). *Lake Notes: Common Lake Water Quality Parameters*. https://epa.illinois.gov/content/dam/soi/en/web/epa/documents/water/conservation/lake-notes/quality-parameters.pdf

[9] Washington State Department of Ecology: Water Quality Program (2007). *Newman Lake: Total Phosphorus Maximum Daily Load – Water Quality Report. https://apps.ecology.wa.gov/publications/documents/0610045.pdf*

[10] Washington State Department of Ecology: Water Quality Program (2007). *Newsman Lake: Total Phosphorus Maximum Daily Load – Water Quality Improvement Report.* https://apps.ecology.wa.gov/publications/documents/0610045.pdf

Resources

Washington Department of Ecology - Water Quality Standards Resources
https://ecology.wa.gov/water-shorelines/water-quality/water-quality-standards

Washington Department of Ecology - Surface Water Criteria
https://ecology.wa.gov/water-shorelines/water-quality/water-quality-standards/criteria

United States EPA: National recommended-water quality criteria aquatic life table
https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table

Plant Community Assessment

Background Information

On October 13th, 2024, we conducted an assessment of plants growing in the fall season at Reflection Lake. This gives us an idea of the plants that are successfully growing, and what the community looks like in terms of physical structure, nutrient cycling, and water filtration. By better understanding what vegetation is able to grow in Reflection Lake currently, we are hoping to assess what species could be added to the lake and which present species should be controlled to allow the ecosystem to flourish.

Aquatic plants are fundamental to the food chain within a lake ecosystem, as they are primary producers that photosynthesize creating energy from the sun that is then consumed by other living things and therefore a vital food source. Additionally, photosynthesis creates oxygen which is necessary in fresh water for all living things to survive. Plants are also very important sources of habitat for many organisms in and around lakes, as they provide physical structure in soil via roots and through their leaves/stalks.

There were 4 types of vegetation observed and assessed in Reflection Lake. Additional resource to further understand the role of vegetation in freshwater ecosystems here[9].

Submerged vegetation - plants that are growing beneath the water, or are fully aquatic. These plant species are crucial for the physical habitat structure of fish, insects, and other aquatic organisms that live in the lake. This habitat provides refuge from predator species and also a place to lay eggs for breeding each season.

Sago Pondweed (Stuckenia pectinata) more info here[10]

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11 NH Dep. of Env. Services. (2019). Aquatic Plants and Their Role in Lake Ecology.

12 Gilbin, D., & Knoke, D. (n.d.). Stuckenia pectinata—Burke Herbarium Image Collection. Retrieved May 2, 2025, from https://burkeherbarium.org/imagecollection/taxon.php?Taxon=Stuckenia%20pectinata

Range and Habitat: Native to North America, flowers from July-September in shallow to deep waters

Information: Sago Pondweed is very successful in waters with strong currents or disturbance because of its extensive root system. It is a crucial nutrient-filled food source for the many waterfowl species that inhabit Reflection Lake and pass through during migration seasons.

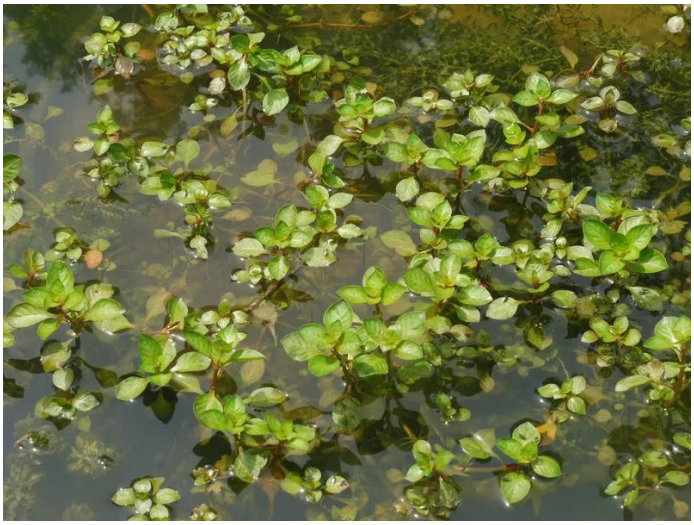
Coontail (Ceratophyllum demersum) more info here[11]

Range and Habitat: Coontail is native to freshwater in all parts of the US and a large portion of Canada. Coontail is found in freshwater at depths of up to 20m and must be fully submerged, though it can float near the surface. Coontail tolerates shade and grows in high nutrient conditions.

[13] Haberland, M. (2014). FS1236: Coontail (Cerstophyllum demersum), a Native Aquatic Plant of New Jersey Waterways (Rutgers NJAES). https://njaes.rutgers.edu/fs1236/

Information: Coontail continues to grow and stay green throughout the winter freeze. It creates important habitat for perch, bluegill, bass, and many aquatic insects making it a vital resource for the lake ecosystem. Coontail can also improve water quality due to its ability to absorb nutrients and other particles from the water.

Marsh Seedbox (Ludwigia palustris) *more info here*[12]



Range and Habitat: Marsh Seedbox is native to much of the western US and Alaska. It is found growing out of mud and in fully aquatic habitats, making it a very versatile plant. It grows in large clumps or mats typically.
Information: Marsh Seedbox has very fast and continuous growth of roots throughout the year, making it quick to grow and spread. It's root system is extensive and important for maintaining soil banks' physical composition at the edge of water bodies and preventing erosion. It is also important for filtration of water and has been shown to remove toxic compounds from water.

Spiral Ditch Grass or Tasselweed (Ruppia cirrhosa) more info here[13] and here[14]

14 NC State. (n.d.). Ludwigia palustris (Marsh Seedbox, Water Purslane) | North Carolina Extension Gardener Plant Toolbox. Retrieved May 2, 2025, from https://plants.ces.ncsu.edu/plants/ludwigia-palustris/

15 Kitching, A. (2025). Spiral Tasselweed Plant Info—Wildflower Web. Wildflower Web. http://www.wildflowerweb.co.uk/plant/1967/spiral-tasselweed

16 MN DNR. (2025). Ruppia cirrhosa: Spiral Ditchgrass | Rare Species Guide. Minnesota Department of Natural Resources. https://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=PMRUP01020

Range and Habitat: Native to states along the Pacific Coast. It can grow underwater at shallow depths, as it needs a lot of sunlight, and typically picks higher pH, or alkaline, environments. It prefers soft, muddy soils.
Information: Spiral Ditch Grass is a crucial food source with high nutrient levels for many fish, waterfowl, and other organisms at varying levels of the food chain. Additionally, it provides structural habitat for many organisms and support for soil structure with its root system. This plant is also an important source of filtration for toxins and pollutants in the water system.

Floating vegetation - plants that grow on the surface of water without attached roots. These plants are important food sources and places to lay eggs for many organisms because they are easily accessible at the surface of the water. They are also important for removing nutrients from the water, and this combined with their use of surface space causes them to compete with algae and prevent large algal blooms.

Duckweed (Lemna minor) more info here[15]

[17] Fertig, W. (n.d.). Common duckweed. USDA. Retrieved May 2, 2025, from https://www.fs.usda.gov/wildflowers/plant-of-the-week/lemna_minor.shtml

Range and Habitat: Found throughout the US and Canada. Found on the surface of slow moving or stagnant freshwaters.
Information: Duckweed is an important food source for waterfowl and fish in lakes, and it's fast growth rate makes it a fundamental plant that these species rely on throughout the year. It is also important for purifying water and can be used to filter excess nutrients and toxins out of water systems by harvesting it from polluted waterways.

Emergent vegetation - growth occurs closer to the shoreline, in waterlogged soils but not completely submerged at all times. These plants are crucial for preventing shoreline erosion, as their root systems are often extensive and keep sandier soils from washing away at the edges of the lake. They are also very important sources of habitat, especially for nesting birds like the red winged black bird.

Hardstem Bulrush (Schoenoplectus acutus) more info here[16]

[18] Stevens, M., & Haog, C. (n.d.). HARDSTEM BULRUSH. USDA National Resources Conservation Service.

Range and Habitat: Found in wetland areas throughout North America. These plants grow in very wet soils along the edges of water bodies.
Information: Bulrush has extensive root systems and thick stems that make it an important part of stabilization for eroding soils. It is also crucial food sources for the vast majority of wetland bird species, and provides habitat for mammals, amphibians, insects, and nesting birds alike.

Broadleaf Cattail (Typha latifolia L.) more info here[17]

Range and Habitat: Found in marshes across the US and in tropical global regions and elevations of less than 2000 meters. They can tolerate a range of soil conditions, including floods, droughts, and moderate salinity.
Information: Many parts of the cattail plant are edible, including the seeds, stalks, and roots, making it an important food source for many organisms including geese, moose, elk, and muskrats. Additionally the stalks and fluff can provide habitat and nesting material for many avian species.

19 Stevens, M., & Hoag, C. (n.d.). BROAD-LEAVED CATTAIL. USDA National Resources Conservation Service.

Rice Cutgrass (Leersia oryzoides) more info here[18]

Range and Habitat: Cutgrass is found in wetlands across the US. It tends to live in wet, sunny conditions with nutrient rich soils and stagnant water. Adult plants can survive flooding events very easily.

Information: This plant is known for its sharp blades which can leave cuts and scrapes on people who walk through it. It can grow in very dense patches, which causes it to outcompete other native grasses in many cases because it so easily grows. It is a food source for many birds and mammals, ducks feed on underground parts of the plant. It also provides habitat to many fish and amphibians and has dense root systems that stabilize soils.

Watercress (Nasturtium officinale) more info here[19]

[20] Stevens, M., & Hoag, C. (n.d.). RICE CUTGRASS. USDA National Resources Conservation Service.

[21] Moore. (n.d.). Watercress. USDA. Retrieved May 2, 2025, from https://www.fs.usda.gov/wildflowers/plant-of-the-week/nasturtium_officinale.shtml

Range and Habitat: Watercress is very common and found all across the US and Canada. It grows in wet soils near cold, running water like streams and springs in dense patches.
Information: Watercress has a peppery flavor and is commonly used in salads. This flavor is also a predatory defense to avoid consumption by animals and insects. It is important as a food source for ducks, deer, and muskrats and creates shaded habitat for aquatic organisms and amphibians.

Yellow Flag Iris (Iris pseudacorus) (Invasive) more info here[20]

Range and Habitat: Native to Eurasia and Northern Africa, the Yellow Flag Iris has invaded many areas in the US, mainly Northern states from coast to coast. This plant thrives on shorelines surrounding shallow waters.
Information: This plant has toxic compounds in it that cause irritation to human skin if you come into contact with it and can cause harm to many animals if ingested. It is avoided by herbivores,

22 Washington State Noxious Weed Control Board. (n.d.). Yellow Flag Iris. Retrieved May 2, 2025, from https://www.nwcb.wa.gov/weeds/yellow-flag-iris

allowing it to continue spreading. It also can easily grow new plants from roots that are cut or damaged, and has seeds that are resilient to drought and fire in late summers which contribute to its spread.

Terrestrial (land) vegetation - plants that grow on the land surrounding the lake, not in water drenched soils. These plants are important because of their stabilization of soils surrounding the water from their root systems, preventing large erosion or wash out events. They are also important sources of food and habitat, particularly for birds that live in the surrounding area.

Curly Dock (Rumex crispus) (Invasive) more info here[21]

Range and Habitat: Native to Europe and Western Asia, has been introduced to the US through grain shipments. It typically lives in wet soils and can be spread easily through flooding events. *Information:* Grows very quickly in a large variety of habitats, and seeds can live in soils for up to 80 years. The plant has seeds that can be toxic to animals if ingested, and outcompetes many native plant species for resources because of its ability to root and grow quickly.

Reed Canary Grass (Phalaris arundinacea) (Invasive) more info here[22]

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23 Stevens County WA (n.d.). Curly Dock. https://www.stevenscountywa.gov/files/documents/Curlydock1343121717021621PM.pdf

24 King County WA. (2025). Reed canarygrass identification and control—King County, Washington. https://www.kingcounty.gov/en/dept/dnrp/nature-recreation/environment-ecology-conservation/noxious-weeds/identification-control/reed-canarygrass

Range and Habitat: This invasive species is native to some parts of the US and Europe, but has invaded the Western and Midwestern US. It grows in wetter soils with access to full sun and tends to create monocultures, or areas where it is the only plant in close proximity.
Information: Reed Canary Grass can create issues by filling in ditches and creeks, preventing proper drainage and perpetuating flooding. It also grows thick, dense roots and rhizomes that outcompete other plants for space and resources very easily, damaging native plant populations.

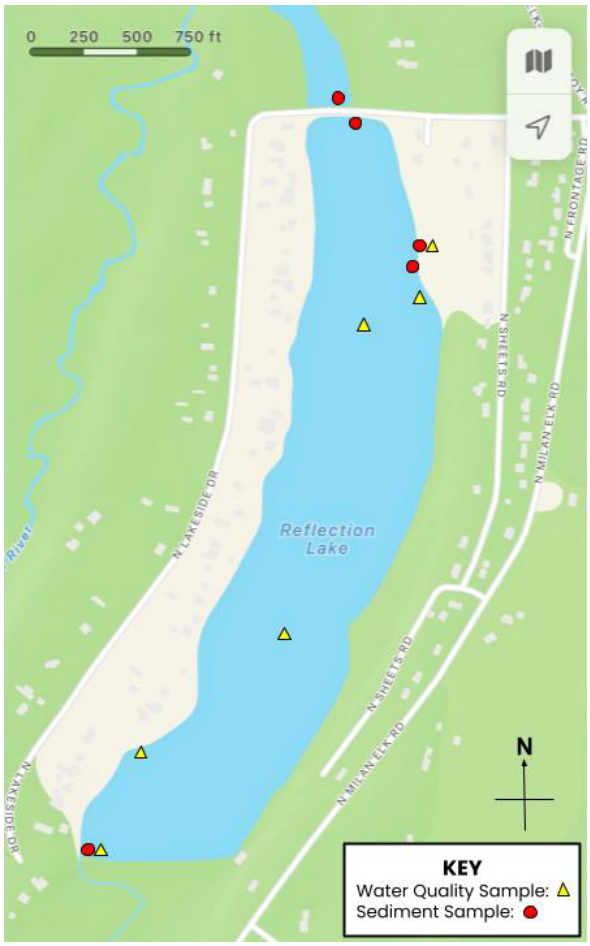
Seed Bank Assessment

Background

In order to truly fully assess the plant community at Reflection Lake, we had to know both what was currently growing but also what could potentially grow. This latter aspect is the focus of this section. To properly assess what could grow, we conducted a seed bank analysis. This is based on the concept that sediment will hold seeds of plants for potentially many years before the seeds germinate and become viable plants when environmental conditions are suitable. By collecting sediment samples and hosting them in our campus greenhouse, we hoped to grow plants from some of the seeds found in the sediment in the lake bed.

Sampling

Due to the time it would take for plants to grow in our greenhouse, our group made the trip to collect sediment samples on January 26th. This meant that 99% of the lake was covered in ice and made sediment collection difficult. Despite this, we were still able to collect sediments from five locations around the lake. These locations included the dam outflow on the south side of the lake, the dam outflow on the north side of the lake, the wetland just north of the lake, the spot where the spring flows into the plant pen at Turtle Haven, and from the actual spring stream itself (see right). Although we had other places we planned on sampling, these were the spots with no ice or where the ice was thin enough to reach the floor of the lake. While these samples do not encompass the whole lake, we do believe that the variety of habitats we sampled between these five locations can still provide a good picture of the existing seed bank. These samples were collected by both a pointed shovel and bottom dredge sampler.



Experiment Setup

After collecting our sediment samples, they were subdivided into multiple individual open containers. Three containers from each site were submerged into 10 gallon tanks to promote aquatic plant growth. Additionally, two more containers from the north wetland, the spring outflow/plant pen, and the spring stream, were placed in a tray where the sediment would be exposed to the air of the greenhouse while inundated with water. Water levels and plant emergence were monitored multiple times a week until late April.

Results

Tank Samples

Tank 1

- S Dam Outflow: Unfortunately, no plants grew from these samples. The sediment was likely too sandy
- N Dam Outflow: Unfortunately, no plants grew from these samples. The sediment was likely too rocky

Tank 2

- N Wetland: Sago Pondweed*, Duckweed*
- Spring Outflow/Plant Pen: Sago Pondweed*, Duckweed*
- Spring Stream: Duckweed*
- Other observations: Beginning in mid-March, we began to notice increased activity in the tank. This included various zooplankton, snails in the Physidae family, and worms in the sediment. This aligns with what we found in an initial sediment sample taken from Bing's Landing where we found multiple snails and zooplankton species.

Tray Samples

- N Wetland: Hardstem Bulrush*, Yellow Flag Iris*, American Plantain
- Spring Outflow/Plant Pen: Hardstem Bulrush*, Watercress*, Sedge, Willowherb, one unknown plant
- Spring Stream: Hardstem Bulrush*, Watercress*, Seep Monkeyflower, one unknown plant

*Found in Current Plant Assessment Section

Given the relatively short window to grow these samples, it is likely that there is a greater number of species present than was observed in the sediment samples.

American Water Plantain (Alisma subcordatum) more info here[23]

Range and Habitat: American Water Plantain is native to most of the eastern and central United States and parts of Canada. It grows in shallow freshwater environments such as marshes, shallow ponds and slow-moving streams. It prefers soft, muddy sediment, and can tolerate periodic flooding and low water levels.

Information: American Water Plantain is an emergent aquatic plant that produces tall flowering stalks with small, white to pinkish flowers. It provides important habitat and food for aquatic insects and waterfowl. Its roots help stabilize muddy soils, while its presence improves water quality by filtering sediments and excess nutrients. It is commonly used in wetland restoration projects due to its adaptability and ecological benefits.

Sedge (unknown member of Carex genus) more info here[24]

25 USDA Natural Resources Conservation Service. (n.d.). Alisma subcordatum: American water plantain [Fact sheet]. Retrieved April 29, 2025, from https://plants.usda.gov/DocumentLibrary/factsheet/pdf/fs_alsu.pdf

26 University of Maryland Extension. (2022, November). Sedges (Carex spp.) [PDF]. Retrieved April 29, 2025, from https://extension.umd.edu/sites/extension.umd.edu/files/2022-11/Sedges.pdf

Range and Habitat: Sedges are widely distributed across North America, occurring in nearly every state and province. They are most commonly found in wetlands, along streambanks, lake edges, and wet meadows. Sedges thrive in wet soils and can tolerate both sun and shade depending on the species.
Information: Sedges are grassy, perennial plants that play a vital role in wetland ecosystems. Their dense root systems help stabilize soil, reduce erosion, and improve water infiltration. Sedges provide habitat and food for a wide range of wildlife, including waterfowl, amphibians, and insects. Many species are also effective at filtering and absorbing nutrients, making them valuable for water quality improvement and wetland restoration projects.

Willowherb (unknown member of Epilobium genus) (possibly invasive) more info here (invasive species)[25]

Range and Habitat: Willowherbs are found across much of North America, with species ranging from lowland wetlands to alpine meadows and streambanks. They typically occur in moist, disturbed, or early-successional habitats, often thriving in areas with full to partial sun and consistently moist soils.
Information: Willowherbs are recognized for their slender stems and small, often pink or purple flowers. They are important early colonizers after disturbance, helping to stabilize soil and prepare the ground for later successional species. Willowherbs attract pollinators such as bees and butterflies and contribute to plant diversity in wetland and riparian systems. Their adaptability makes them useful in ecological restoration, especially in moist, open environments. Some species of willowherb are considered invasive weeds while others are an important successional plant. The additional information above is for one such invasive species.

[27] Washington State Noxious Weed Control Board. (n.d.). *Hairy willowherb (Epilobium hirsutum)* [PDF]. https://www.nwcb.wa.gov/images/weeds/Hairy-Willowherb_Island.pdf

Seep Monkeyflower (Erythranthe guttata) more info here[26]

Range and Habitat: Seep Monkeyflower is native to western and central North America and is commonly found along stream banks, wet meadows, and other consistently moist or saturated areas. It grows well in full sun to partial shade and thrives in wet soils, especially in low-lying riparian zones.

Information: Seep Monkeyflower is a herbaceous perennial known for its vibrant yellow flowers and rapid growth. It is a valuable nectar source for pollinators such as bees and hummingbirds and contributes to biodiversity in aquatic ecosystems. The plant's dense root system helps reduce erosion and stabilize wet soil, making it useful in streambank and wetland restoration efforts.

Results in Context

Understanding these results is extremely beneficial in informing future restoration recommendations. Knowing not only what plants grew from the sediment but also what places on the lake have the most diverse seed bank will allow for the most effective restoration planning. The greatest biodiversity was observed at our two sample sites near the Turtle Haven spring. When combined with the plants identified in the Current Plant Assessment, it was clear that this area of the lake had the greatest potential for early restoration efforts. Knowing this, and the characteristics of this place, we can reasonably assume that relatively high levels of plant diversity can also be found near the other spring outlets along the Eastern edge of the lake. Establishing new plant pens in this section of the lake can result in greater levels of natural regeneration than other sections of the lake. Once the new plant pens are up, it would largely be a hands-off way of restoring the plant community. See the Restoration Recommendations section for more information.

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28 Southwest Desert Flora. (n.d.). Mimulus guttatus, Seep Monkeyflower. https://southwestdesertflora.com/WebsiteFolders/All_Species/Scrophulariaceae/Mimulus%20guttatus,%20Seep%20Monkeyflower.html

Restoration Recommendations

Background

In freshwater lake systems, shoreline restoration (vegetation specifically) is often overlooked. Lake restoration projects often focus on primarily water quality restoration before addressing riparian habitats. Lake shorelines, however, are often critical for functioning lake ecosystems while simultaneously facing the most anthropogenic degradation.[27] Coupled with the continued threat of invasive species, it is essential that this aspect of the lake ecosystem be restored in a way that promotes overall ecosystem health while maintaining a space for human use and recreation. Common restoration practices to address this issue include the fencing of areas for vegetation, the implementation of floating islands, and the monitoring of wildlife in the area.

Restoration Recommendations for Reflection Lake

1. Plant Pen Additions

Establish more fenced off plant growth areas at Turtle Beach and Bald Eagle Point while grass carp remain in the lake to continue monitoring of the seed bank. Adding two additional plant pens in the locations listed above will promote better water quality and provide more chances to observe the contents of the seed bank without encroaching on established swimming areas. See "Propagation and Establishment of Aquatic Plants: A Handbook for Ecosystem Restoration"[28] in the resource section for a guide to plant pen set up.

- Assessing plant communities within these plant pens at different locations around the lake will give us a better idea of the community diversity and structure.
- These plant pens can also provide a healthy seedbank to pull from during future restoration work.

2. Shoreline Revegetation

Revegetate the shoreline with emergent bulrush, cattails, and sedge (see Current Plant Assessment and Seed Bank Assessment for plant details) to restore habitat, enhance nutrient cycling, and provide water filtration. Plant caging should be placed around new plantings to prevent herbivory.

3. Floating Island

Implement a floating island to reduce algal blooms in summer, provide habitat to wildlife, and allow aquatic plant establishment. In addition, artificial floating islands adapt well to fluctuations in water level, making them resilient to varying climate conditions. They also provide aesthetic appeal to the lake and do not subtract from designated swimming areas.

- Boats can disrupt islands and break them apart. Considering anchoring it and materials to construct would be very important
- Deep rooted aquatic vegetation and emergent vegetation on top could be useful to

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[29] Mackay, E. B., Gunn, I. D. M., & Carvalho, L. (2022). *A review of lake shoreline restoration techniques* (UKCEH Report Version 5.0). UK Centre for Ecology & Hydrology. https://nora.nerc.ac.uk/id/eprint/539179/1/N539179RE.pdfNERC Open Research Archive

[30] U.S. Army Corps of Engineers. (1999). *Shoreline erosion control: Demonstration of vegetative stabilization techniques in the upper Mississippi River system* (Technical Report No. ADA369779). U.S. Army Engineer Waterways Experiment Station. https://apps.dtic.mil/sti/pdfs/ADA369779.pdf

establish, especially if placed in a plant pen area. This could potentially help bind Phosphorus inputs in the lake.
- Outline specific goals for this island and make sure they are feasible with the constraints (recreation, water depth, etc.)

For more information and installation techniques, see "A Review of Shorline Restoration Techiques" in the resource section.

4. Wildlife Assessment

Perform a wildlife assessment (birds, mammals, insects, etc.) to determine which vegetation types would most benefit the biotic community. Can reference Eloika Lake waterfowl assessment below in the "Reference Ecosystem" section.

- Putting in raised wooden nesting structures for birds in the spring could be useful in areas surrounding the lake. These could also be monitored for species that visit them.

5. Education

Educating all community members about the importance of ecosystem health and the issues facing Reflection Lake specifically.

- Understanding that the presence of grass carp and continual stocking is not conducive to native plant growth.
- Continual nutrient inputs into the lake, phosphates in particular, have the potential to increase harmful algal blooms in summer seasons.
- To promote long term ecosystem recovery, larger changes may need to be considered. See Restoration Recommendation #6.
- Researching restoration strategies undertaken by reference ecosystems, see Eloika Lake, can provide further insights into future projects.

6. Inputting Water Control Structures

Installing control structures would allow complete control of water levels in the lake. This opportunity for full drainage could allow for dredging of soils at the bottom of the lake, which are likely built up with organic materials that are inputting excess nutrients into the system and have risk for creating anoxic conditions during lake stratification in the summer months. Partial drainage is also a useful tool for controlling vegetation by allowing shoreline to dry out, killing plants growing in shallow swimming or recreation areas. Drainage can also be used to gather carp into smaller areas of the lake so future population control methods can be carried out more efficiently.

- Flushing of lake sediments could be done in fall and spring months
- Input would be needed from Department of Ecology, Avista, Spokane Riverkeeper, Army Corps of Engineers, and others to discuss what drainage could look like for the surrounding watershed
- This structure would require extensive planning and funding to be installed, but in the long term would lead to easier management of sediments and vegetation in Reflection Lake

Additional Information

Similar Restoration Projects

Restoration of vegetation in freshwater lakes, particularly those invaded by grass carp, has been attempted in many other water bodies. Looking at case studies and using examples of methodologies implemented by other restoration teams can be useful in determining restoration recommendations.

- In Cooper Lake Texas, there was an invasion of grass carp that, similar to Reflection Lake, decimated the native vegetation in the lake.[29] The solution they implemented was to create enclosures that were fenced in with wire, in some smaller enclosures even tomato cages, to prevent grass carp from entering. These enclosures have previously been shown to increase vegetation survival and establishment ingrass carp-infested communities.[30] Implementing enclosures is also important to preventing the uprooting of plants as they establish along with preventing herbivory.[31] In Cooper Lake they additionally lined with erosion control fabric to ensure no carp were able to enter.[32] A variety of floating, submerged, and emergent vegetation species were planted within the fenced areas. Larger pens that included erosion control fabric proved to be successful, particularly in the growth of floating plants. However, the survival for plants that grow outside of the enclosed are does decrease significantly despite the reintroduction and regrowth, so this is something to consider if carp populations remain large.[33] This is similar to the plant pen that has already been implemented by the RLCA and suggests that implementing more extensive and permanent structures like this could be a good future recommendation.
- While the use of enclosures to grow plants can be very useful, the continual success of plants given the health of the water and the lake is also vital to the success of vegetation restoration. At Lake Mattamuskeet, they attempted to address this issue in submerged vegetation by propagating plants indoors and then transferring them to areas of the lake after carp removal.[34] In-depth surveys of the abiotic conditions in various locations around the lake may be important to determine the places where plant transplants would be most successful. Factors like water quality parameters, light attenuation, exposure to wind and the elements, and presence of invasive plants could all be considered.[35] Placing plants around 2m apart with a steel sod staple has been found to be a successful method of aquatic plant transplantation.[36] There was success at Lake Mattamuskeet, though some

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31 Dick, G. O., Smart, R. M., & Smith, J. K. (2004). *Aquatic vegetation restoration in Cooper Lake, Texas: A case study*. U.S. Army Engineer Research and Development Center. https://www.researchgate.net/publication/235016499_Aquatic_Vegetation_Restoration_in_Cooper_Lake_Texas_A_Case_Study

32 Dick, G. O., Smith, D. H., Schad, A. N., & Owens, C. S. (2016). Native aquatic vegetation establishment in the presence of triploid grass carp. *Lake and Reservoir Management*, 32(3), 225–233. https://doi.org/10.1080/10402381.2016.1167147CoLab+1OUCI+1

33 Lamb, A. D. (2020). *Informing common carp (Cyprinus carpio) removal and submerged aquatic vegetation restoration in Lake Mattamuskeet* (Publication No. 28122865) [Master's thesis, North Carolina State University]. ProQuest Dissertations & Theses Global. https://www.proquest.com/docview/2465469566/abstract/165BBBA067C94157PQ/1

34 Dick, G. O., Smart, R. M., & Smith, J. K. (2004). *Aquatic vegetation restoration in Cooper Lake, Texas: A case study*. U.S. Army Engineer Research and Development Center. https://www.researchgate.net/publication/235016499_Aquatic_Vegetation_Restoration_in_Cooper_Lake_Texas_A_Case_Study

35 Ibid.

36 Lamb, A. D. (2020). *Informing common carp (Cyprinus carpio) removal and submerged aquatic vegetation restoration in Lake Mattamuskeet* (Publication No. 28122865) [Master's thesis, North Carolina State University]. ProQuest Dissertations & Theses Global.

37 Ibid.

38 Knopik, J. M. (2014). *Aquatic macrophyte response to carp removal and the success of transplanting aquatic macrophytes to restore the littoral community* (Publication No. 1561833) [Master's thesis, University of Minnesota]. ProQuest Dissertations & Theses Global. https://www.proquest.com/docview/1562783571/abstract/898E7B7F8634245PQ/1

plants were found to be better candidates for such restoration projects than others.[37] Some species known to resist grass carp invasion are *N. odorata, E. cordifolius, J. americana,* and *P. cordata*.[38] It has been suggested that it will take many years and intense evaluation of the growth of many different plant species' growth patterns to successfully restore vegetation in a lake where grass carp have been removed.[39]

Reference Ecosystem

Eloika Lake

- Eloika Lake has been characterized by fishing activity for hundreds of years, starting with Native Tribes. Many residents wanted to keep the lake at a constant water level for ideal recreation, and with the building of a road there were culverts put underneath a bridge to reduce streamflow and manage water levels. However, this eventually led to issues of nutrient pollution and eutrophication, sedimentation, and excessive vegetation in fishing areas. Since 1985 there has been management of the lake by the ELCA to reduce the amount of aquatic vegetation and maintain the water level at a desirable height.
- Eloika Lake has a public boat access point, RV camping areas, recreational areas, and some residential areas. It also is known to be a warm water fishery. Surrounding agricultural facilities and lands create instances of disturbance via fertilizers, pesticides and herbicides, and livestock grazing. A goal of the restoration of this lake is to maintain wildlife habitat and water levels in surrounding wetland areas, as well as in the lake itself.
- Completed work:
    - Assessment of bird species present and their associated habitat to understand what species are important to the lakes ecosystem
    - Assessment of fish species and the way in which vegetation control measures will impact that community - it was observed that excessive removal would likely harm native fish populations and therefore plant communities must be carefully managed
    - Suggestions for aquatic vegetation have been manual removal (raking) or chemical (herbicide) treatments
    - Assessment of soil type was done to characterize areas as wetlands and those in need of restoration work in particular
    - Restoration work on private land is a component of this project, and they have looked to work with landowners to improve aquatic and wetland conditions on their property
- Currently Eloika Lake has identified a need for wetland delineation to correctly identify areas in need of restoration work. Additionally they are creating guidelines for the water

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39 Lamb, A. D. (2020). *Informing common carp (Cyprinus carpio) removal and submerged aquatic vegetation restoration in Lake Mattamuskeet* (Publication No. 28122865) [Master's thesis, North Carolina State University]. ProQuest Dissertations & Theses Global.

40 Dick, G. O., Smith, D. H., Schad, A. N., & Owens, C. S. (2016). Native aquatic vegetation establishment in the presence of triploid grass carp. *Lake and Reservoir Management*, 32(3), 225–233. https://doi.org/10.1080/10402381.2016.1167147CoLab+1OUCI+1

41 Lamb, A. D. (2020). *Informing common carp (Cyprinus carpio) removal and submerged aquatic vegetation restoration in Lake Mattamuskeet* (Publication No. 28122865) [Master's thesis, North Carolina State University]. ProQuest Dissertations & Theses Global.

levels and flooding of the lake to maintain flow rates that will help to naturally control excessive vegetation and algae growth in their water. Reduction of water levels has been a crucial solution identified to reduce the stagnant nutrient rich waters that are conducive to excessive plant growth.

- The actions taken by this lake community to restore their lake in the face of vegetation issues may be useful for future control of vegetation growth on Reflection Lake as well. Making a contact there may also be helpful for consultation on future work.
- Information obtained from: PBS&J 2009: Eloika Lake Management Plan Final Report[40] Divens, Woller, and Phillips 2001: 2000 Warmwater Fisheries Survey of Eloika Lake (Spokane County)[41]
- Additional information available here[42]

Resources for Recommendation Implementation

- Dick and Smart 1999: Propagation and Establishment of Aquatic Plants: A Handbook for Ecosystem Restoration
- Gunn and Carvalho, 2022: A Review of Shorline Restoration Techniques

42 PBS&J (2009) *Eloika Lake Management Plan Final Report.*

43 Divens, M., Woller, H., & Phillips, L. (2000). *2000 Warmwater Fisheries Survey of Eloika Lake (Spokane County).*

44 Eloika Lake Water Storage and Wetland Restoration | Spokane County, WA. (n.d.). Retrieved May 1, 2025, from https://www.spokanecounty.gov/4997/Eloika-Lake-Water-Storage-and-Wetland-Re

Additional Resources

Guidelines for creating a management plan - Washington State Department of Ecology
https://apps.ecology.wa.gov/publications/documents/0410053.pdf
Native aquatic plant guide for ponds and aquariums - Washington State Department of Ecology
https://s3.wp.wsu.edu/uploads/sites/2054/2014/04/WA-Native-aquatic-garden-plants.pdf
Clearwater Seed Company in Spokane - has native seeds available for purchase