CANDLEWOOD LAKE AUTHORITY
Member Municipalities: Brookfield • Danbury • New Fairfield • New Milford • Sherman
PO BOX 37 • SHERMAN, CT 06784 • P (860) 354-6928 • F (860) 350-5611

Candlewood Lake Plant Management Strategy 2023: "Striking the Balance"

Plants are a critical part of the ecosystem in lakes, and provide habitat to species of small fish, plankton, and other creatures that live in shallow parts of the lake, as well as a key component of the food web. Over the past two years the aquatic plant community in Candlewood Lake experienced dramatic changes. Unfortunately, it was recognized in June of 2022 that the lake's normally abundant plant life has been almost entirely absent. This page is meant to give some background about the history of Candlewood Lake's plant community, how overabundant and invasive plants have been managed in the past, the current status of management and the plant community, and what the "goals" and strategy are for achieving a healthy ecosystem in the lake.

Candlewood is Dominated by one Invasive Species: Eurasian Watermilfoil

For as long as many people remember, Candlewood Lake's plant community has been dominated almost exclusively by one invasive species: Eurasian Watermilfoil. However, this plant wasn't always here. Milfoil likely infested Candlewood Lake by hitching a ride from another lake on a boat in the 1970's. Milfoil is so good at growing and outcompeting other plants for space and resources that it quickly beat them out to become 80% of all lake plants in Candlewood. The other 20% are mostly species native to this area. Although Candlewood is man-made, it still has native species! The lake was built on top of ponds, the Rocky River, and small streams that all had native species of plants in them.

Milfoil in Allen's Cove, 2008

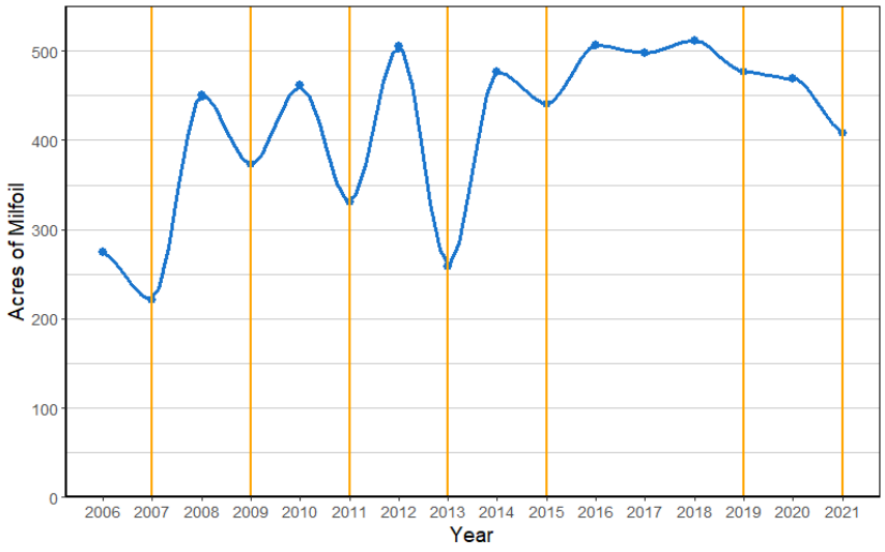
Milfoil can be troublesome because it grows fast and tall, quickly reaching the water's surface. Not only does this have some negative effects on the ecosystem, it also isn't nice for

swimming, boating, or fishing. In response to the overabundant milfoil, in the 1980's the power company that owned the lake began annual "drawdowns" of the water in the winter, aimed at exposing shallow plants and their roots to freezing temperatures and hopefully reduce the total acreage of milfoil to a healthier level. This focuses the growth in deeper water where the plants will impact recreation less.

Goal: Establish a balanced, healthy Milfoil presence

While the drawdowns helped manage the milfoil, especially in the shallowest areas, milfoil remained a major challenge. The plant community has been regularly monitored every year since 2007, and since then there has consistently been 300-500 acres of milfoil in the lake. A more well balanced, healthy plant abundance would be roughly 15-25% of that total. Thus, other techniques were researched to work in tandem with the winter drawdown to help balance the number of plants in the lake at a healthy level. Initially a native weevil that can help manage milfoil was tried but failed to have a noticeable impact. After careful scientific and logistical evaluation of Candlewood and other lake plant management strategies, the best option was to stock the lake with sterile grass carp that eat milfoil. The strategy aimed to have more consistent and long-term control of the overabundant milfoil. These sterile fish cannot reproduce, and thus also do not represent an irrevocable commitment.

Figure 1. *Acres of Eurasian Milfoil in Candlewood Lake 2006 - 2021, deep drawdowns indicated with orange vertical lines.*



Northeast Aquatic Research, 2021 Monitoring Report

Sterile Carp as a Plant Management Strategy

Based on comprehensive research of the carp in other waterbodies, a stocking rate of 15 fish per acre of milfoil in the lake was determined by the state DEEP, and a plan was created for two stockings of the fish through a state of CT permit – one of 3,813 fish in 2015, and a follow up stocking of 4450 fish in 2017. 585 fish were also stocked in Squantz Pond in 2017. The expectation for these fish as a management strategy was that they would not eat all of the plants,

but to capitalize on their tendency to eat milfoil from the top down. Carp graze on the milfoil and keep it from reaching the surface helping preserve a healthy amount of plants for the ecosystem. Once again, working to "strike a balance." After the stocking, no large change was expected until the fish grew for a few years. 2018 -2021 had promising results – with much less milfoil acreage at the surface of the lake, but most of the plant acreage still present below the surface. Even during that period, the total acreage was still too high, sitting at approximately 450-500 acres.

The Beginning of Changes in Candlewood and Squantz's Plant Community

The impact of the carp began to appear in annual monitoring in 2018. While total acreage didn't change below the surface, the amount of milfoil reaching the surface began to decline. This indicated that the lake was approaching a better-balanced state; less abundant milfoil that doesn't impact recreation while still preserving plant acreage that provides an important link the food web as well as fish habitat. The first evidence of a more dramatic change came to Squantz Pond, which lost most of its plant material in 2019. At that time, plant material in Candlewood was still as abundant as in the past, but not as tall.

Candlewood plant life stalls in 2022 and 2023

In early 2022 a substantial change in the plant community was noticed in Candlewood. In the spring the beginning of plant growth was observed, but quickly stopped and disappeared. For the remainder of the season, little new plant growth was observed, although some areas did still display modest growth, and all the plants historically found in Candlewood were found in small quantities in various places in the lake. Some regrowth was observed using sonar in the late season in late September and October. The plants did not have time to re-establish the population while lake temperatures and sunlight were conducive to growth. In 2023, very similar conditions to 2022 are being observed as of July. We are once again seeing very little plant growth, with a few small quantities of plants being found in different places around the lake.

Research Points to Change in Lake Ecological Balance

Of course, these observations beg the question, what happened? Where did all the plants go? . While it can be tempting to search for a single culprit for the change in plant life, research supports multiple factors leading to the current ecological state. Based on the observations on the lake, continued data collection, and what is known about milfoil and plant management, we can establish some hypotheses supported by sound science.

Alternative Stable States Theory Suggests the Balance Between two Ecological Positions Shifted

Put simply, "Alternative Stable States" is an ecological theory that describes how ecosystems tend to exist in one of two opposing stable conditions. The two stable conditions in question here are a lake that has overabundant overly dense plants (AKA: Macrophytes), and one that has very few plants at all. It can be useful to visualize the ecosystem as a ball, and the state of that ecosystem as a track, with the ball resting in one of two "cups" in that track. This is meant to visualize the tendency of Candlewood's plant community to exist most commonly in one of these two states; importantly, the position that the ecosystem has a difficult time staying in is the balanced position in-between these two extremes.

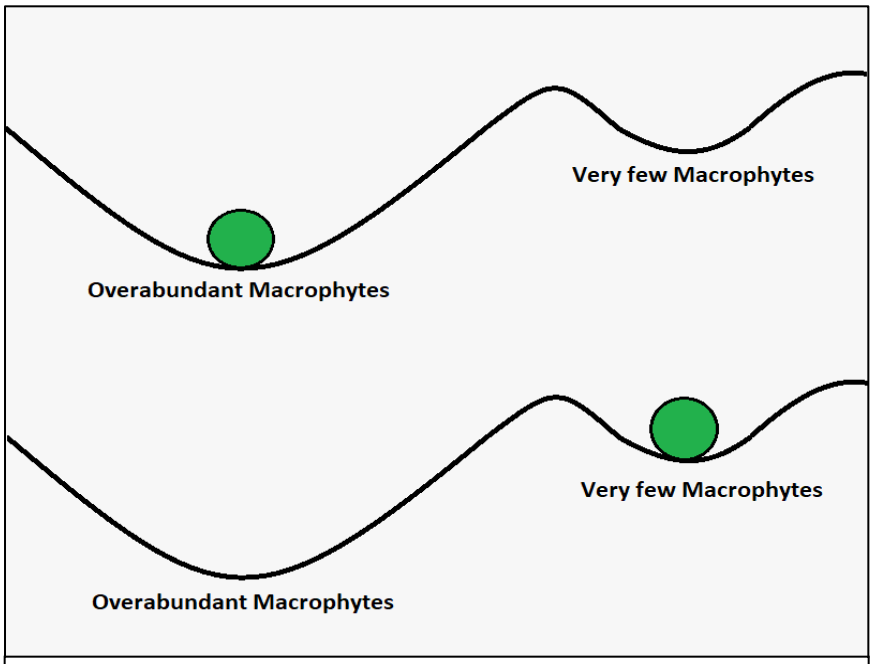


Illustration of Alternative Stable States in Candlewood

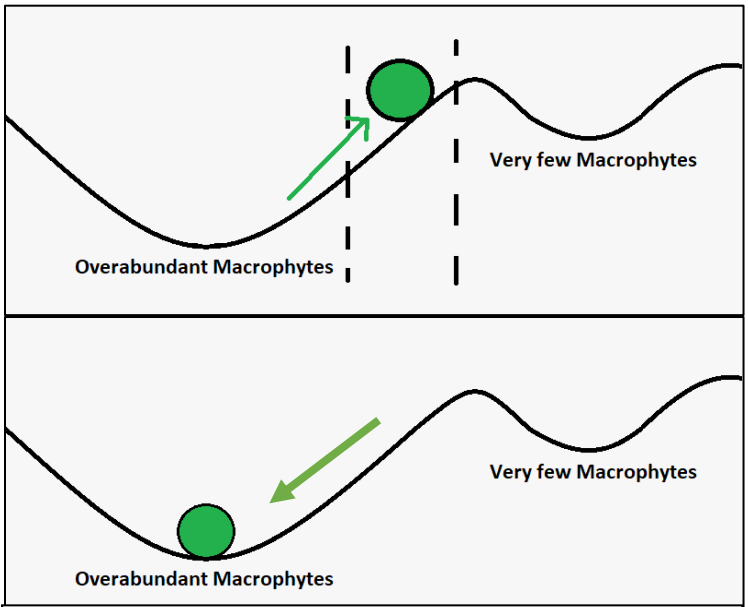


Illustration of how management attempts to balance the ecosystem between stable states.

Since milfoil invaded in the 1970s, Candlewood's stable state of plant material has been solidly "Overabundant." This is because there were enough forces in the ecosystem that helped the plants grow so effectively that the remained overabundant for years (thus the term "stable"). More plants means they have an easier time reproducing, which in turn helps stabilize the population in overabundance. In the past, plant management techniques like the drawdown, or more recently the sterile grass carp, were strategies meant to push the ecosystem to a

balanced state in-between these two stable extremes. However, most years that push wasn't enough to keep the ecosystem in that balanced position and it would instead roll back into its more stable, overabundant state. Of course the difference in 2022 was that the ecosystem was pushed over the hump into the *other* stable state that it historically had not been in: very few plants at all.

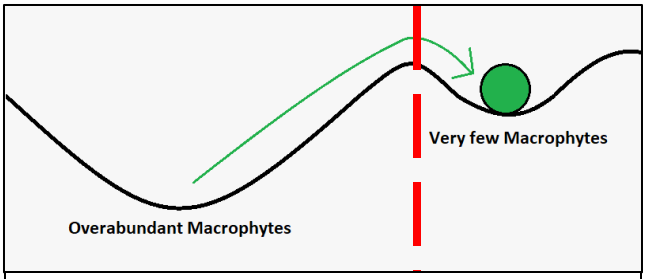


Illustration of a "regime shift" when the ecosystem reaches the tipping point into a new stable state.

So the question we have to ask is, **what are the factors that contributed to that green line, pushing the ecosystem into this new extreme?** The answer unfortunately isn't exactly a simple one. Ecosystems like Candlewood are incredibly complicated with lots of factors interacting with each other and changing every year.

Systemic impact of Sterile Carp, Drawdown Depth, Climate, and Ecosystem Competition Collectively Impacted Ecosystem

We do however know a number of factors that almost certainly contributed to the shift. Primarily, any management techniques that were meant to help balance the ecosystem contributed to that push: so the sterile grass carp and the drawdown both, which are meant to reduce the plant material, were strong contributions to the change. It's possible in 2022 their contributions might have increased as well, as that was following a deep drawdown, and the carp had time to continue to grow and require more food to sustain their size and diet.

There are some natural factors that likely contributed as well: including natural "boom and bust" cycles of plant growth as they compete with each other for resources, and the specific climate might have made the drawdown more effective and prevented plants from surviving below the surface over the winter.

A rake being thrown into a Candlewood plant exclosure.

No Evidence to Support Microscopic Organism Threat

Other factors have been studied too – including the possibility of a microsopic organism that infects milfoil, however there have been no indications in chemical testing of the water of any unusual agents, and if there was a disease

or chemical, it would travel downstream to lakes Lillinonah and Zoar and impact them similarly, which is not what is being observed.

New Plant "Exclosures" will Offer More Research Opportunities

We have also placed "exclosures" in the lake to effectively fence off areas and protect any plants that might grow in those places from sterile grass carp feeding. This allows us to study the effects of just the plants ability to grow without this pressure, and will give us some insight into how each of the previously mentioned factors might have contributed to the change.

Shared Lake Management Goal to Balance the Ecosystem Between Overabundance and Shortage of Plants

What are the goals for the ecosystem? What does a healthy state for the lake and for recreation look like, and how do we get there? Ultimately, the answer is the goal has not changed. The CT DEEP, FirstLight, and the CLA agree that the ideal scenario for Candlewood is the return of a healthy stand of plants to provide resources and habitat to the ecosystem. However, all the stakeholders also agree that nobody wants to see the ecosystem return back to the *other* stable state of overabundance again. So the goal is **balancing the ecosystem between overabundance and shortage of plants**. This would probably look something like 60-150 total acres of reasonably dense plant material that ideally does not grow to the surface very often.

Multi-step Action Plan Targets Stable Ecosystem with Balanced Plant Life

So how do we get there? Well we have to think about our alternative stable states again. We need to consider the factors that pushed the ecosystem into the shortage of plants state, and begin to work against those. However, we don't want to push the ecosystem so far that an overabundant plant community returns. So the best course of action is smaller, step-wise actions to begin trying to help the plants begin to grow, while keeping some management strategies in place so the ecosystem doesn't rapidly return to where it was before.

In the immediate future, that means a shallower drawdown in the winter time, and small removals of parts of the grass carp population until we begin to see the plants returning.

Once we get to that point however, the work isn't finished. Management strategies will then have to shift to keep the ecosystem balanced to avoid a return to the state of overabundance. This is a very difficult thing to do in the face of how complex and multi-faceted the ecosystem is. With continued scientific study and analysis, lake management experts can make strategic decisions to help keep the lake balanced, and preserving our beautiful resource for generations.

Frequently Asked Questions

1. "Why haven't the grass carp died if their food is gone?"
    a. There are two parts to this question. First, carp do have plants to eat! Every time a plant bed begins to grow, the grass carp are there to immediately eat it down. The lake is in a cycle of a tiny growth that is quickly stopped by the carp. Second, grass carp are extremely hardy, and when there's no other option, they eat the decomposing algae and biological material at the bottom of the lake. That helps explain why we also haven't seen many swimming around as much… many of them are at the bottom feeding.

2. "Wasn't the point of the fish to get rid of the plants? No plants seems like a good thing!"
    a. It's important to remember that the lake isn't a swimming pool, it's a complex ecosystem with food webs, habitats, and lots of organisms that rely on the plants for food or shelter. Losing the plants can have an unfortunate effect on the sportfish in the lake as it removes the habitat for their young to hide from predators. Some scientists also note the possibility that plants might also be a nutrient sink, holding nutrients away from algae – so we don't want all those nutrients the plants use to suddenly become available for algae to use.

3. "Could there be chemicals or pathogens in the water that caused this change?"
    a. First, there are plants in lakes downstream of Candlewood. So, lakes that get Candlewood's water like Lillinonah, Zoar, and Housatonic all have plants. This means our water isn't carrying anything with it that has this impact on other water bodies.
    Secondly, in a lake the size of Candlewood, the concentration of chemicals required to see a change of this magnitude would be extraordinarily high and expensive. It would require a large-scale investment and application.
    Third, there are indeed natural pathogens that occur in lake ecosystems for plants including milfoil. It isn't possible to directly test for pathogens, but it's possible that this might have been another natural factor that pushed that green arrow

down causing the stable states to shift, however as mentioned previously, the state in downstream waterbodies make this explanation unlikely.

4. "Are the carp reproducing and not actually sterilized?"
    a. The good news here is that the checking for carp sterilization is federally managed and extremely rigorous before they're purchased. The other good news is that juvenile grass carp have never been found in the lake by the CLA, homeowners, anglers, or by DEEP during the initial removals. Keep in mind also that there is a population of common carp in the lake, which are not sterile, but are native and do not feed on the plants.