Opinion

Cattail harvest and diseased wood turned into biochar for improved soil health and water quality. an analysis of phosphorus mitigation for the Red River of the North

Abbreviations: RRB, red river basin; MPCA, minnesota pollution control agency; NOI, north ottawa impoundment; TDS, two stage ditch; TSS, total suspended solids

Introduction

Excess nutrients are one of the most common impairments for the watercourses of the Red River Basin (RRB) and much of the State of Minnesota, USA. About 80% of the land use of the RRB is agricultural cropland. Over 90% of the phosphorus and nitrogen found in the rivers and streams of the RRB originate from nonpoint sources. The Minnesota Pollution Control Agency (MPCA) has completed watershed assessments on the sub-basins within the RRB. The MPCA and the International Red River Board through the International Joint Commission are currently in discussions on completing a nutrient reduction strategy for the Red River including where the Red River crosses the international boundary and eventually empties into Lake Winnipeg. Lake Winnipeg is the primary reason we should care; yet smaller bodies of water have local importance and require thought and action to restore or protect water quality. Nevertheless, an international border and good will between Canada and the USA are at stake. The USA is creating a problem the Canadians must deal with to ensure a high-quality Lake Winnipeg. The question we address in this editorial is not only improving lake water quality but also improving soil health that has the potential to limit pollutant transport. We present a case for using diseased urban trees that must be disposed of by the City of Minneapolis and the production of biochar – a byproduct of burning wood at high temperatures. This would create a viable useful carbon rich soil product that could be utilized to benefit Lake Winnipeg by improving soil properties related to water storage and polluted runoff at strategically placed locations within the RRB.

The RRB is subject to significant flooding and damage reduction has been the top priority for the USA side of the Red River (Figure 1). Flooding is an issue because the Red River of the North flows north into Canada. Flowing north is a problem because the northern latitudes are still frozen and can easily back up water in the spring of the year.

One approach adopted by the Red River Water Management Board is to construct shallow off-channel flood storage reservoirs to reduce flood damages. The North Ottawa Impoundment (NOI) constructed by the Bois de Sioux Watershed District is one such example (Figure 2).[1]

We believe the use of these types of flood reservoirs/impoundments can also provide water quality benefits. Both ditches and impoundments in the RRB grow cattails; if streamflow above these reservoirs can be routed through vegetation, then total suspended sediment (TSS) and nutrients can be captured. Routing can occur in a linear fashion within the ditch geometry in the form of a two-stage ditch (TSD)[2] or in a water holding cell. The treatment cells will capture and hold TSS and the phosphorus bond to the silt/clay size material in the vegetation, which is dominated by cattails. The phosphorus that is currently being discharged downstream to Lake Winnipeg would then be sequestered within the watershed of origin. The vegetation in these treatment zones/cells can be harvested to remove the excess nutrients and the vegetation can be utilized as a soil amendment, to capture and reuse phosphorus and other beneficial uses, such as carbon, can be explored, and may have some merit.

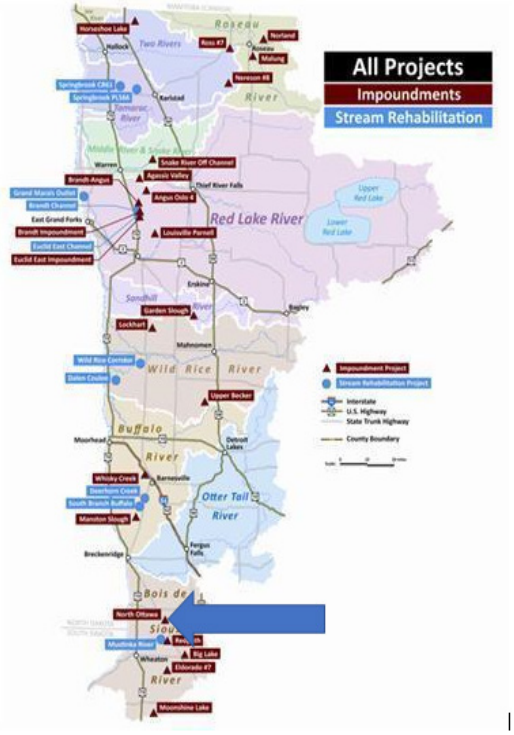

Figure 1 The Red River in the USA and suggested flood management practices and locations, and the location of the North Ottawa Impoundment (NOI)[1] Beach ridges occur at varying location east of the Red River of the North.

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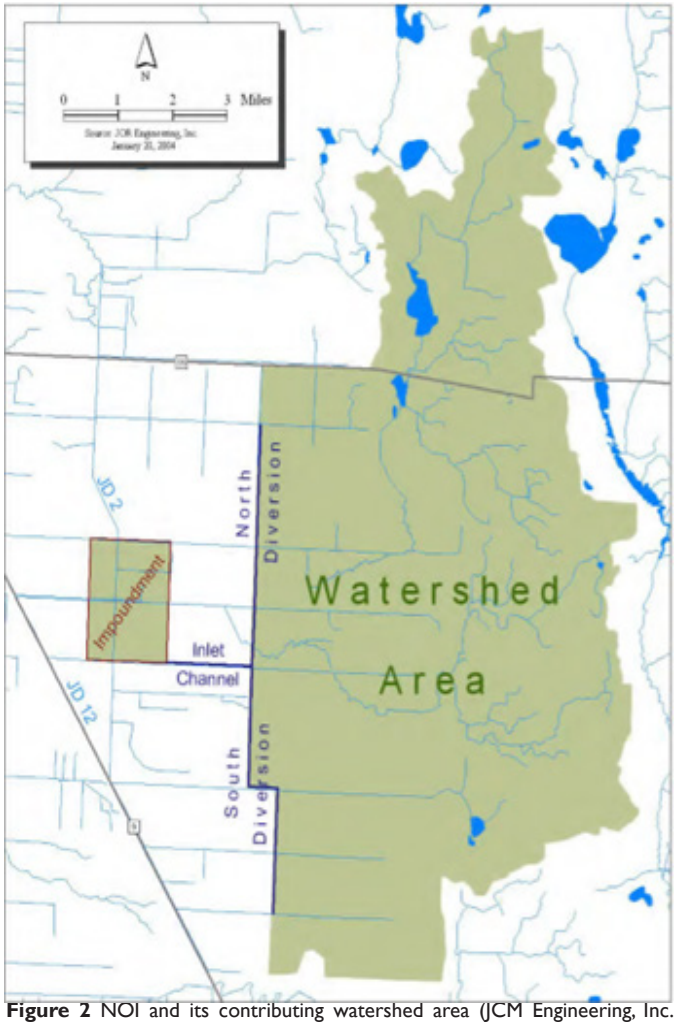

Figure 2 NOI and its contributing watershed area (JCM Engineering, Inc. 2004).[1]

This editorial will focus on logistics of cattail harvest and its use as a soil amendment to build organic carbon in the soil as composted biomass with the potential placement on selected soil types to build soil organic matter and improve soil ecology. We also consider pyrolysis of woody material mixed with composted cattail (biochar) to create a high-quality soil amendment for use in urban settings.

Work completed in Manitoba[3] indicates a potential phosphorus capture of 11-22 kilograms of phosphorus per hectare of cattail harvested. Depending on the capture rate of the treatment zone/cells/TSD, it is possible to design a system that would capture and harvest all phosphorus being exported from the watershed above the NOI.

Cattail as a soil health amendment

Cattails provide carbon, phosphorus and nitrogen and reproduce quickly, making them a valuable renewable resource for developing healthy soil conditions. Cattails can be mulched into soils or composted with other materials such as manure or wood chips and applied as a nutrient dense fertilizer for successful crop production. Sandy glacial soils, as typically found in the Glacial Lake Agassiz beach ridges of the RRB, have a low percentage of carbon-based litter which results in the sand unable to hold water and nutrients at adequate levels to support successful high yield row-crop production. Under these conditions, irrigation, and additions of inorganic fertilizer during the growing season are needed to protect crops from desiccation and nutrient deficiency that limits successful production. Amending sandy soil with cattail compost can improve crop production and soil health through improving topsoil protection and by supporting the below ground soil ecology that provides better aeration, moisture retention, and increases nutrient availability to plants. A healthy soil ecology can also tie up excess nutrients and prevent leaching of soluble nitrogen to surface and groundwater.

Cattails: a multi-purpose renewable resource and soil health amendment

Native Americans used cattails for multiple purposes, such as for food, medicine, fiber for clothing and bedding. The remnants of the plant were then worked back into soil where it decomposed overtime, providing structure and nutrients to the soil. Another benefit of using cattails for compost is that cattails will not reseed and grow as weeds in upland soils as other green plants used for compost can (https://www.gardeningknowhow.com/ornamental/water-plants/cattails/mulching-with-cattails.htm). Cattails can be cut and harvested above the root which leaves the main plant to overwinter. In the spring and summer, they are quick to grow back and then re-harvested in the late summer and/or early fall making them a valuable renewable resource.

The addition of high amounts of organic matter amendments composted with cattail combined with other carbon and nitrogen sources (wood chips, biochar, straw, manure) can transform nutrient poor sandy soils into nutrient rich loam soils that feed the soil ecology[4] that benefits crop production. The compost residues and soil food web that develops (i.e., bacteria, fungi, protozoa, nematodes, microarthropods, etc., https://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcs142p2_049822.jpg) help to protect topsoil and bind soil particles together while building pore spaces for air and water and deep roots to grow. The cropland plants are served a steady supply of nutrients during the growing season when the bacteria and fungi die or are eaten by the protozoa (e.g., amoeba, flagellates, ciliates), nematodes, and earthworms that are all part of a healthy soil system.[4]

Cattail in RRB: for soil health and water quality benefits?

The topography and geology of the RRB is well suited for growing cattail and other wetland species such as bulrush and sedges in ditches and streams (Figure 3). Due to the historical presence and draining of Glacial Lake Agassiz, the topography of the beach ridge is not steep and the slow current of water in ditches and streams in the headwaters and lower floodplains of the Red River valley allow wetland species to naturally grow and thrive.

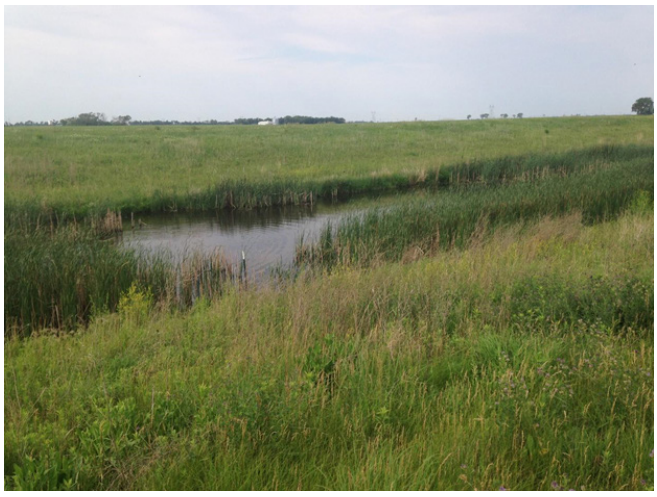

Figure 3 A ditch with cattail in the Red River of the North Basin.

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Wetland species are deep rooted and are accustomed to the saturated growing conditions of ditches, stream banks and bottoms where they can root and hold soil in place to prevent scouring and bank sloughing that requires repeated and costly ditch maintenance.[2] The roots of wetland species on the lower banks can enhance bank stability and reduce stream bank erosion, thereby reducing sediment production and the delivery in the headwaters and tributaries to downstream water bodies such as the Red River. Wetland species can retain TSS and therefore excess sediment bound phosphorus. Additionally, labile phosphorus and nitrogen can be taken up by wetland plants. These wetland species can be utilized for multipurpose soil and water quality benefits both within waterways where they grow as well as harvested and used as a soil amendment on the land. Cattail has been successfully composted and used as a soil amendment in other countries (e.g., Tunisia[5], Greece[6]).

Emerging research,[1],[3] is finding ways to utilize cattail and other wetland species to benefit water quality through nutrient removal. The phosphorus and other nutrients that are taken up by these wetland plants can be harvested and applied to croplands as a soil health amendment. Harvested plants can be applied directly to land as a crop residue or composted with manure and other carbon rich materials (e.g., wood chips, straw, Biochar) which can be land applied during the fall or spring for additional soil protection from erosion and as a stored nutrient pool. During the spring, when temperatures warm, the compost can begin to decompose and deliver nutrients in a bioavailable form to crops.

Other studies in the RRB are looking for ways to use cattail and other wetland species to benefit water quality through phosphorus and nitrogen removal using TSD but little information has been provided to engineers and watershed districts about the benefits of a TSD. These TSDs have flat, floodplain benches with vegetation (Figure 4) for enhanced ditch stability and water quality benefits. The cattail and other species that grow on these benches can be harvested to both reduce phosphorus locally and then used as a soil health amendment elsewhere.

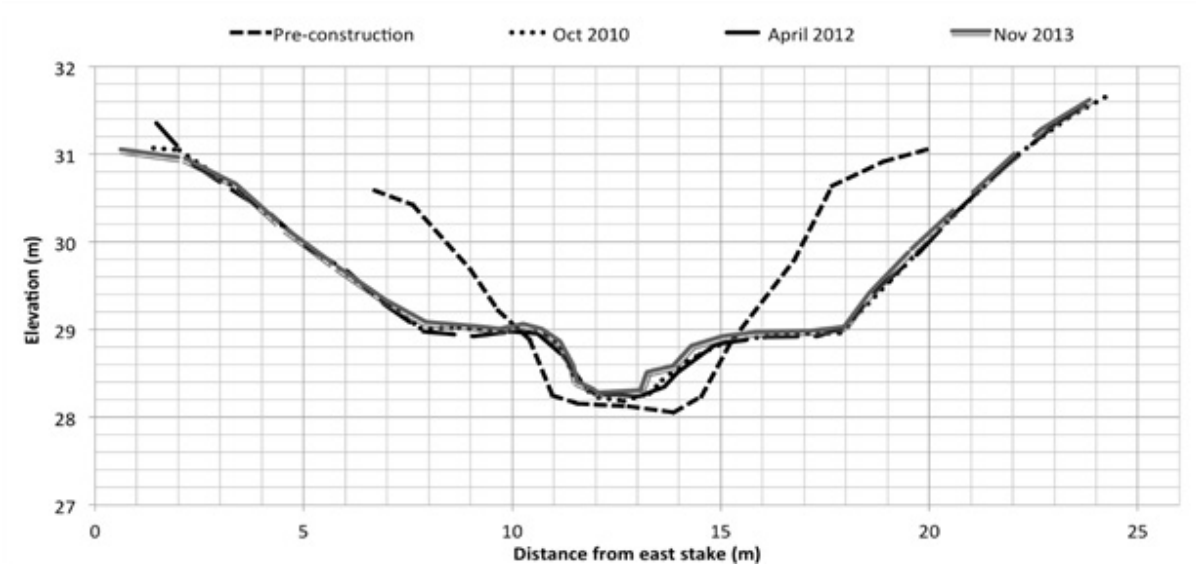

Figure 4 Two-stage ditch construction in Mower County, MN[7] showing the pre-construction ditch and TSD design with a small floodplain (with vegetation) that when harvested provides nitrate and phosphorus removal.

Biochar: what it is and how it can be used

Biochar is made from partially burning wood chips that can then be composted with manure and other greens (including cattail), to create a living, organic matter soil health amendment. When piles of biochar are left to be cured for a time before transporting, fungi and other organisms that can use the Biochar as food, or eat other organisms that do, can be added to the mix so that the Biochar becomes a living, readily transportable mix of soil ecology as a steady and slow-release crop fertilizer. An international team that included University of Minnesota researchers studied the nutrient availability between fresh and cured Biochar using manure amendments. They found that the manure amendments improved its use as a fertilizer due to the growth of a bacterial coating on the charred pieces that enhances Biochar's use as a fertilizer.[8]

Cattail: mechanical harvesting

Mechanical harvesting is a means of extracting cattail shoots that has been proposed as a solution for reducing excess nutrients in other regions (e.g., wetlands of the Laurentian Great Lakes[9]). The critical challenge is finding a contractor with the right equipment to harvest. We believe a custom design that fits on a 10-foot wide TSD bench holds much promise for finding a win-win solution to harvesting cattail shoots in August or September, a season time when nutrients are still located in the shoots.

Currently, a portion of NOI is being farmed for crop production, assuming non-flooding conditions, only the C-cell and at times cell B4 have open water and concordant cattail growth. Because these cells have slow moving water, they trap TSS which can accumulate over time. Harvesting cattails in this environment can be challenging during wet conditions; during dry August conditions cattail harvesting in these cells is viable with the correct equipment. As of 2022, limited cattail harvesting occurred due to wetness and machinery limitations. An alternative harvest could occur in the header ditch (Figure 2) that feeds NOI; this ditch has an extra wide bed to accommodate the funneling of watershed runoff into NOI. The header ditch has a harder bottom than the NOI cells that would better support harvesting equipment weight. To make this a viable option additional earth work would be required to construct on/off ramps for the equipment

to access the cattail material. Based on the University of Minnesota team observation over the past four years the header ditch is typically dry in August. We recommend a future study to validate ditch cattail harvest in the header ditch and any TSD that is constructed in the Red River Valley.

Biochar: solution for urban emerald ash borer, sandy RRB soils, and water quality?

Within the last decade, infestations of the Emerald Ash Borer (*Agrilus planipennis* Fairmaire) are expanding and killing large areas of ash trees (*Fraxinus sp*.) in Minneapolis and St Paul, Minnesota. One of the largest unsolved problems, post-tree removal, is the disposal of these diseased trees. There are tens of thousands of trees that are in process of being removed and disposed of on an annual basis. Due to a tight quarantine zone, these ash trees need to be disposed of near where they are harvested in order to prevent further movement into new areas that are not currently infested. Since disposal of such a large quantity of trees will require a very large land area to store and to incinerate logs and debris, solutions are currently being sought and proposed. One emerging idea is to create Biochar which can be applied to urban landscapes as well as cropland systems to improve soil health. Biochar could be made by heat-treating or partially burning the tree wood which would incinerate bark and kill insects but not burn the wood completely into charcoal, so the carbon content remains high. The final Biochar product produced could then be transported and used outside of the quarantine zone for urban landscaping as well as for use as an organic matter soil health amendment for cropland systems, possibly even in the RRB given transportations costs. Possibly, other nitrogen sources such as cattail could be added to the composted Biochar mix to further increase the nitrogen and phosphorus content of land applied Biochar. Collaboration between RRB crop producers, the University of Minnesota, and Minneapolis and St Paul Park Services should occur to explore ways of how to put this idea into practice. This would help solve three large problems at the same time: 1) how to convert quantities of diseased trees into usable Biochar, 2) where to locate large quantities of wood chips for supplementing cattail compost, and 3) improving soil health while enhancing water quality improvements in the RRB and ultimately Lake Winnipeg.

Conclusion

We believe governing districts, boards and agencies can justify cattail harvest in NOI, and the header ditch because there will be a return on investment for sandy soils in the beach ridge area and the current demand for soil amendment material in the Twin Cities metro area. The critical component piece is product transportation, given the increased cost of diesel fuel in 2022. Nevertheless, our proposed scenario would solve problems and provide solutions, on both sides of the international border between the RRB in Minnesota, USA and for Lake Winnipeg in Canada.

Acknowledgements

None.

Conflicts of interest

The authors declare there is no conflict of interest.

References

1. Guzner M. *Water Quality Benefits of a MN Flood Water Storage Impoundment*. 2017; Masters Thesis, University of Minnesota. 2017. p. 120.
2. DeZiel (Asmus) B, Krider L, Magner, et al. Habitat Improvements and Fish Community Response Associated with an Agricultural Two-Stage Ditch in Mower County, Minnesota. *JAWRA*. 2017;55(1):1–35.
3. Grosshans R, Grieger L. *Cattail Biomass to Energy: Commercial scale harvesting of cattail biomass for biocarbon and solid fuel*. IISD, Winnipeg, Manitoba, Canada 2015; R3B 0Y4.
4. Ingham RE. Interactions of bacteria, fungi, and their nematode grazers: Effects on nutrient cycling and plant growth. *Ecological Monographs.* 198;555:119–140.
5. Manios T, D Laux, V Manios, et al. Cattail plant biomass as a bulking agent in sewage sludge composting. *Compost Science and Utilization.* 2013;11(3):210–219.
6. Kouki, Neila Saidi, Fadhel M'hiri, et al. Co-Composting of Macrophyte Biomass and Sludge as an Alternative for Sustainable Management of Constructed Wetland By-Products. *Clean – Soil, Air, Water*. 2016;44(6):694–702.
7. Krider, Magner, Brad Hansen, et al. Improvements in Fluvial Stability Associated with Two-Stage Ditch Construction in Mower County, Minnesota. *JAWRA*. 2017;53(4):886–902.
8. Hagemann N, Stephen Joseph, Hans-Peter Schmidt, et al. Organic coating on biochar explains its nutrient retention and stimulation of soil fertility. *Nature Communications*. 2017;8(1):1089.
9. Carson, Nancy C Tuchman, Shane C Lishawa, et al. Harvesting invasive plants to reduce nutrient loads and produce bioenergy: an assessment of Great Lakes coastal wetlands. *Ecosphere*. 2018;9(6):1–16.