Cattail Harvesting for Nutrient Capture and Sustainable Energy:

*The Stacked Benefits of Water Retention Green Infrastructure that Drives Economic Sustainability*

From Research to Watershed Application

Richard Grosshans, PhD
and a massive team of colleagues
A Decade of Innovation

For the last decade IISD and partners from Industry, Academia, and Government have pursued innovative strategies to better manage land, water, and energy in the Lake Winnipeg Watershed

- Harvesting Cattail (*Typha*) and other plants to capture phosphorus and contaminants – from water retention sites, ditches, marginal agr lands
- Using the abundant harvested biomass for low carbon energy, GHG offsets, and high value bioproducts
- Applications for rural and urban
The beginning – Lake Winnipeg

- Late 1990s - growing awareness something not right with Lake Winnipeg
- 2000 - dangerous strain of pathogenic E. coli bacteria contaminated water supply of Walkerton, Ontario, Canada
- Awareness of importance of wetlands and natural systems for water quality
- Research team was gathered
The Lake Winnipeg Watershed

- **SERIOUS IMPACTS IN MANITOBA:**
  - Flooding + eutrophication in Lake Winnipeg (*i.e.* *too much phosphorus*)
- Flood water and runoff – carry phosphorus and contaminants downstream
- Phosphorus = Algae blooms in Lake Winnipeg
- Immediate need to reduce phosphorus loading in the watershed
Wetlands are a critical part of a healthy watershed

- Often referred to as “Nature’s Kidneys”
- Store runoff water in spring and storm events - reduce downstream flooding
- Remove nutrients and toxins from the water before reaching downstream rivers and lakes
- Plants (i.e. cattail) important for water quality and wildlife habitat

Wetlands and water retention = reduced flooding & nutrient loading
Cattail Harvesting – The Concept

• **2004** – began to explore innovative ways to reduce P loading using natural systems
• **Lake Winnipeg** – algae blooms = too much P
• **Certain plants are very good at absorbing things such as phosphorus and contaminants**
• **Could we harvest plants** (i.e. cattail, reeds) to capture and remove P?
• **Use of biomass**? For low carbon energy - replace coal/fossil fuels to reduce carbon emissions?
• **Markets and Incentives** to make this work?
• **Combine with water retention (flood protection)** - *holding water on the land also holds nutrients*
• **Met with skepticism and criticisms** –
  
  “Are you crazy?!”...”You want to mow down all the wetlands!?”...“Dumbest idea ever”...“IT WON’T WORK”
Where in the watershed?

1. Harvesting Effects: Harvested sites vs. non-harvested

- Removal of deadfall - Ground thaws earlier - cattail emerges 2 weeks earlier than unharvested sites
- Opens up congested site, improves diversity of plants
- Density of plants and biomass often higher after harvesting
- Cattail returns year after year
Cattail Harvesting Research

What did we discover?

2. Seasonal Nutrient Loss in Cattail – not all biomass is equal

<table>
<thead>
<tr>
<th>Season</th>
<th>Maximum</th>
<th>Median</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer</td>
<td>0.28</td>
<td>0.22</td>
<td>0.18</td>
</tr>
<tr>
<td>Fall</td>
<td>0.25</td>
<td>0.19</td>
<td>0.14</td>
</tr>
<tr>
<td>Winter</td>
<td>0.20</td>
<td>0.15</td>
<td>0.11</td>
</tr>
<tr>
<td>Spring</td>
<td>0.15</td>
<td>0.10</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Phosphorus (% as dry biomass)

Translocation to roots | Loss from freeze/thaw
Can we burn cattail to replace coal?

turning a problem into a sustainable input for the Bioeconomy

- Harvest Cattail - Remove Phosphorus and Nitrogen
- P reduction to Lake Winnipeg – “Ecological biomass”
- Sustainable renewable bioenergy - displace fossil fuels (i.e. coal)
- Carbon offsets - produce “low carbon” bioenergy
- Improve wetland habitat
- Bioremediation + habitat renewal + GHG reductions ++
- “It’s common sense”...”Knew it would work”... “Such a simple yet elegant solution”
Opportunities & Policy Drivers were in play:

- 2010 - Hank and Richard continued to scheme
- LWBSF $$ - Priority to reduce P loading to Lake Winnipeg
- The Market Demand - MB Coal ban 2014 – no more coal use for space heating – market demand = biomass fuel
- MBLL $$ - looking for locally produced carbon offsets
- 2011 Flood - Surface water management - flood protection
- Pelly’s Lake water retention project – we had a location

Manitoba Market Demand = Solid Fuel
We packed up our bags and moved to... Pelly’s Lake Water Retention Project Holland, MB
Stacked Benefits of Surface Water Retention:

Not just for flood management

Pelly’s Lake water retention site - near Holland, Manitoba
Water retention site - reduces downstream flooding, captures nutrients
Excellent conditions for growing cattail and other emergent plants
Pelly’s Lake Cattail Harvesting 2012-2015

Dries up in the fall suitable for harvesting with conventional agr equipment
Commercial scale cattail Harvesting 2012-2015
Cattail Baling 2012 - 2015
The evolution of cattail harvesting:
Research to Commercialization
From research to application success

- **2012 to 2014** - proved large-scale harvesting of cattail and other unconventional biomass
- Proved integration with water retention for management, biomass and STACKED BENEFITS
- **RESEARCH SCALE:**
  - Biomass solid fuel products
  - Combustion testing in biomass systems
  - Higher value products - biocarbon, composites, liquid biofuels, biogas – *NO market demand in Manitoba*

- COMMERCIAL SCALE END USE?
Commercial scale processing - fuel products (2014-2016)

Partnership with Industry and the Hutterites
Industrial & Farm scale
Biomass Stoker Boilers

Residential & Small Commercial
Pellet stoves
Solid Fuel
Blended Fuel Pellets

Commercialization (2014-2016)

• **FUEL PELLETS**
  • 75 tonnes cattail : grasses : peat
  • 300 tonnes cattail : peat
  • 1500 tonnes cattail : wood
  • 3000 + tonnes of wood

• **FUEL PELLET USE**
  • 3 Hutterite colonies
  • Providence University College
  • Several local landowners

• *Generated over 10,000 tonnes of CO2 equiv*
Solid Fuel
Shredded Cattail Bales

Bale Shredding (2016-2017)

- 400 bales
- 200 tonnes of cattail biomass
- Coarsely shredded with tub grinders
- Less time and effort needed for shredding
- More energy efficient
# Energy value and analysis - 2015

<table>
<thead>
<tr>
<th>Biomass</th>
<th>Calorific Value MJ/kg</th>
<th>Moisture (%)</th>
<th>Volatile Components (%)</th>
<th>Fixed Carbon (%)</th>
<th>Ash Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattail</td>
<td>17.29 to 18.2</td>
<td>12</td>
<td>64 to 76</td>
<td>16.82</td>
<td>5.47 – 7.64</td>
</tr>
<tr>
<td>Wood pellet</td>
<td>20.3</td>
<td>8.8</td>
<td>80.9</td>
<td>17.5</td>
<td>1.6</td>
</tr>
<tr>
<td>Cattail : Wood blend pellet</td>
<td>19.8</td>
<td>6.3</td>
<td>77.3</td>
<td>19</td>
<td>3.7</td>
</tr>
<tr>
<td>Wood (15 % mc) b</td>
<td>15.0 to 22.3</td>
<td>7309</td>
<td>&gt; 70</td>
<td>-</td>
<td>0.65 to 1.52</td>
</tr>
<tr>
<td>Wood chips</td>
<td>10.4</td>
<td>4471</td>
<td>&gt; 70</td>
<td>-</td>
<td>0.6 to 1.5</td>
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<tr>
<td>Wheat Straw (dry)</td>
<td>17.3</td>
<td>7438</td>
<td>72.9</td>
<td>-</td>
<td>8.3</td>
</tr>
<tr>
<td>Wheat Straw (20 % mc) b</td>
<td>13.74</td>
<td>5907</td>
<td>-</td>
<td>-</td>
<td>4</td>
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<tr>
<td>Coal (anthracite)</td>
<td>29.5</td>
<td>12683</td>
<td>-</td>
<td>-</td>
<td>10.5</td>
</tr>
<tr>
<td>Coal (Bituminous)</td>
<td>20.9 to 33.4</td>
<td>10748</td>
<td>-</td>
<td>-</td>
<td>6 to 9.8</td>
</tr>
<tr>
<td>Coal (lignite) b</td>
<td>15.31</td>
<td>6582</td>
<td>-</td>
<td>-</td>
<td>7.3</td>
</tr>
</tbody>
</table>
Stacked EGS benefits:
*High value Environmental and Economic benefits*

Harvest of Cattail and other “ecological biomass” =
1. Biomass supply
2. Nutrient capture (P, N)
3. Carbon offsets

+ **Surface Water Management** – hold water to reduce flood damages + irrigation in times of drought

+ **Biodiversity and habitat management** – improved wildlife habitat - payments provided in Europe

+ **Water quality credits** – payments for service of removing Phosphorus ($/kg)

+ **Higher value bioproducts** – biochar, fibres, composites, ethanol, bioplastics, biogas, fertilizer

Investments in GHG offsets (biomass energy) and green infrastructure (water retention) brings added embedded benefits (phosphorus, habitat restoration, biodiversity...
1. Biomass (cattail) harvesting was a component of the NDP Surface Water Management Strategy and Sustainable Drainage initiatives

2. The Manitoba Climate and Green Plan consultations with PC

   ✓ reduce carbon emissions causing climate change,

   ✓ adapt to climate change impacts,

   ✓ preserve wetlands and vulnerable ecosystems,

   ✓ integrate water and land use,

   ✓ build new clean economy growth, and

   ✓ foster sustainable living opportunities for people and communities
Carbon, Methane, and Nitrous Oxide reduction = carbon offset credits

Methane and N2O reduction in managed water retention projects
Reduction in GHG emissions

Cumulative greenhouse gas flux (CO2 + CH4 + N20, expressed as CO2 equivalents; mean +/- SE) for harvested and non-harvested cattail plots in the Pelly’s Lake retention area.
Expanded Applications

*Drainage Ditch Management: Rural and Urban applications*
Compost – another end use demand instead of energy

*Brady Landfill, Winnipeg - 2015 and 2016*

- Harvest ~25 km of drains each year
- Cattail removal maximizes drain capacity/flow
- 63 Truck loads diverted from general landfill to compost = 470 tonnes
- Removed 280 kg P and 1800 kg N
Expanded Applications

*Floating Treatment Wetlands for phytoremediation*

- Water treatment, habitat, phytoremediation
- Bioplatform Research at ELA - 2015 and 2016
- NEW Floating Wetland Islands at ELA in 2017 – Contaminants Project

2015-2016

2017-2019
Keys to Success – from research to application

- Integrating priority issues in the watershed
- Applied research to drive policy change
- Partnerships and collaboration – industry, NGOs, Government, Academics, the public
- Education, engagement, communication, tours – instrumental for acceptance
- Media interviews, events, articles (150+)
- High school students, University classes, Graduate student research, Interns
US Collaborations and Influence

*North Dakota and Minnesota*

- University of Minnesota Crookston and the Red River Basin Commission
- Water Retention in Red River Basin
- IISD concept of harvesting integrated for invasive cattail control, habitat enhancement - use of harvested material for land application
- IISD co-authored cattail management book
US Collaborations and Influence

*Great Lakes management*

- Loyola University, Cleveland Museum of Natural History
- Harvest to control invasive Phragmites and cattail in Great Lakes coastal wetlands
- Habitat enhancement and marsh restoration
- Use of harvested Phragmites for biogas, livestock bedding
International Collaborations and Influence

*Germany and the Netherlands*

- University of Greifswald and the Michael Succow Foundation
- Harvest for biodiversity and habitat - use for roof thatching, land compost applications, and bioenergy
- IISD co-authored publications, book chapters on Paludiculture
- Wageningen University, Netherlands - collaborative research on pesticides and managed wetlands - IISD interns each year
Where to from here?

Developed Tools

• Biostrat – Bioeconomy assessment tool
• Bioeconomy Atlas – GIS mapping and modelling tool - application to other regions

Path Forward

• Partner with local governments - ditch management and harvesting – for compost, biomass energy
• Grow with the MB biomass industry - Expand industry partnerships, energy conversions, fuel products
• FTW at ELA and rural Manitoba – Phytoremediation - storm water ponds, waste & leachate lagoons, dilbit
• Expanding Atlas function
• Collaborative NSERC funded research
• Communication products
IISD Water Program - Bioeconomy Program

**REPLICATION**
- National/International

**Cattail/Biomass Harvesting**

**Sustainable Renewable Biomass**
- Solid Fuel (fuel pellets, cubes)
- Liquid Fuels
- Charcoal (biochar)
- Composites
- Compost
- Biogas (methane)

**Sustainable Agriculture**
- Marginal Agr lands
- New markets
- Additional revenue
- Custom equipment
- Custom services (harvest/bale)
- Flood protection
- Wetland protection

**Policy**
- Water Quality credits
- Surface Water Management
- Drainage Management

**Nutrient Capture**
- Reduce Phosphorus loading to Lake Winnipeg
- Reduce Algae blooms
- Lake remediation technology
- Bioremediation (toxins, contaminants)
- Phosphorus reuse and recycling $$$

**Water Retention**
- Flood protection
- Wetland restoration
- Maintenance of municipal lands

**Watershed Management**
- Habitat/Biodiversity
- Invasive species control
- Drainage ditches

**Wetland restoration**
- Drought Protection
- Erosion control

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**Wetland restoration**
- Drought Protection
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**Biodiversity**
- Invasive species control
- Drainage ditches

**Drought Protection**
- Erosion control

**Erosion control**
- Drainage ditches

**Drought Protection**
- Erosion control

**Phosphorus reuse and recycling $$$**
- Charcoal (biochar)
- Compost
- Biogas (methane)
- Flood protection
- Wetland protection
From research to watershed application
Success built on support of funders

- Funders have allowed us to apply these practices in the watershed
- Influence management practices locally, nationally and internationally
- Have changed government policies at all levels
- Without our funders, this program area would not exist at IISD
Thanks!

Questions?
A Decade of Innovation at IISD 2006-2016

Manitoba Excellence in Sustainability Awards

SUSTAINIA 100

Winnipeg researcher tapping into cattails for energy and helping lake to heal

The Nature of Things | Season 2010-11 | Jul 22, 2012 | 45 Mm

Save My Lake!

Richard Grosshans
Water Innovation Centre

The Chamber

Spirit of Winnipeg
Awards Gala

CBC player

CBC television

Bio or Bust

Does the solution to Lake Winnipeg’s peak phosphorus problem herald a new bioreconomy for Manitoba? • KERRY PRIDJE

“The solution to Lake Winnipeg’s peak phosphorus problem is not a new bioreconomy, but a new way of thinking about how we manage our water,” says John Petitfather, executive director of the Manitoba Environmental Task Force. “It involves taking the existing practices that are working and scaling them up.”}

“We’re not just spending on an environmental issue: we’re investing in new value chains. We estimate those to be in the multi-billion-dollar range.”

—Heinz David Vizenar

The initial goal, however, is to better understand the science, says Richard Grosshans, research associate with the University of Manitoba’s Institute for Sustainable Food Systems. “We want to understand more about the nutrient cycle and its importance in the health of Lake Winnipeg,” says Grosshans. The idea is that science will help determine bioremediation techniques, which can then be scaled up to be integrated into larger systems and communities.