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Kelley Christensen 11/5/2016

Michigan researchers use remote sensing, hydrodynamic modeling and ecological observation to monitor the control of invasive Eurasian watermilfoil in the Great Lakes.

Eurasian watermilfoil is an invasive aquatic weed that spreads rapidly when cut. Image Credit: Public domain

During the summer of 2012, the Les Cheneaux Watershed Council was confronted with a confounding problem: Invasive Eurasian watermilfoil choked the waterways between islands, making it difficult for boaters to pass through the water.

“In 2011-2012, when we had the low water, we had two of our major bays totally infested with the milfoil to the point we couldn’t get boats through without fouling the props,” said Rob Smith, a retired ecological microbiologist and president of the Les Cheneaux Watershed Council in Cedarville, Michigan.

“About 40 percent of our work force is associated with tourism, so they rely on tourism for their business. That’s the economic issue. The environmental issue is when the milfoil takes over and becomes a monoculture, to the point the fishery suffers because the fish don’t go in certain spots,” he said.

The invasive weed has been a problem in the islands for some years, but to combat the spread of the aquatic plant throughout the Great Lakes, the watershed council teamed up with Michigan Technological University scientists to try a new approach to detecting, monitoring, and controlling Eurasian watermilfoil.

Colin Brooks, senior research scientist and environmental science lab manager at Michigan Tech Research Institute (a research center of Michigan Technological University), is the principal investigator in a U.S. Environmental Protection Agency Great Lakes Restoration Initiative-funded study of the effectiveness of using multispectral imagery to differentiate Eurasian watermilfoil from other submerged aquatic vegetation, and to monitor the effectiveness of different control methods.
Recently Eurasian watermilfoil levels have dramatically dropped off, which scientists say is perhaps due to rising lake levels (a cyclical decadal occurrence in the Great Lakes), but that doesn’t mean the watershed council or researchers plan to back off their plan to address the invasive weed.

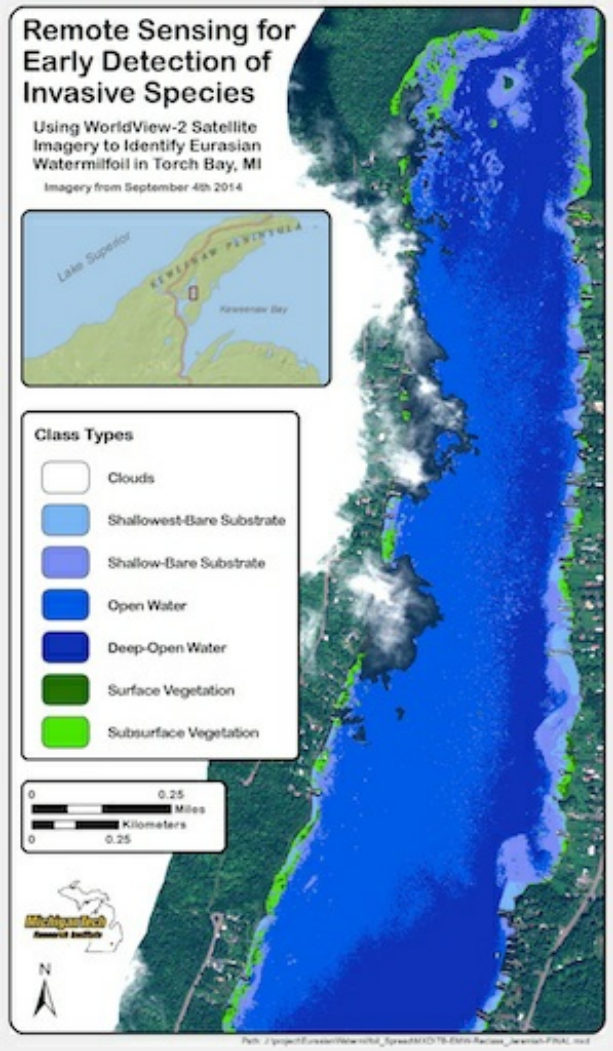
“We expect the milfoil to catch up with rising lake levels. We want to be ready to go out and control it if it surges back to the level in 2012,” Brooks said.

To that end, Brooks, along with fellow Michigan Tech scientists Casey Huckins and Amy Marcarelli, are using commercial high resolution imagery from DigitalGlobe’s WorldView-2 satellite and multispectral imagery from a six cameras attached to an unmanned aerial vehicle – a drone – to assist the watershed council with its efforts.

A previous project conducted by the researchers in partnership with the Michigan Tech’s Great Lakes Research Center worked to couple remote sensing with sonar sensing to determine if the combination of the two methods could provide better data to determine the location of Eurasian watermilfoil and differentiate it from other submerged aquatic vegetation. With the lessons learned from that project in mind, Brooks is using sensing techniques to help the watershed council determine the effectiveness in deploying the native fungus Mycoleptodiscus terrestris – Mt fungus for short – to control the watermilfoil.

But while the imagery from the WorldView-2 satellite was informative to about 1-meter resolution, Brooks needed imagery with 1- to 5-centimeters resolution. Cue the drone.

In 2015, Brooks gathered spectral profiles of submerged aquatic vegetation to differentiate Eurasian watermilfoil. This summer, Brooks is collecting multispectral imagery on six bands. His research team has rented tunable multispectral cameras made by Tetracam, which are mounted on the drone. Each camera has a filter designed to collect data in narrow bandwidth. The goal is to determine the bands most likely to differentiate Eurasian watermilfoil from other submerged aquatic vegetation species.



Using WorldView-2 imagery, the project team was able to differentiate aquatic vegetation at the surface versus submerged aquatic vegetation in Torch Bay in Michigan’s Keweenaw Peninsula, helping to screen areas for further analysis. Image Credit: Colin Brooks and Jeremiah Harrington

An area of dense submerged aquatic vegetation that includes Eurasian watermilfoil, as photographed with a small unmanned aerial vehicle to help with mapping and monitoring in the Les Cheneaux Islands area in Michigan's southeastern Upper Peninsula. Image Credit: Colin Brooks

Brooks is developing an algorithm to differentiate based on the six bands, work that is also part of his Ph.D. research. He said the next step is to use 50-100 bands of spectral imagery.

Brooks' work studying the effectiveness of the Mt fungus by using spectrometry and multispectral imagery will continue into 2018. He noted that the six bands are designed to differentiate milfoil from other plants, so if the milfoil is reduced in the 10-acre test site after the fungus application, researchers and the watershed council will know how to most effectively deploy the fungus going forward. The information from the sensing imagery will inform methods of placing the fungus as well as how much to place.

With Eurasian watermilfoil spreading in the Great Lakes watershed, this information could be invaluable to controlling the weed as an alternative to applying chemicals going forward. Other parts of the country are experiencing invasive Eurasian watermilfoil in lakes and rivers, and Brooks said he hopes what the watershed council learns from its test site will be applicable beyond Michigan's state borders.

"We have a very environmentally conscious community," Smith said. "Even when we were inundated with the milfoil, the community at large said, 'We really don't want to deal with chemicals.'"
Smith added that the toxicology profile of the fungus appears to have no adverse effects on fish, mammals, fowls or non-target plants.

Applying Mt fungus to a test area in the Les Cheneaux Islands. The photo has been enhanced to illustrate plume. No dyes or additives are used. Image Credit: Rob Smith

Because Eurasian watermilfoil isn't contained to the Les Cheneaux Islands, and because of the sheer size of the five Great Lakes, researchers at the Great Lakes Research Center have built a hydrodynamic model to calculate currents, waves, and water temperature.

Pengfei Xue, an assistant professor at Michigan Tech, said the model helps the research team grasp more fully how invasive milfoil may spread throughout the lakes if brought in on boats that have not been properly cleaned and inspected for the aquatic hitchhikers.

"Eurasian watermilfoil can develop based on fragmentation. Breaking into parts, those small pieces can develop into individual plants and once developed, they're hard to control," he said. "The numerical modeling simulates the water flow condition and allow us to predict the dispersal and retention of Eurasian watermilfoil fragments in different regions."

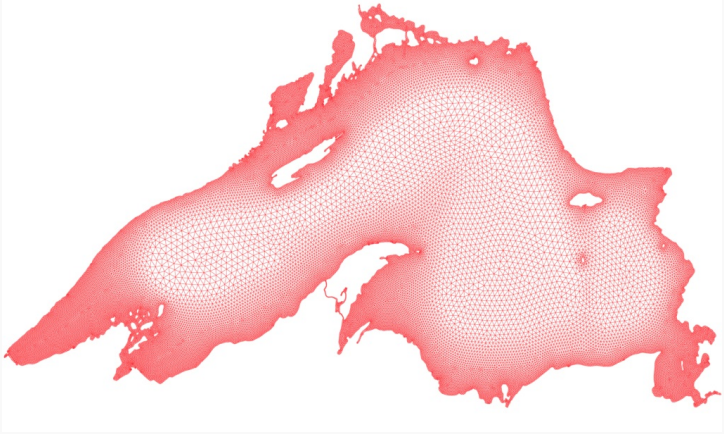
Xue calls the fragmentation and spread of milfoil by careless boaters "the plague of the launch ramps", because where boats put into the water are where the invasive species is most likely to be introduced. His model simulates where milfoil might take up residence based on circulation and wind patterns, solar radiation, thermal structure, and warm-cold water mixing in the water column.

The hydrodynamic model is a set of mathematical equations that describe the motion of fluids. The Superior supercomputer, housed at the GLRC, provides the computational power to run the model to generate the hydrodynamic conditions of the lake.

To validate the model, Xue relies on "ground truthing" – observations from buoys, satellite images, and reanalysis data. Comparing the model results to these data sets gives researchers confidence in model's performance and using the model-predicted comprehensive flow conditions comes at much less expense than deploying buoys and monitoring with research vessels. The hydrodynamic model can simulate various scenarios of predicted events with probabilistic analysis to give state and municipal departments of natural resources the ability to react in advance to prevent potential milfoil infestation.

From an ecological standpoint, the watermilfoil infestations have given researchers the ability to study the macrophyte beds in Great Lakes region water bodies to better understand the impact of macrophytes – rooted aquatic plants – on the ecosystem. Casey Huckins, a professor at Michigan Tech, wonders how algae, invertebrates and fish are affected if invasive macrophytes like Eurasian watermilfoil replace native macrophytes.

Amy Marcarelli, an associate professor at Michigan Tech, has focused on how nutrient loading – elements like nitrogen and phosphorus found in fertilizers and sewage – and how macrophytes and phytoplankton interact in terms of nutrient uptake and the ability of the organisms to photosynthesize.



This image shows the triangular mesh grid that, when programmed for a variety of weather and water conditions, allows researchers to accurately model lake conditions on Lake Superior. Image Credit: Pengfei Xue

“In the years the milfoil has died off in the Les Cheneaux region, we’ve seen phytoplankton communities decrease by several orders of magnitude,” she said. “Potentially it’s the lake levels. Whatever is affecting the macrophytes is also affecting the algae in the water column.”

Identifying and quantifying aquatic macrophytes at Les Cheneaux Islands test site. Image Credit: Rob Smith

Studying the interactions of the varying organisms that inhabit the water column has and will continue to give scientists insight into how best to help communities manage invasive species. In Torch Bay, just a short boat ride from the Michigan Tech campus, the Chassell and Torch Bay townships are dealing with Eurasian watermilfoil infestations of their own.

Both communities have elected to use chemical herbicides to kill invasive watermilfoil. Both communities formed special assessment districts to raise the money to purchase and apply the herbicide. In Chassell, the herbicide has been applied, and if regrowth occurs, it is again treated. This cycle continues annually until native plants can regain a foothold.

In Torch Bay, however, which experienced the milfoil infestation later than Chassell, leaders moved quickly to begin

treatment. But after the harsh winter of 2014 and with increasing lake water levels, the milfoil hasn't returned as expected. Torch Bay leadership wants to prevent milfoil re-emergence and so consequently have turned to performing small-scale spot treatments. Marcarelli argues this could worsen, rather than improve, the problem. Just as a virus can become resistant to antibiotics if a patient doesn't complete the full antibiotic regimen, so too can the milfoil become resistant to herbicides, especially if the plant hybridizes with native Northern watermilfoil.

To prevent creating herbicide-resistant hybrids, researchers are experimenting with diver-assisted suction harvesting (DASH). Essentially, a scuba diver vacuums up small stands of milfoil in early infestations or as spot-treatment in recovering native macrophyte beds. Marcarelli said this could be a more strategic way to remove invasive weeds that doesn't require herbicide application.

"For any invasive species – everyone is looking for the silver bullet, and there is no silver bullet," Marcarelli said. "There needs to be a sustained combination of treatments … and education to prevent spread."

Huckins said the use of alternative control methods such as DASH may best be used to treat early stage infestations or, as Huckins and Marcarelli are examining, as a post-herbicide treatment to remove residuals or regrowth. He hopes the interdisciplinary research will lead to important consequences for the protection against, and detection and control of invasive species like Eurasian watermilfoil. He also hopes the research team can distill down the information so it's accurate but approachable and useable by community leaders and decision-makers in the Great Lakes and beyond.

"We have started to create a living document, a data portal so communities don't have to reinvent the wheel every time (there's an infestation)," he said. "Communities don't have the people power or time and they need to solve this problem right now."

Kelley Christensen is IEEE Earthzine's science editor.