Investigating invasive plants as roadside contaminant removal tools

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Equipment harvesting the invasive plants. Credit: Sam Schurkamp/Loyola University Chicago Photo

Tall, densely growing Phragmites and cattail (Typha) are familiar plants alongside highways and byways in the northern United States, flourishing in salty roadsides and degraded wetland environments created by chemicals applied to roads in the colder months known as deicers.

Recently, a team of researchers from UConn's College of Agriculture, Health, and Natural Resources and Loyola University Chicago decided to investigate whether these invasive species can help remove some of the salt and metal contaminants along those same roads. Their findings are published in *Ecological Engineering*.

Department of Natural Resources and the Environment Associate Professor Beth Lawrence has been working with researchers at Loyola interested in the management and restoration of wetlands in the Great Lakes region, focusing primarily on invasive plant species. After wetlands are invaded by tall, nutrient-loving, and salt-tolerant species like Phragmites and cattail, conditions become too shady and crowded for native species to thrive, eventually resulting in a homogenized environment that reduces wildlife habitat viability, changes nutrient cycling, and alters greenhouse gas emissions.

"When these invasive species come in, they change the nature of the ecosystem. We are interested in promoting biodiversity and oftentimes managers want to get rid of those invasive species," Lawrence says.

Typically, herbicides are used to kill invasive plants, but this approach is limited in effectiveness, says Lawrence, so the researchers were interested to see if mechanical harvesting methods could be a sustainable option for restoring the ecosystem.

Lawrence says that after World War II, the quantity of road salt application has grown exponentially, and there are growing concerns about their impact on the environment. Roadside ecosystems are increasingly saline and contain high loads of heavy metals like zinc and lead from cars and their emissions. The chemistry of salt ions mobilizes heavy metals in soil, making it easier for them to move around the environment and cause problems.

"There is pressure from the public and environmental groups to mitigate road salt impacts. As a society, we demand drivable roads after storms, but there are clear environmental costs. Once road salts get out into the environment they can contaminate our aquifers, groundwater or surface waters," says Lawrence.

Once the salt is in the environment, it is very difficult to remove; however, some plants that grow in brackish conditions take up and store salt in their tissues. The researchers wondered if cattail and Phragmites are taking up salts and metals along busy roads, and if so, whether harvesting the plant material would reduce the contaminants in the environment.

The team worked with the Illinois Tollway to identify 10 wetland detention basins that were all between half a hectare to one-and-a-half hectares in size. Lawrence says what's unique about this study is the scale: much of this kind of work has been done experimentally in the greenhouse in small pots, but the researchers here got to work with hectares of land.

The locations were all dominated by either cattail or Phragmites, and the team estimated the percentages of each. Half of the locations were randomly designated as controls and the team harvested biomass from the other half for two growing seasons. They also measured a variety of conditions before they started the experiment, such as biomass, soil chemistry, and the chemistry of the plant tissues.

After harvest, the researchers analyzed the plant materials for salts and metals and they found that cattail was more effective at taking up salts, with the highest amounts stored in green tissue.

"Plants have different strategies for dealing with salt and cattail is a salt accumulator," Lawrence says. "This makes it an ideal plant to target for salt remediation, especially the green tissue, because we found much higher sodium and chloride content in the green live tissue than the senesced litter, or dead plant material from previous years."

In contrast, Lawrence says Phragmites tended to be better at accumulating metals and contained higher levels of zinc and copper stored evenly between the green and dead tissue.

"Your target contaminant should determine when and what to harvest. If you're focusing on metals, maybe focus on Phragmites and you could probably harvest in the winter, whereas if you are focusing on removing salts, it makes more sense to harvest cattail during the growing season."

These results sound promising, but Lawrence says that when the amount of salt applied to roads each year is compared to the amount of salt these plants take up, this method is not a silver bullet for removing road salts and metals.

"We really need to focus on reducing the amount of salt that we're applying to this already very salty system," says Lawrence. "Assuming the rates of salt applications along with our estimates of how much biomass was growing, a complete removal of all above-ground biomass within a one-hectare basin would remove less than half of a percent of the salts that were applied along a one kilometer section of the Illinois Tollway. The percent of salts that are removed is dependent on the rate of application, how robustly the plants are growing, and the residence time of the water."

Fortunately, Lawrence says in a lot of areas of Connecticut, less salt is added to the roads compared to application rates on Chicago area roads, so harvesting cattail would likely remove a higher percentage of the salt in less-urban areas of the Nutmeg State.

Another issue for consideration is what to do with the contaminated biomass once it's been harvested.

"In our work over the last decade or so looking at invasive species and biomass harvest, we've pursued different avenues for what we can do with this. We're trying to close the loop and be more sustainable," says Lawrence.

"We've had projects where we've made pellets for pellet stoves out of invasive species biomass, and that's potentially viable, but it needs to be done at scale with an industrial partner to move forward. We've taken invasive species biomass and digested it in anaerobic digesters in the Midwest, and it's a viable feedstock but it really depends on where the feedstock or the biomass is collected because the potential for contaminants is a big deal. If there's salt and metal in your plant tissue, you don't necessarily want to compost it and then spread it in a garden because you're just spreading the salt and metals elsewhere, you're just moving the problem."

Lawrence says her main take-home message from the project is that plant remediation by harvesting plants along road edges could be a viable strategy to reduce downstream salt and heavy metal loads, but what we really need to do is reduce how much salt we're adding to the environment in the first place.

"It takes a lot of energy to run the harvesting equipment and to move the biomass around. Then can we remove the pollutants from the biomass? Yes, I'm sure we could, but again, it's going to take a lot of energy to extract. We need to be more conservative with how much salt we're releasing into the environment in the first place, but this is a tool in the roadside manager's toolbox to improve environmental quality."

More information: Andrew M. Monks et al, Complementarity of road salt and heavy metal pollutant removal through invasive Typha and Phragmites harvest in urban wetland detention basins, *Ecological Engineering* (2023). DOI: 10.1016/j.ecoleng.2023.107058

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