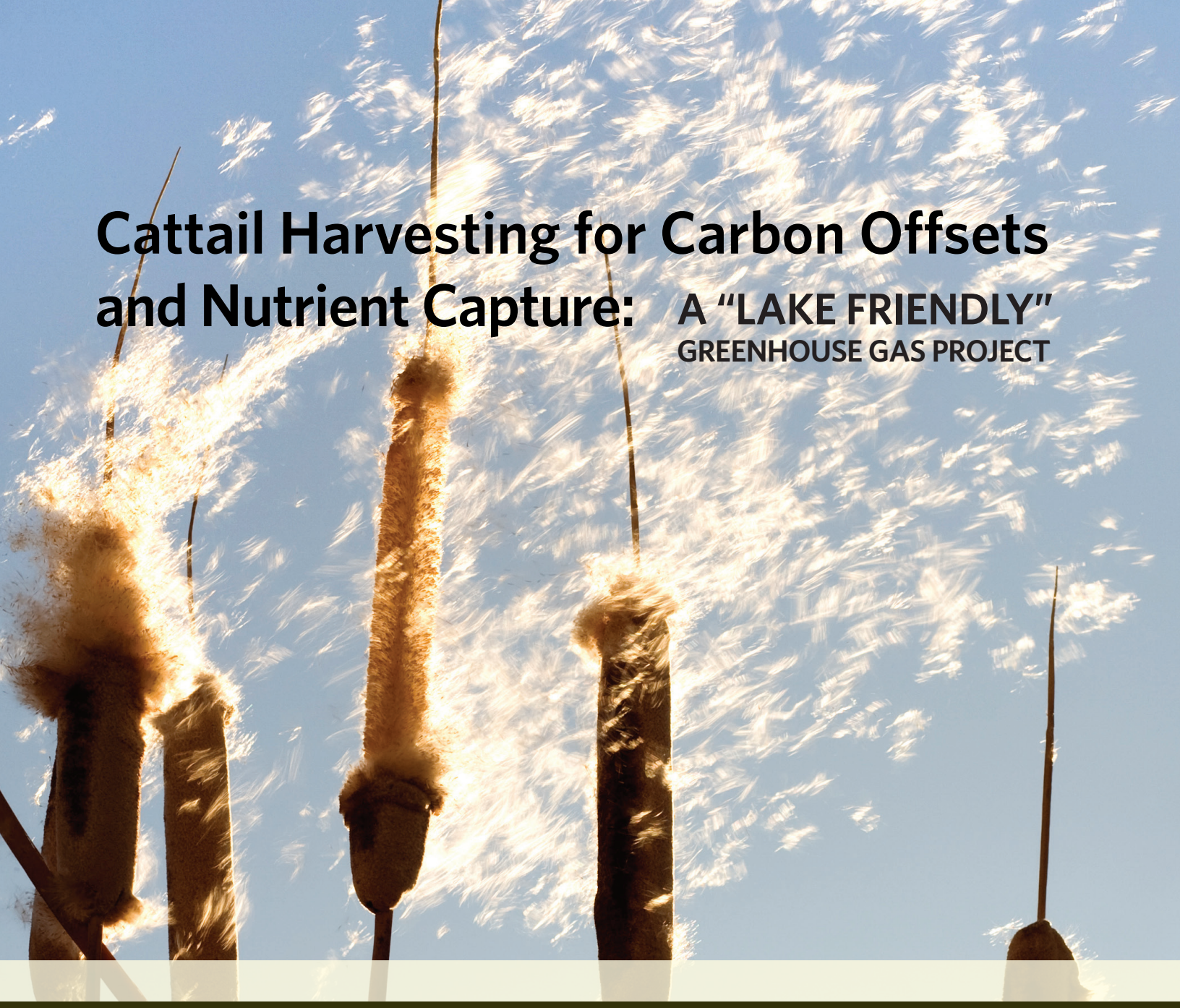
Cattail Harvesting for Carbon Offsets and Nutrient Capture: A "LAKE FRIENDLY" GREENHOUSE GAS PROJECT



Netley-Libau Nutrient-Bioenergy Project

Innovative Environmental and Economic Solutions for Flood Control, Nutrient Management, and Sustainable Renewable Energy in the Manitoba Bioeconomy

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March 2012

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Working paper to Manitoba Lotteries (2011–2012)

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Executive Summary

The Cattail Biomass Harvesting project is a component of the International Institute for Sustainable Development's ongoing Netley-Libau Nutrient-Bioenergy Project, co-funded by Manitoba Lotteries, Manitoba Conservation Department of Water Stewardship, and Manitoba Hydro. This project is pursuing and evaluating the commercial-scale harvesting of cattail (Typha spp.) for its multiple co-benefits, in particular:

1. Nutrient capture (i.e., phosphorus) through harvesting of nutrient-rich biomass to reduce phosphorus loading to Lake Winnipeg
2. Use of harvested biomass as a viable feedstock for bioenergy to displace coal used for heating
3. Certification of cattails through the voluntary market for generation of carbon offset credits
4. Demonstration of commercial-scale agricultural equipment for harvesting in wet environments

Progress to Date

Over the past year, efforts focused on developing cattail harvesting protocols and building partnerships in the biomass and bioenergy industry in Manitoba to advance commercial-scale harvesting opportunities of cattail and alternative biomass feedstocks. Important partnerships were formed and several new sites have expanded the scope of the current project beyond the Netley-Libau Marsh area.

Key highlights of current progress:

- **Formed important new partnerships** with conservation districts, rural municipalities, communities and individual private landowners to secure cattail harvesting sites for 2012.
- **Developed a new partnership** with Manitoba Hydro to investigate cattail biochar as a viable end-use bioproduct for cattail biomass.
- **Investigated protocols for carbon accounting** for carbon offset trading and certification within available carbon markets, identifying existing federal and provincial carbon offset models.
- Continued communication and outreach of project concept through media and events. The Netley-Libau Nutrient-Bioenergy Project continues to gain the attention of national and local media, appearing on *The Nature of Things* "Save My Lake," CBC television news, and articles in the *Winnipeg Free Press, Interlake Spectator, Manitoba Cooperator, Brandon Sun, CBC News (online), Farm Show Magazine, World Watch, Pellet Mill Magazine, Biomass and Bioenergy,* and *Water Canada Magazine.*
- **Involved in planning and development** integrating biomass and production agriculture with surface water and nutrient management in Manitoba; establishing the cattail harvesting concepts as a key example of integrated watershed management with multiple co-benefits.
- Advanced the research as we continue to explore new pathways and end-uses of the harvested cattail biomass; working with Hydro on biocarbon, and University of Manitoba exploring lignocellulosic biofuels.

Research Forward

Under the Cattail Harvesting project, cattail biomass will be harvested from several pilot-scale demonstration sites in Southern Manitoba, including Netley-Libau Marsh at the mouth of the Red River along the south end of Lake Winnipeg—a lake experiencing significant eutrophication issues.

Key objectives for 2012:

- **Further develop existing harvesting plan** to outline a full harvest protocol for planned cattail harvests in 2012 and utilization of the harvested biomass.
- **Identify, modify and test harvesting equipment and technologies** working with the Prairie Agricultural Machinery Institute (PAMI) and Manitoba Hydro to mobilize low-impact harvesting equipment for wet environments in Manitoba.
- **Project site monitoring and assessment** to evaluate a full resource assessment and demand analysis of cattail project sites with continued monitoring and assessment.
- **Cattail biomass and ash analysis** to further assess cattail nutrient capture and phosphorus re-use, and as a viable biomass feedstock through several bioenergy and bioproduct pathways.
- **Calculation of cattail carbon offset potential and pursuing Verified Carbon Standard (VCS) certification** for carbon offsets.

Carbon Offset and Certification for Manitoba Lotteries Offsets

Potential carbon and greenhouse gas (GHG) offset credits are currently being explored through existing federal and provincial offset models. There is currently no national strategy or market for offsets for GHG mitigation at the federal level in Canada. In this absence, provinces have developed their own offset regimes with varying levels of coverage, standards and pricing. Alberta has the most mature offset regime within Canada with an established protocol for biomass combustion. This protocol, with some amendment, is being explored as a basis on which to build an offset protocol for the cattail harvesting project.

For the Cattail Harvesting for Carbon Offsets project, like other projects in stages of development that have GHG mitigation opportunities, the presence of a voluntary market serves as an outlet to gain a crediting benefit while regional compliance markets form. Overall, the VCS is one of the most commonly used standards in the world. It is also a viable option, at least upon initial review, to look at bringing cattail biomass offsets to the voluntary carbon market. For this reason, it is the model that we will focus on in terms of how our project gets accredited, leading towards voluntary certification of cattail biomass and its harvesting for multiple co-benefits.

A thorough evaluation of existing offset markets; voluntary certification of cattail biomass to displace fossil fuel use; and research, development, and implementation of the commercial-scale harvesting opportunities of cattail biomass will provide organizations like Manitoba Lotteries with local Lake Friendly[1] carbon offsets that are produced from a sustainable biomass feedstock with multiple co-benefits.

[1] Lake Friendly is a non-profit organization that focuses on reducing the nutrient load to Lake Winnipeg and other lakes, to encourage environmentally responsible consumer choice and to build awareness about the issues facing Lake Winnipeg. A "Lake Friendly" designation identifies products or practices that are friendly to Lake Winnipeg's recovery process.

1.0 Introduction

1.1 Innovative Solutions – The Lake Winnipeg Bioeconomy Project

Lake Winnipeg is considered one of the most eutrophic large lakes in the world and suffers from excessive loading of nutrients (i.e., nitrogen and phosphorus) from throughout its watershed. Phosphorus is a critical nutrient for plant growth but high levels in Lake Winnipeg are causing massive algae blooms of increasing intensity and frequency that consume oxygen and can release dangerous toxins (Lake Winnipeg Stewardship Board, 2005). The phosphorus comes from a complex diversity of sources in the watershed: runoff from sewage, intensive agriculture, cattle and hog production, and fertilizers. The Red River delivers approximately 60 per cent of the phosphorus load to the lake. Much of the watershed encompasses the prairie agricultural region, a heavily modified and drained landscape. Wetlands are a critical component of a healthy and diverse watershed, providing essential environmental and economic benefits or ecological goods and services (EGS)[2]: nutrient and contaminant removal, carbon storage, water storage and ground water recharge, reduction of flood impacts, and wildlife habitat and biodiversity (Gabor et al., 2002). An estimated 70 per cent of wetlands have been drained, resulting in a loss of these natural benefits (Ducks Unlimited Canada, 2012). This drained landscape is prone to flooding in the spring with a lot of dissolved nutrients transported in flood waters. Consequently, nutrient loading to the lake is made worse by dramatic spring flood events (McCullough et al., in press).

The goal to reduce nutrient levels in Lake Winnipeg by protecting wetlands, controlling runoff and reducing nutrient loading within the watershed was most recently identified in Bill 46, the Save Lake Winnipeg Act. Because of the ecological significance of Lake Winnipeg, further environmental protection measures need to be taken to protect and restore the lake to an ecologically healthy condition (Government of Manitoba, 2011a). To accomplish these goals, the Government of Manitoba has set a key objective of exploring innovative solutions.

As part of its Lake Winnipeg Bioeconomy project, the International Institute for Sustainable Development (IISD) has been exploring innovative integrated environmental and economic solutions to address flooding and water resources management, nutrient loading, greenhouse gas (GHG) emissions, climate change and sustainable energy issues in Manitoba (IISD, 2012). IISD has identified that integrated solutions to address these sustainability challenges can provide opportunities through alternative energy, biomass bioenergy, bioproducts, bioprocessing, technologies and advanced biofuels.[3]

[2] Ecological goods and services (EGS) are the benefits arising from the ecological functions of healthy ecosystems. Such benefits accrue to all living organisms, including animals and plants, rather than to humans alone. However, there is a growing recognition of the importance to society that ecological goods and services provide for health, social, cultural and economic need. http://en.wikipedia.org/wiki/Ecological_goods_and_services

[3] For example, second- and third-generation biofuels such as ethanol made from lignocellulosic material (i.e., plant-based material).

FIGURE 1. The Lake Winnipeg Watershed encompasses an enormous geographic region that crosses provincial and U.S. borders, draining an area of approximately 1 million square kilometres (km^2). This highly drained and modified landscape is prone to spring flood events. An overabundance of phosphorus in Lake Winnipeg causes algae blooms that wash ashore on beaches. Of concern is the increasing size and frequency of algae blooms in the north and south basins of the lake.

1.2 The Netley-Libau Nutrient-Bioenergy Project

For the past six years, IISD in collaboration with the University of Manitoba and Ducks Unlimited Canada has been researching cattails (*Typha* spp.) for nutrient capture and phosphorus reclamation in the Lake Winnipeg watershed, and use of harvested cattails as an alternative biomass feedstock to be integrated into solid and cellulosic bioenergy systems to help meet increasing sustainable energy demands and reduce GHG emissions. Bioenergy—the production of energy from biological material—is a promising sustainable and renewable energy source. Use of biomass in Canada is growing and it is anticipated that this growth will continue with federal and provincial renewable energy policies and regulations to reduce the use of coal (Sawyer, 2011). Typical sources are forestry waste, wood and agricultural residues (e.g., wheat straw, flax chives and corn stover), but there are alternative biomass feedstocks that can provide additional environmental and economic co-benefits. Developing biomass into a sustainable source of affordable biopower and fuels will require the flexibility to use a wide variety of sustainable biomass resources (U.S. Department of Energy, 2012), and exploration of economic instruments such as carbon offset markets that identify biomass as a low-carbon fuel source with multiple benefits.[4]

Nutrient loads can be intercepted through riparian and wetland biomass management. Grosshans et al. (2011a) demonstrate harvesting cattail biomass as a valuable tool to reduce excess nutrients in aquatic systems, sequester atmospheric carbon dioxide (CO_2), and displace greenhouse gas emissions while providing multiple environmental and economic co-benefits, such as incentives for wetland restoration and habitat improvement (Grosshans et al., 2011a). By utilizing cattails as an alternative sustainable low-carbon fuel source to displace the use of fossil fuels (i.e.,

[4] There is a protocol for biomass combustion within the Alberta system, both related to the avoided GHGs from switching to biomass from fossil fuels as well as GHGs avoided by combusting biomass versus undergoing anaerobic decomposition. Theoretically, with some amendment, this protocol could be used as a baseline on which to build an offset protocol for the cattail harvesting project. Biomass protocol: http://environment.gov.ab.ca/info/library/7908.pdf

coal), nutrients (i.e., phosphorus) captured in the harvested biomass are removed from the environment, addressing nutrient management challenges in Manitoba. Additionally, these nutrients can be reclaimed and reused (Grosshans et al., 2011a). Not only are nutrients prevented from flowing to Lake Winnipeg by harvesting cattails, phosphorus (and nitrogen depending on the bioenergy pathway) can be recovered for application to agricultural lands to support crop growth. Phosphorus is causing eutrophication issues in Lake Winnipeg, but it is also a limited strategic natural resource critical for agricultural fertilizer and global food security (Ulrich, Malley & Voora, 2009).

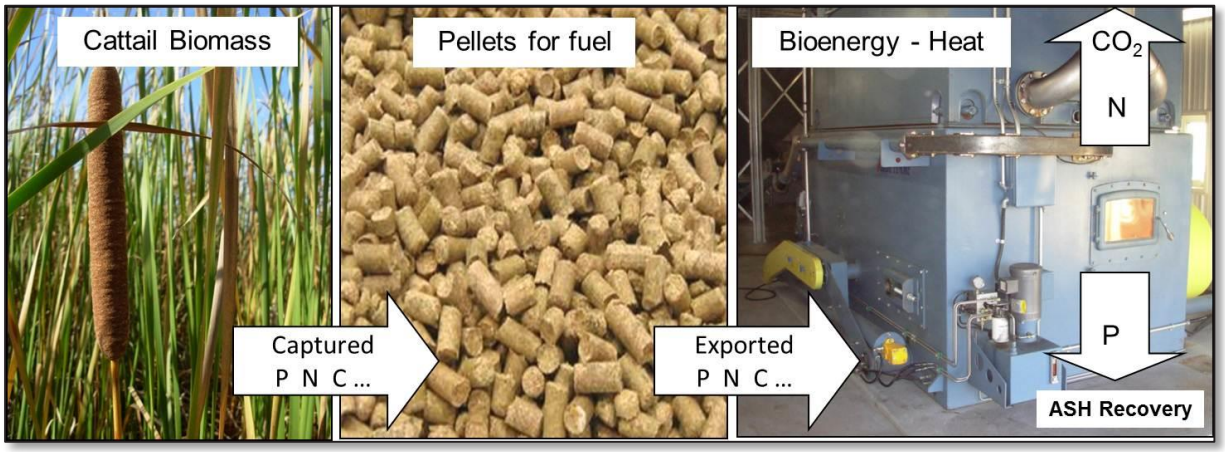

FIGURE 2. Cattails to bioenergy: Cattails sequester carbon and take up nutrients from the sediment as they grow. Once harvested, the biomass can be used as a solid fuel to replace fossil fuels, thereby reducing overall carbon emissions and enabling recycling of captured nutrients (Grosshans et al., 2011b).

1.3 Project Concept – Cattail Harvest for Carbon Offsets and Nutrient Capture

The Cattail Biomass Harvesting project is a component of IISD's ongoing Netley-Libau Nutrient-Bioenergy Project, co-funded by Manitoba Lotteries, Manitoba Conservation Department of Water Stewardship, and Manitoba Hydro. This project will examine the commercial-scale harvesting of cattails (*Typha* spp.) for multiple benefits. Of particular interest:

1. Nutrient capture (i.e., phosphorus) through harvesting of nutrient-rich biomass to reduce phosphorus loading to Lake Winnipeg
2. Use of harvested biomass as a viable feedstock for bioenergy to displace coal used for heating
3. Certification of cattail through the voluntary market for generation of carbon offset credits
4. Demonstration of commercial-scale agricultural equipment for harvesting in wet environments

Evaluating cattail as a sustainable alternative biomass feedstock directly addresses goals of the recently released *Manitoba Bioproducts Strategy* (Government of Manitoba, 2011b) to "further develop the sustainable production of Manitoba's renewable resources" and "to reduce GHG emissions from the use of fossil fuels in the energy sector," while the nutrient recovery strategy of harvesting cattails for nutrient capture directly addresses ongoing objectives of the provincial government most recently identified in Bill 46, the Save Lake Winnipeg Act, towards "reducing nutrient loading within the Lake Winnipeg watershed" (Government of Manitoba, 2011a).

PROJECT EVALUATIONS	
1) Cattail biomass yields	Availability for use as a viable biofuel source
2) Potential nutrient capture	From harvesting cattails (phosphorus and nitrogen)
3) Carbon sequestered	In harvested cattail biomass
4) Carbon displaced	From bioenergy production and displacement of coal
5) Carbon and GHG offsets	Fossil fuel displacement and reduction of GHG emissions
6) Certification	Cattail biomass for offsets
7) Recovery of phosphorus	Post-combustion for re-use
8) Harvesting technologies	Sustainable use in wet environments
9) Biomass processing	Logistics and economics

This project will demonstrate the multiple benefits of bioenergy projects to restore sensitive ecosystems, improve water quality and recycle nutrients for agricultural fertilizer. The harvested cattail biomass will be used as a solid fuel source to displace coal for bioenergy production and produce valuable carbon and GHG offsets (potentially including reduction in methane emissions), while reaping the additional benefits of phosphorus reduction in Lake Winnipeg and habitat conservation (Grosshans et al., 2011a). The goal is for the carbon investor to highlight this unique "made-in-Manitoba" concept that delivers greenhouse gas emission reductions and is Lake Friendly by reducing nutrient loads on Lake Winnipeg.[5] Current federal and provincial carbon models will be explored and the appropriate certification processes applied. This project will diversify the portfolio of sustainable biomass feedstocks for current space heating demands and combined heat and power production (CHP) applications, and introduce a new commercial feedstock for cellulosic ethanol production to help meet the ethanol demand created by Canada's Renewable Fuel Standard.

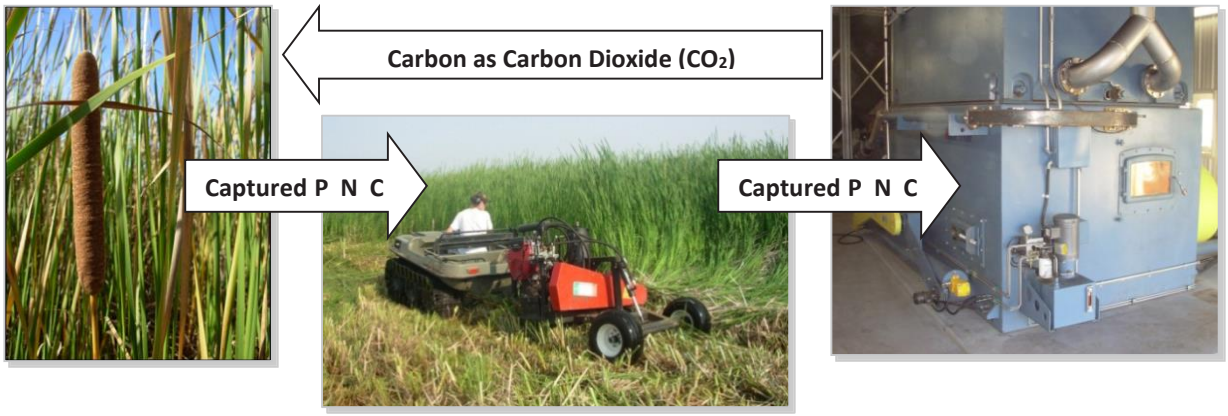

FIGURE 3. Biomass energy is considered a "low carbon" fuel source, since CO_2 absorbed from the atmosphere by plants during growth is returned to the atmosphere when burned

[5] Lake Friendly is an organization dedicated to protecting Manitoba's waterways and raising awareness about the threats to one of our greatest resources—fresh water: http://www.lakefriendly.ca/

1.4 Project Scope

Under the Cattail Harvesting project, cattail biomass will be harvested from several pilot-scale demonstration sites in southern Manitoba, including Netley-Libau Marsh, a large freshwater coastal wetland located at the mouth of the Red River along the south end of Lake Winnipeg—a lake experiencing significant eutrophication issues.

- The current harvesting plan will be used to develop a full harvesting protocol for harvesting of cattail biomass in wet environments, and utilization of the harvested biomass.
- Harvesting equipment and technologies will be evaluated and tested, leading to implementation of low-impact harvesting equipment.
- Several new project sites will be further assessed for their biomass resource opportunities, identifying harvestable cattail areas from different landscapes and land-use types.
- Cattail biomass will be used and evaluated as a feedstock through several bioenergy pathways to displace use of fossil fuels and reduce GHG emissions.
- Potential nutrient capture from harvesting cattails will be assessed at each project site, and potential for nutrients will be reclaimed post-energy production (i.e., ash).
- Nutrient reclamation will be evaluated through analysis and fertilizer growth trials.
- Carbon and GHG offset credits will be calculated from the use of cattail biomass to displace coal for heat production. Federal and provincial offset models will be used in these calculations.[6]
- Certification of cattail biomass through VCS for carbon offsets. The prospect of a Lake Friendly CO_2 offset credit might be very attractive to organizations with corporate social responsibility mandates and carbon neutrality mandates.

[6] For example, the opportunity for generating carbon offsets through the Alberta Biomass Protocol arises from the direct and indirect reductions of GHG emissions resulting from replacing fossil fuel-derived energy through biomass combustion facilities and using material that otherwise would have undergone anaerobic decomposition. Alberta Biomass protocol: http://environment.gov.ab.ca/info/library/7908.pdf

2.0 Progress Report

2.1 Current Progress To Date (2011–2012)

The goal is for the carbon investor to highlight this unique "made-in-Manitoba" concept that delivers greenhouse gas emission reductions and is Lake Friendly by reducing nutrient loads on Lake Winnipeg

Over the past year, efforts focused on developing the harvesting protocol and building partnerships within many sectors of the biomass and bioenergy industry in Manitoba and internationally, to advance the commercial-scale opportunities of cattail and other alternative biomass feedstocks within the Manitoba bioeconomy. Important partnerships were formed with several conservation districts (CDs), rural municipalities (RMs), communities, and individual private landowners to secure cattail harvesting sites for 2012. Several new project sites have been established through southern Manitoba, expanding the scope of the current research project beyond the Netley-Libau Marsh area. These project sites will allow us to evaluate the benefits of harvesting cattails further upland in the watershed as a critical component of integrated surface water management and production agriculture by intercepting nutrients upstream to prevent loading downstream. Harvested biomass will be evaluated and tested through several new end-uses and bioenergy pathways.

Current progress over the past year focused on several key areas:

- New partnerships and collaborations were formed for additional cattail harvesting and demonstration sites in different landscapes and land-use areas of the province.
- A new partnership was developed with Manitoba Hydro to investigate cattail biochar as a viable end-use for energy, fertilizer and phosphorus recovery, and to evaluate anaerobic digestion of cattails with manure for methane.
- A cattail harvest and logistics plan was developed with pilot-scale harvests for 2012.
- Field visits and assessments identified potential harvest areas in the Netley-Libau Marsh area. Several collaborations with landowners have been established for cattail harvesting.
- Project partnerships for design and modification of agricultural equipment to harvest in wet environments were developed. Initial design concepts are based on European models. Currently, the project is evaluating modification of corn forage harvesters for use in wet conditions.
- Discussions with Manitoba Agriculture identified new economic values for alternative biomass with multiple benefits for Manitoba and the agricultural sector.
- Planning with project partners identified end-users of the harvested cattail biomass, potential carbon value and offsets, area load demands and uses.
- Research was conducted in methods for carbon accounting and carbon value of cattails, certification as a carbon credit within available carbon markets, existing federal and provincial biomass and carbon models.
- Economic evaluation of harvesting cattail was compared to agricultural biomass sources (i.e., wheat straw, corn stover); energy value comparisons were made to fossil fuels and electricity.
- Progress was presented at international, national and local conferences and workshops.

- A printed project brochure and an online video for public communication of the project and its multiple economic and environmental benefits was produced.
- Communication and outreach of the project concept through media and events continued.
- The project involved planning and development of integrating biomass and production agriculture with surface water and nutrient management in Manitoba. The cattail harvesting concepts were established as key examples of integrated watershed management with multiple co-benefits.

2.2 New Project Partnerships

Manitoba Hydro – Bioenergy Optimization Program Demonstration Projects

IISD, in partnership with Manitoba Hydro, was successful in matching Manitoba Lotteries funding for the Cattail Biocarbon Project—a three-year project to begin in 2012. The Cattail Biocarbon Project is a further component of IISD's ongoing Netley-Libau Nutrient-Bioenergy Project, and represents a new opportunity to strengthen partnerships with Manitoba Hydro, local communities and the Manitoba biomass industry. This project is part of Manitoba Hydro's Bioenergy Optimization Program Demonstration Projects (CEF Ref. 013 BI) through a Natural Resources Canada Clean Energy Fund: Small Scale Demonstration Mid-Cycle Project Add-On targeted at the biocarbon demonstration project with the Rock Lake Colony at Grosse Isle, MB.

The Cattail Biocarbon Project complements the Manitoba Lotteries Cattail Carbon Project in its aim to develop commercial-scale opportunities and further explore end-uses and bioproduct streams for harvested cattail (*Typha* spp.) and available GHG emission reduction credits.

Objectives of the Cattail Biocarbon Project component:

1. Carry out large-scale pilot harvests to demonstrate feasibility of commercial-scale harvests of cattail biomass as a novel and innovative alternative feedstock for biocarbon and nutrient capture.
2. Modify and test appropriate conventional agricultural equipment to harvest—as sustainably as possible—suitable quantities of cattails for biocarbon demonstration trials; examining various sites, under varying conditions, and at different seasonal periods.
3. Trial the use of cattails and agricultural residue (i.e., locally available straw bales) as readily available, low-cost, sustainable sources of biomass for the production of biocarbon at the Rock Lake Colony carbonization facility located near Grosse Isle, MB.
4. Examine soil conditioning and soil fertility characteristics of biocarbon and ash from combustion trials in solid fuel burners.
5. Life-cycle analysis: evaluate harvesting logistics, transport, drying, and storage options.

La Salle Redboine CD – Pelly's Lake Project

IISD recently became involved with the La Salle Redboine CD to be part of the new Pelly's Lake backflooding water retention and nutrient mitigation project.[7] The land occupied by Pelly's Lake has been drained many times in the past for hay production or pasture, but all attempts have failed and the land is filled with cattails and other undesirable species. The idea is to create a backflood system to reduce spring flooding, increase hay production and recharge the downstream reservoir later in the season. In total, roughly 260 hectares will be flooded. Cattails will then act as natural sponges for phosphorus before being harvested for fuel for use in solid fuel burners (La Salle Redboine, 2011). The Oak Ridge Hutterite Colony nearby has expressed interest in harvesting and utilizing the cattail biomass to reduce coal use.

2.3 Project Communications and Media

The Netley-Libau Nutrient Bioenergy Project continues to gain the attention of national and local media. Project leader Richard Grosshans appeared on *The Nature of Things* "Save My Lake," which aired April 3, 2011. On September 1, 2011, CBC television news aired a piece in which Richard Grosshans toured Netley-Libau Marsh with CBC reporter Mychaylo Prystupa. Articles have appeared in the *Winnipeg Free Press*, *Interlake Spectator*, *Manitoba Cooperator, Brandon Sun, CBC News (online), Farm Show Magazine, World Watch, Pellet Mill Magazine, Biomass and Bioenergy*, and *Water Canada Magazine*.

Innovation of the Week: Turning Cattails into Fuel
http://blogs.worldwatch.org/nourishingtheplanet/innovation-of-the-week-turning-cattails-into-fuel/

Cattail Farming Could Help Save Troubled Lake
www.iisd.org/pdf/2011/producer_cattails.pdf

Bio or Bust: Does the Solution to Lake Winnipeg's Peak Phosphorus Problem Herald a New Bioeconomy for MB?
http://www.iisd.org/pdf/2011/WC57_MarApr11_12-15.pdf

An Unconventional Pellet Feedstock – Pellet Mill
Online version: http://biomassmagazine.com/articles/5461/an-unconventional-pellet-feedstock

Digital magazine: http://issuu.com/bbiinternational/docs/spring11_pmm?mode=embed&layout=http%3A%2F%2Fskin.issuu.com%2Fv%2Flight%2Flayout.xml&showFlipBtn=true

Wetlands Good Flood-Fighters: Also Offer Economic Spinoffs – *Winnipeg Free Press*
http://www.winnipegfreepress.com/opinion/columnists/wetlands-good-flood-fighters-122381493.html

Nature of Things: "Save My Lake"
http://www.cbc.ca/documentaries/natureofthings/2011/savemylake/

Cattail Harvester Provides Fuel, Captures Phosphorus – *Farm Show*
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[7] Pelly's Lake Project: Cattails and water retention go hand in hand http://agcanada.com/manitobacooperator/2012/01/24/pellys-lake-project-moving-ahead/

Converting Cattails to Fuel Could Save Vital Marsh – *Winnipeg Free Press, Brandon Sun*
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http://www.brandonsun.com/breaking-news/converting-cattails-to-fuel-could-save-vital-marsh-129017433.html

Swollen Lake Slowly Killing Wetland: People and Vegetation Disappearing, Too – *Winnipeg Free Press*
http://www.winnipegfreepress.com/local/swollen-lake-slowly-killing-wetland-128738958.html

Invasive Cattails Choking Marsh to Become Fuel – *Nanaimo Daily News*
http://www2.canada.com/nanaimodailynews/news/story.html?id=ac8042c8-057c-4289-87de-ed2d0092bde4

Turning Lake Winnipeg pollution into profit - Research on cattails for biofuels and fertilizer – *CBC NEWS*
http://www.cbc.ca/news/canada/manitoba/story/2011/09/02/mb-lake-winnipeg-cattail-iisd.html

Netley–Libau Nutrient-Bioenergy Project Video – Manitoba Chamber of Commerce
http://www.mbchamber.mb.ca/2011/08/%E2%80%9Cnetley%E2%80%93libau-nutrient-bioenergy-project-video%E2%80%9D-iisd-publications-centre/

Lake Winnipeg in Serious Ecological Trouble, says New Report – *Outdoor Canada*
http://outdoorcanada.ca/11278/news/lake-winnipeg-in-serious-ecological-trouble-says-new-report

Netley–Libau Nutrient-Bioenergy Project Brochure – Manitoba Chamber of Commerce
http://www.mbchamber.mb.ca/2011/06/%E2%80%9Cnetley%E2%80%93libau-nutrient-bioenergy-project%E2%80%9D-iisd-publications/

Premier to Tackle Rehab of Wetlands: Phosphorous Levels Threaten Lakes – *Brandon Sun*
http://www.brandonsun.com/breaking-news/premier-to-tackle-rehab-of-wetlands-123008333.html

Premier Unveils Plan To Save Lake Winnipeg – *Nation Talk*
http://www.nationtalk.ca/modules/news/article.php?storyid=43949

3.0 Project Background

3.1 Cattail (*Typha* spp.) Nutrient-Bioenergy Project – Manitoba Bioeconomy in Action

Harvesting for Nutrient Capture and Bioenergy

Cattails (*Typha* spp.) are large, emergent wetland plants characteristic of wet environments and prairie marshes, and can assimilate and store significant amounts of nutrients and carbon in its biomass. They are extremely competitive and prolific aquatic plants that produce a lot of biomass within a single growing season (Table 1). They are also important for nutrient removal in treatment wetland systems (Lakshman, 1979; Kadlec & Knight, 1996). Cattails sequester carbon from the atmosphere and take up nutrients from the sediment as it grows, incorporating them into plant biomass.

TABLE 1. BIOMASS YIELDS AND COMPARISON TO TRADITIONAL BIOMASS.

BIOMASS	AVERAGE YIELD (T/HA)	TIME TO MATURITY
Cattail [a]	**14.7–18.8**	**90 days**
Cattail [b,c]	12–42	90 days
Switchgrass	9.1–13.5	3 years
Miscanthus	6.3–48.3	3–5 years
Trees (willow, poplar)	7–10	3 years, 6–12 years
Wheat straw	1.8–2.4	90–100 days
Corn stover	5.1	110–120 days
Flax residue	1.2	99–110 days

Sources: [a]Grosshans et al. (2011b), [b]Dubbe et al. (1988), [c]Suda et al. (2009)

Since 2006 IISD, the University of Manitoba and Ducks Unlimited Canada have collaborated on research efforts in Netley-Libau Marsh focused on reducing nutrient loading to Lake Winnipeg. A major research study has examined nutrient capture through cattail harvesting and combustion of harvested biomass for heat production—an approach that intercepts, sequesters and recovers stored nutrients to reduce loading in aquatic systems and to Lake Winnipeg, while providing a low-carbon biomass feedstock to displace fossil fuels (i.e., coal) for bioenergy production and carbon offsets (Grosshans et al., 2011b).

Cattails reach maturity in less than 90 days and biomass yields average 15 to 20 tonnes per hectare (t/ha) (Table 1). Harvesting cattail biomass removed 20 to 60 kilograms of phosphorus from litter and sediment per hectare per year (Grosshans et al., 2011b). Once harvested, nutrients locked in plant tissue are prevented from being released into the environment via natural decomposition. Additionally, cattail carbon sequestration research in California demonstrates cattails can annually sequester up to 75 tonnes of carbon per hectare (California cattail). Additionally, harvesting cattails appears to improve wetland habitat by removing dead material and increasing plant diversity (Figure 4) (Grosshans et al., 2011b).

FIGURE 4. Cattail is an extremely competitive emergent wetland plant, and can produce considerable biomass in a single growing season. Harvesting cattails removes stored nutrients and carbon.

Utilizing the harvested cattail biomass as a bioenergy feedstock provides an additional benefit by displacing fossil fuels (i.e., coal) in solid fuel boilers used for heating or electricity, and thereby generating CO_2 offsets. Cattail biomass was compressed into pellets and cubes for use in a variety of biomass burners, and had a heat value comparable to commercial wood pellets and biomass cubes. Research by Grosshans et al. (2011b) showed that cattail biomass is a viable feedstock for bionergy production. Since nutrients bound in the harvested cattail biomass are permanently removed, cattail provides a Lake Friendly feedstock for bioenergy production. ***Utilizing cattail has its greatest economic feasibility if evaluated for its multiple co-benefits.***

If environmentally and economically feasible, the periodic harvest of cattails could be part of a flood-protection, nutrient-management, and GHG-mitigation strategy applied throughout the Lake Winnipeg Watershed. This could apply to managed restored wetlands, municipal and city stormwater ditches, and wastewater treatment wetlands where cattails are viewed as a nuisance plant species (Beule, 1979), and need to be managed and removed for drainage and landscaping (City of Winnipeg, personal communication). Creating a greater economic value for cattails as a biomass feedstock greatly increases the value of marginal agricultural lands, while creating incentives for wetland protection and restoration to restore valuable EGS benefits. Nutrients are captured while reducing infrastructure costs associated with flood damages downstream, such as damaged culverts and roads.

Five major co-benefits were identified with harvesting cattails:

1. Permanent removal of nutrients from aquatic systems and reduction of nutrient loading to Lake Winnipeg (i.e., phosphorus) by harvesting nutrient rich cattail biomass
2. Improved habitat conditions by removing dead plant material
3. Biomass bioenergy production for distributed heat or CHP to displace fossil fuels
4. Mitigation of GHG emissions and revenue from carbon credits
5. Recovery of phosphorus retained in the ash following combustion—a valuable agricultural commodity critical for global food security

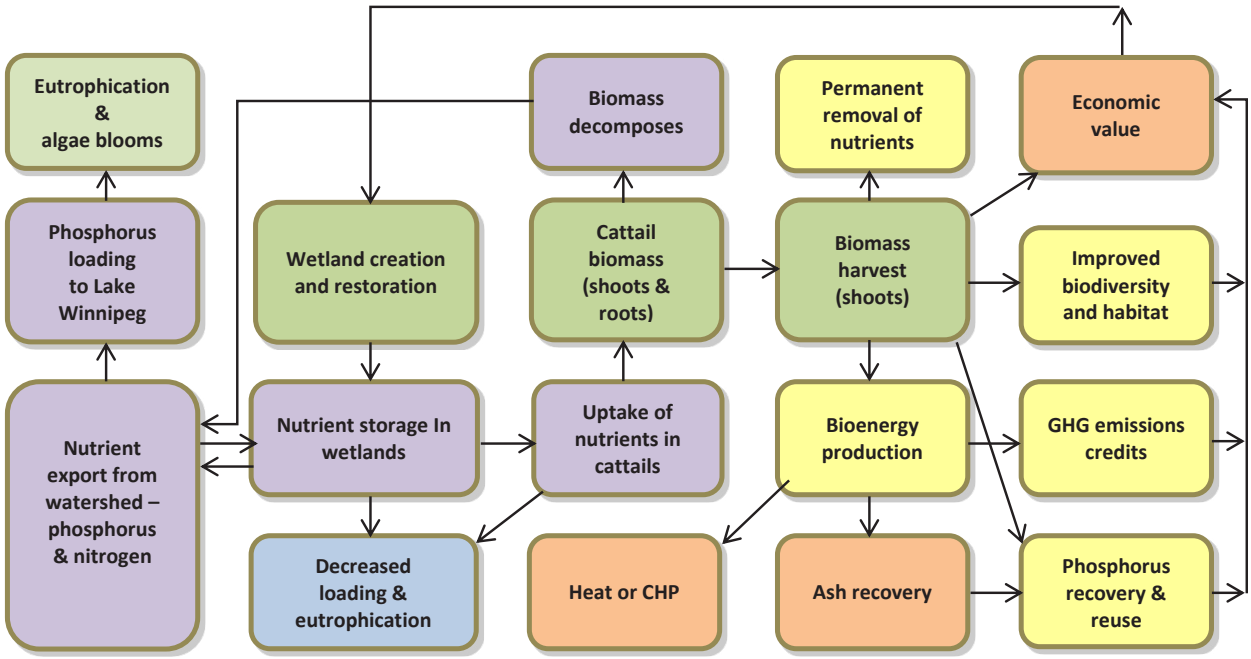

FIGURE 5. The multiple co-benefit pillars of cattail biomass harvesting—permanent nutrient removal (i.e., phosphorous) from the aquatic ecosystem, biomass for bioenergy production, wetland habitat improvement, GHG credits from displacement of fossil fuel use and phosphorous recovery from ash.

Bioenergy Characteristics

As early as the 1970s, the U.S. Department of Energy (Pratt et al., 1984) and the Saskatchewan Research Council (Lakshman, 1984) evaluated cattails as a bioenergy feedstock, but the economics of harvesting or cultivating cattails solely for bioenergy was not considered viable. In considering modern environmental and economic benefits beyond heat production, the benefits of harvesting cattails are significant (Cicek, et al. 2006; Grosshans et al., 2011a; Grosshans et al., 2011b).

Combustion trials indicate that cattails are a suitable feedstock for use in a variety of bioenergy technologies with excellent combustion properties and a calorific heat value averaging 17 MJ/kg to almost 20 MJ/kg, comparable to commercial wood pellets at 17 MJ/Kg (Table 2). Average potential energy yield of cattail (GJ/ha) compared to other biomass is almost 300 GJ/ha (Grosshans et al., 2011b). No major concerns were identified regarding combustion emissions and analyzed ash. With an ash content of 5–6 per cent, it is higher than wood's less than 3 per cent, but less than typical agricultural residues at 7–10 per cent. Densification of wetland plant biomass produces an economically viable standardized feedstock that can be integrated into available markets in North America and Europe. Up to 88 per cent of total phosphorus was recovered in ash following combustion in solid fuel burners. The potential to refine biomass into high-value end products such as biochemicals, bioplastics and third-generation biofuels is part of a broader innovation agenda for Manitoba and the bioeconomy.

TABLE 2. Elemental analysis of cattail, with comparison to other typical biomass feedstocks

BIOMASS	CARBON (%)	HYDROGEN (%)	NITROGEN (%)	SULPHUR (%)	OXYGEN (%)
Cattail	38.8 to 43.6 ± 0.13	5.39 to 5.74 ± 0.11	0.83 to 1.28 ± 0.04	0.23 to 0.30 ± 0.10	37.0 to 43.3 ± 0.25
Wood (*various*)	47.6 to 52.6	6	0 to 0.35	0 to 0.1	43
Straw	42	5.1	0.38	0.16	37.5
Corn stover	43.7	-	0.61	0.01	-
Coal (Anthracite)	80		0.90	0.70	
Coal (Bituminous)	52.5 to 81.7		1 to 1.5	1 to 1.5	
Coal (Lignite)	40.1		0.70	1	
Natural Gas	75	24	0.9	0	0.9

Source: Grosshans et al. (2011a)

TABLE 3. Energy value and proximate analysis (per cent dry basis) of cattails and densified cattail pellets, compared to standard wood pellets and common biomass feedstocks and fuel sources

BIOMASS	CALORIFIC VALUE MJ/KG	BTU /LB	VOLATILES (%)	FIXED CARBON (%)	ASH (%)
Cattail	17.29 to 18.2	7,739 to 7,837	64 to 76	24 to 30	5.47 – 7.64
Cattail pellet (no binder) [a]	19.89 ± 0.15	8,551	64.52 ± 0.11	28.94 ± 0.14	6.54 ± 0.03
Cattail pellet (starch binder) [a]	16.80 ± 0.03	7,223	68.54 ± 0.69	25.25 ± 0.74	6.21 ± 0.05
Wood pellet (standard) [a]	> 16.9 to 18.0	7,266 to 7,739	-	-	< 0.5 to 3
Wood (15% mc) [b]	15.0 to 22.3	7,309	> 70	-	0.65 to 1.52
Wood chips	10.4	4,471	> 70	-	0.6 to 1.5
Wheat straw (dry) [b]	17.86	7,678	> 70	-	3.5
Wheat straw (20% mc) [b]	13.74	5,907	-	-	4
Flax straw (dry) b	19.97	8,586	-	-	-
Flax straw (20% mc) [b]	15.43	6,634	-	-	-
Corn stover [c]	17.6	7,567	-	-	5.58
Sunflower hulls [c]	19.7	8,469	-	-	2.86
Propane [b]	46.37	19,936	-	100	0
Natural gas	48	20,636	-	100	0
Fuel oil [b]	37	15,907	-	-	-
Coal (anthracite)	29.5	12,683	-	-	10.5
Coal (Bituminous)	20.9 to 33.4	10,748	-	-	6 to 9.8
Coal (lignite) [b]	15.31	6,582	-	-	7.3

Sources: [a] Grosshans et al. (2011a) [b] PAMI (1995); [c] Blue Flame Stoker (2011); [d] Cicek et al. (2006)

Coal Displacement and Carbon Offset Potential

In Manitoba, approximately 3 per cent of energy used comes from burning coal. This represents about 385,000 megatonnes (MT) of coal, 40 per cent of which is simply used for industrial and commercial heating (Figure 6). Although cost-benefit will strongly depend on economic and environmental circumstances for each application, this amount of coal could be displaced by the use of biomass—from agricultural straw, forest products or alternative sources like cattails.

GHG emission credits from the production of low-carbon bioenergy greatly enhance the value of harvesting alternative biomass like cattail for mitigation of these carbon sources (Cicek et al., 2006). GHG mitigation can be determined from the direct displacement of fossil fuels using biomass. Using cattail, a low-carbon emitting fuel source as a solid fuel replacement for coal, a high carbon fuel source, results in a direct reduction in net carbon emissions. Additionally, methane avoidance could be considered as well, associated with harvesting of biomass that could naturally decompose anaerobically to produce methane—a GHG 21 times more potent than CO_2 (Alberta Environment, 2007).

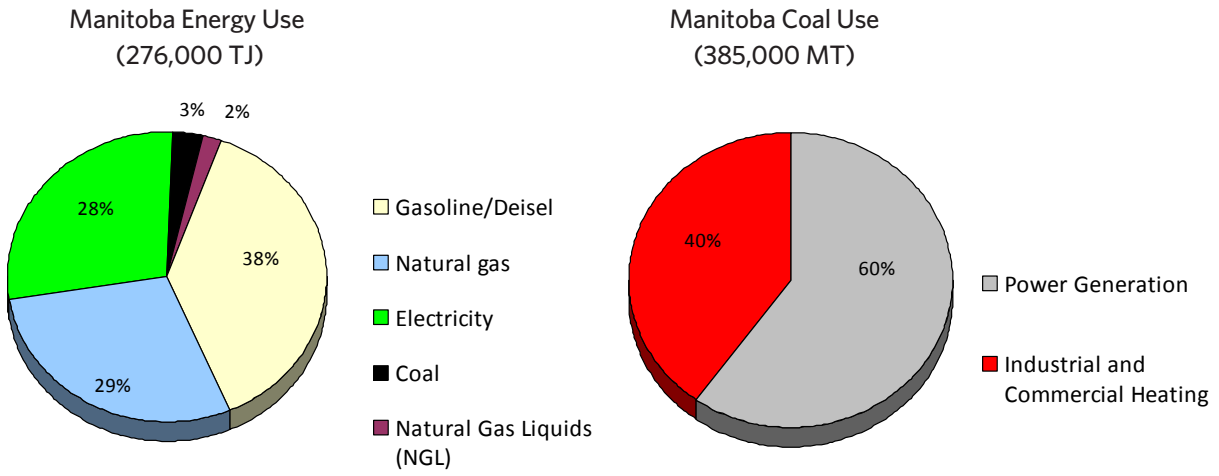

FIGURE 6. Left: Manitoba energy usage of 276,000 TJ. Right: coal use in Manitoba of 385,000 MT—40 per cent of which is used strictly for heating. Source: MAFRI (2008)

Based on coal emission data obtained from the literature (Intergovernmental Panel on Climate Change [IPCC], 2010), preliminary calculations estimate that the displacement of coal[8] by one tonne of cattail biomass used as a feedstock for bioenergy production, would generate 1.05 tonnes of CO_2 offsets (Table 4). Further research is needed to confirm and quantify potential additional methane reductions associated with cattail harvest and associated wetland restoration as a result of incentives from cattail biomass production. With continued concern over global warming and reduction in carbon emissions, processes that can generate energy with minimal net-carbon emissions are of importance.

[8] These calculations assume the coal replaced is Alberta bituminous. Substituting with other types of coal would yield different results.

TABLE 4. Cattail carbon offsets[a] and GHG emission credits displacing coal (Alberta bituminous[b]).

BIOMASS	YIELD (T/HA)	ENERGY CONTENT (MJ/T)	ENERGY CONTENT (MJ/T) AT 80% EFFICIENCY	EMISSIONS (T CO_2/T BIOMASS)	EMISSIONS PER UNIT ENERGY	PHOSPHORUS CONTENT (KG/T)	CO_2 OFFSET PER T
Cattailb	15	17,500	14,000	0.5	0.0357	3.5	1.05
Coalb	-	25,800	-	2.44	0.0945	0.5	-

Source: [a] Grosshans et al. (2011b); [b] IPCC (2010)

3.2 Carbon Tax and Biomass Policy Context

The federal and provincial governments of Canada are taking significant action to reduce GHG emissions,[9] and expect to reduce GHG emissions by 2020 to 607 megatonnes (Mt) (Government of Canada, 2012). Manitoba's recently announced annual coal tax of CAD$10[10] per tonne of CO_2 equivalents (Government of Manitoba, 2012), and a mandate to eliminate coal for heat production by 2014, requires an immediate need for alternative energy sources for industries, communities and small coal users in Manitoba to reduce their reliance on coal.

Manitoba Emission Tax rates[11]

Subject to the regulations of Manitoba's Emissions tax, the rates for different grades of coal (which are roughly equivalent to $10 per tonne of CO_2 equivalent emissions) are:

a. *bituminous coal, $22.57 per tonne*
b. *sub-bituminous coal, $17.37 per tonne*
c. *lignite, $14.27 per tonne*
d. *any other grade of coal, including anthracite, $23.97 per tonne*

Biomass provides an alternative fuel source for direct replacement of coal (Government of Manitoba, 2011b). The emerging Manitoba bioeconomy is evidenced by the release of provincial policies such as the *Manitoba Bioproducts Strategy* (Government of Manitoba, 2011) and the Emissions Tax on Coal Act (Government of Manitoba, 2012), which provides an enabling environment to the development of renewable energy, including biomass. In addition, recent changes to the Retail Sales Tax Act expands a retail sales tax exemption for straw pellets and other biomass materials used for heating.

Many Hutterite colonies in Manitoba still rely on coal for heat production, or have recently switched to natural gas. Over 25 of the colonies have switched to some form of biomass for heat generation and many others are exploring biomass combustion (Eric Liu, Manitoba Agriculture, Food and Rural Initiatives, personal communication, March 2012). Biomass currently used for heat production includes fire wood, construction wood waste, pallets, oat hulls, sunflower shells, agricultural straw residue and flax shives, and demand for these products has increased significantly. Further evaluation of alternative biomass sources is needed to expand the portfolio of sustainable feedstocks for GHG emission reductions and climate change mitigation. Of particular interest are those that include multiple benefits such as nutrient management (i.e., cattails); however, the nutrient management benefit of typical feedstocks is relatively unknown.

[9] http://www.climatechange.gc.ca/default.asp?lang=En&n=DC025A76-0
[10] All currency is expressed in Canadian funds unless otherwise indicated.
[11] Manitoba's Emissions Tax http://web2.gov.mb.ca/laws/statutes/ccsm/e090e.php

4.0 Project Sites – Cattail Biomass Harvest

4.1 Site Descriptions

Several potential cattail harvest sites have been identified from diverse areas and land-use types in Manitoba (Figure 7). These project sites will be further explored and assessed in 2012 for harvestable cattail biomass. Potential sites are listed below, and described in further detail in the following section.

WETLAND TYPE	PROJECT SITE	STATUS
Natural marsh	Netley-Libau Marsh	Confirmed
Stormwater ditches	RM of St. Clements RM of St. Andrews City of Winnipeg	Confirmed Confirmed In discussion
Private lands (marginal agricultural land)	Dennis Lake area in EICD	Confirmed
Engineered backflooding	Pelly's Lake – Holland, MB	Confirmed
Engineered treatment wetland	Oak Hammock Marsh, MB Niverville, MB	Pending Pending
Urban wetlands	St. Norbert, Winnipeg	In discussion
Mixed biomass	Willow and cattails – west MB	In discussion

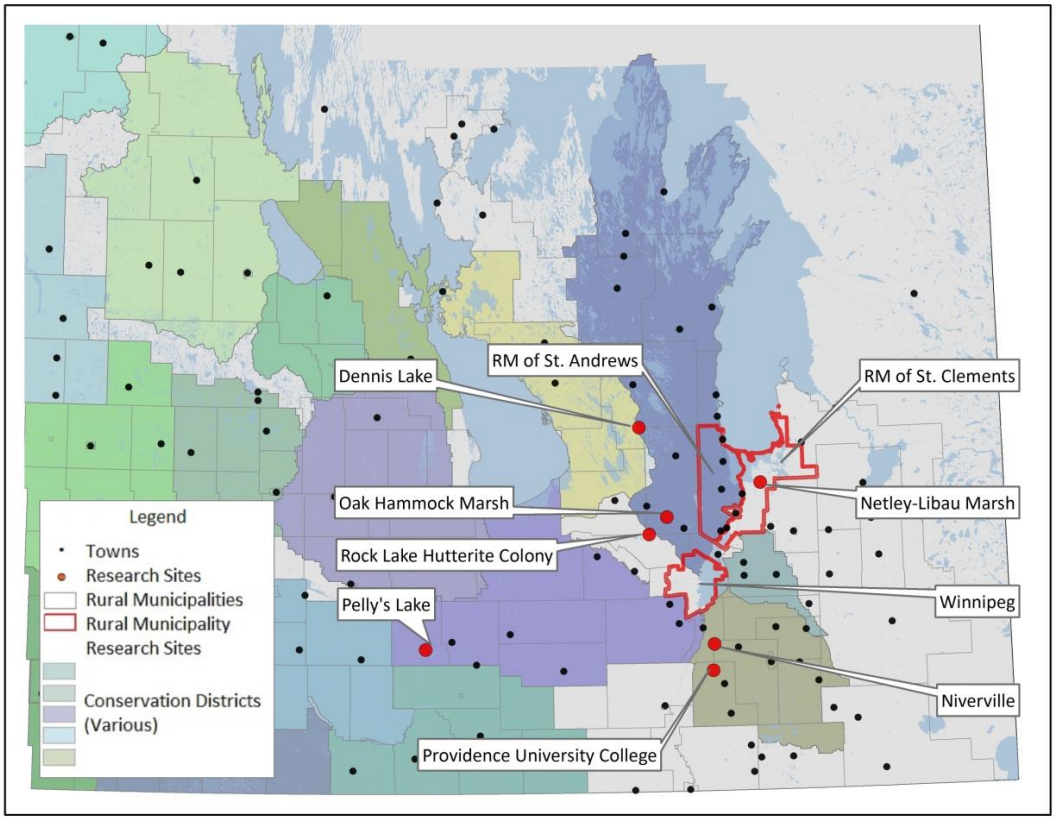

FIGURE 7. Location of current project sites in southern Manitoba. Represents cattail harvest sites in various landscapes and land-use areas.

Natural Marsh – Netley-Libau Marsh: Lake Winnipeg's Coastal Wetland

At 250 km^2 in size, Netley-Libau Marsh is one of the largest freshwater coastal wetlands in Canada. It is comprised of shallow lakes, channels and wetland areas through which the Red River flows on its way to Lake Winnipeg (Figure 8). It is designated an Important Bird Area by Bird Studies Canada and the Canadian Nature Federation, and provides an important habitat for wildlife. The area is traditionally used for agriculture and recreation, but more significantly, the wetland provides an array of diverse EGS. It functions as a filter, sequestering nutrients from the eutrophic Red River and Lake Winnipeg. Unfortunately, EGS benefits have been compromised by drainage, dredging and water management over decades, resulting in the significant loss of habitat, gradual loss of plant communities, erosion of channels and islands, and subsequent decline in wildlife populations (Grosshans et al., 2004). Nevertheless, revitalization through restoration and management of this important coastal wetland could help restore degraded environmental benefits. IISD is working with several key project partners as part of the Wetlands Working Group for management and rehabilitation of this and other major coastal wetlands in Manitoba.

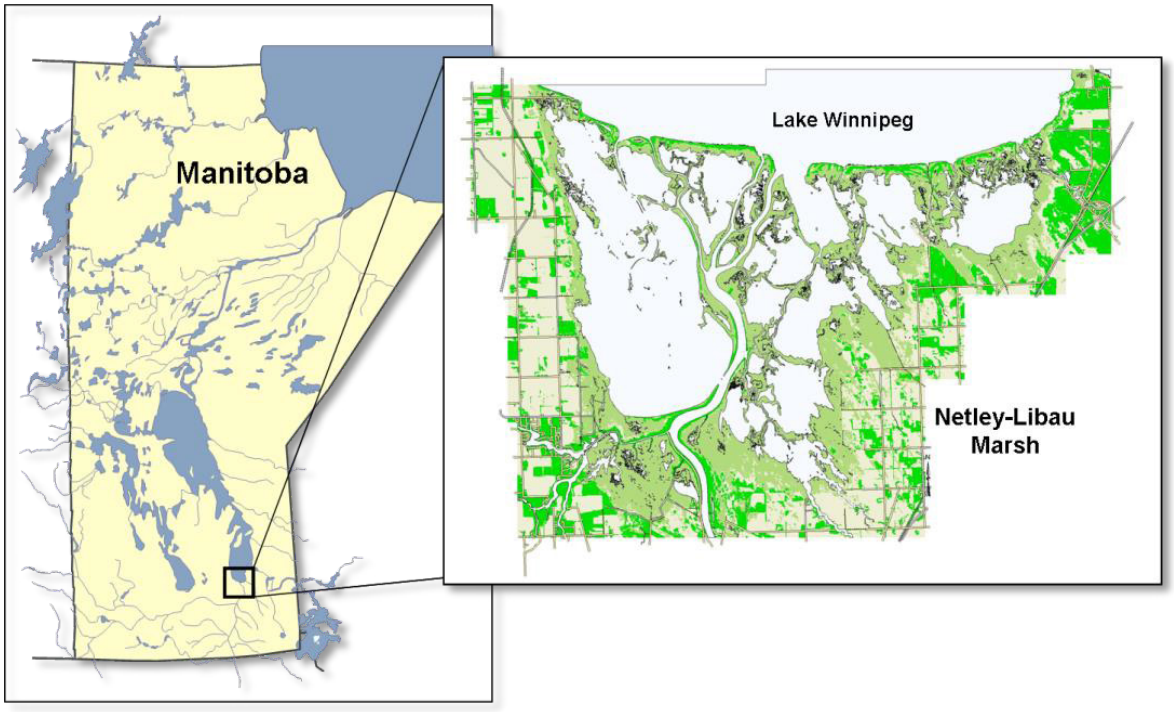

FIGURE 8. Location of Netley-Libau Marsh at the south end of Lake Winnipeg, Manitoba, Canada, and the research site on private land owned by Dr. Dennis Anderson, north of Libau, Manitoba.

Rural Stormwater Ditches – RMs of St. Clements and St. Andrews

The RMs of St. Clements and St. Andrews have both expressed interest in harvesting cattails from within the ditches throughout the RM (Figure 9). Currently, all vegetation in ditches is mowed for maintenance and to maintain drainage, leaving mowed plant material to clog culverts. Shredded plant material also greatly enhances the release of previously

stored phosphorus in this plant material, greatly enhancing the transportation and mobilization of dissolved phosphorus during runoff events. Mowing ditches is a direct annual cost to the municipality, while harvesting cattails and other mixed vegetation represents a potential revenue from bioenergy and nutrient capture opportunity. Many of these ditches are already partially full of cattails.

Calculation of total length of major roadways in the RM will give an estimation of total ditch length and potential cattail yield. Average ditch width will be used to calculate total cattail resource assessment, with ground site surveys for verification and analysis.

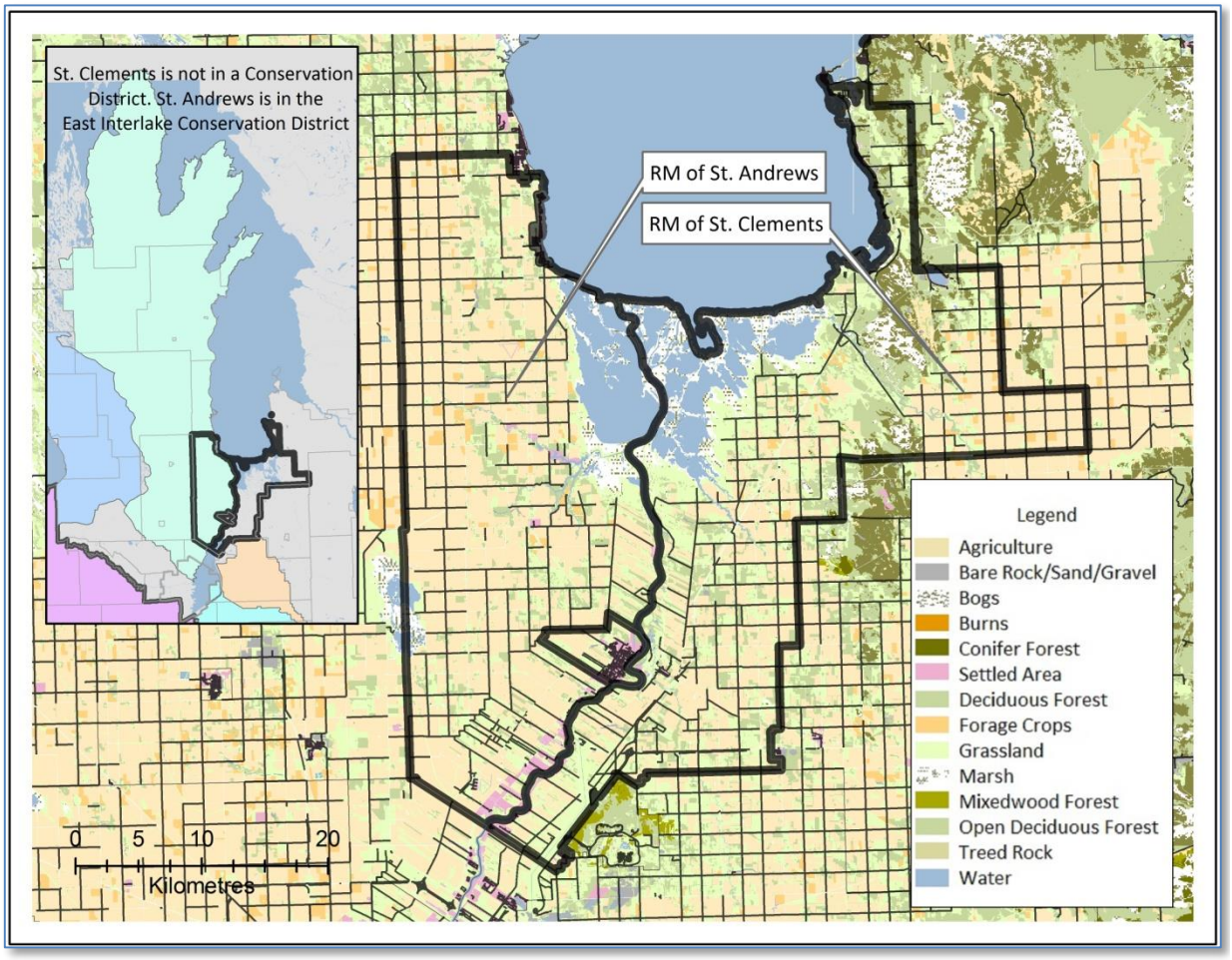

FIGURE 9. Location of RMs of St. Andrews and St. Clements, with major roadways shown and potential for cattail and other biomass resource opportunities.

Municipal Stormwater Ditches – City of Winnipeg

Around the perimeter highway and along major routes such as Lagimodiere Boulevard and Bishop Grandin Boulevard are stormwater ditches, many of which already grow cattails or are partially vegetated with cattails. These ditches are regularly mowed and maintained for drainage and noxious weed control (Figure 10).

Calculation of the entire length of the perimeter highway, excluding areas of clover leafs, would give an estimation of potential biomass resource. Ditches on north and south sides of the perimeter highway, are on average quite wide and flat, ideal for biomass harvesting. Assessments will be verified with ground surveys and site visits.

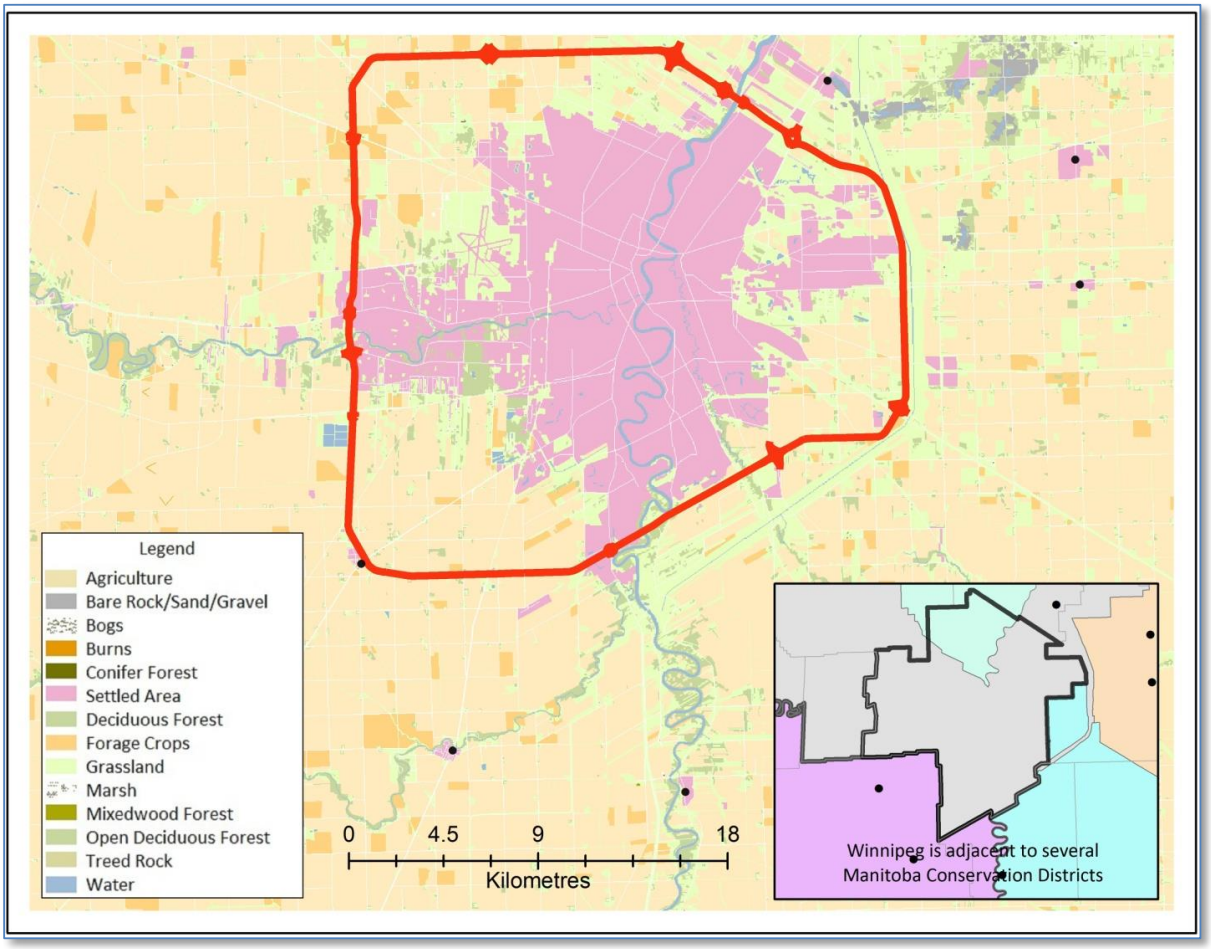

FIGURE 10. Location of City of Winnipeg with perimeter highway highlighted to show potential for cattail and other biomass resource opportunities.

Private – Marginal Agricultural Lands – Dennis Lake Area, East Interlake CD

The Interlake area has been experiencing significant wet periods and increases in water levels with resulting loss in former pasture and hay lands. Dennis Lake is located in the East Interlake CD (Figure 11), and is experiencing a similar situation to Shoal Lake, Manitoba: lake levels are rising higher and higher, consuming former pasture and hay lands. Landowners have expressed great interest in having the cattails harvested from their formerly agricultural lands.

Landowner #1 is one example of potential harvestable area in a region with many hectares of marginal agricultural land being taken over by cattails. These sites will be visited and marked by global positioning system (GPS), with full resource assessments calculated from geographic information system (GIS) and ground verification.

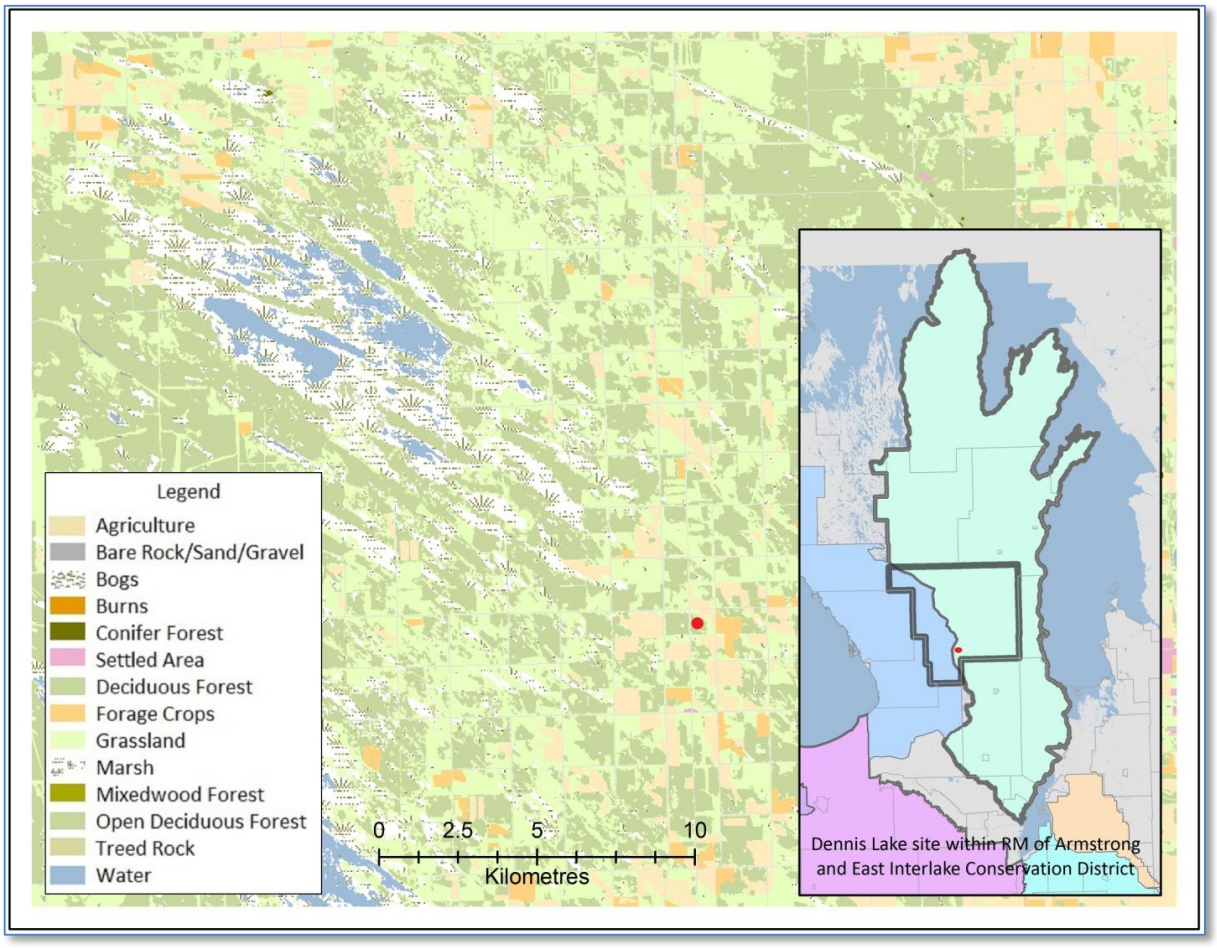

FIGURE 11. Location of Dennis Lake in the East Interlake CD and one potential landowner location (red point). Cattail and other biomass resource opportunities will be explored on private marginal agricultural land in the CD.

Engineered Backflooding – Pelly's Lake, La Salle Redboine CD

Pelly's Lake project in the La Salle Redboine CD (Figure 12) is an example of backflooding for flood water storage to prevent flooding downstream, and for nutrient capture and biomass harvesting. The land occupied by Pelly's Lake has been drained many times in the past for hay production or pasture, but all attempts have failed and the land is filled with cattails and other undesirable species. The idea is to create a backflood system to reduce spring flooding, increase hay production and recharge the downstream reservoir later in the season. In total, roughly 250 hectares will be flooded. Cattails will then act as natural sponges for phosphorus before being harvested for fuel for use in solid fuel burners. The Oak Ridge Hutterite Colony nearby has expressed interest in harvesting and utilizing the cattail biomass to reduce coal use.

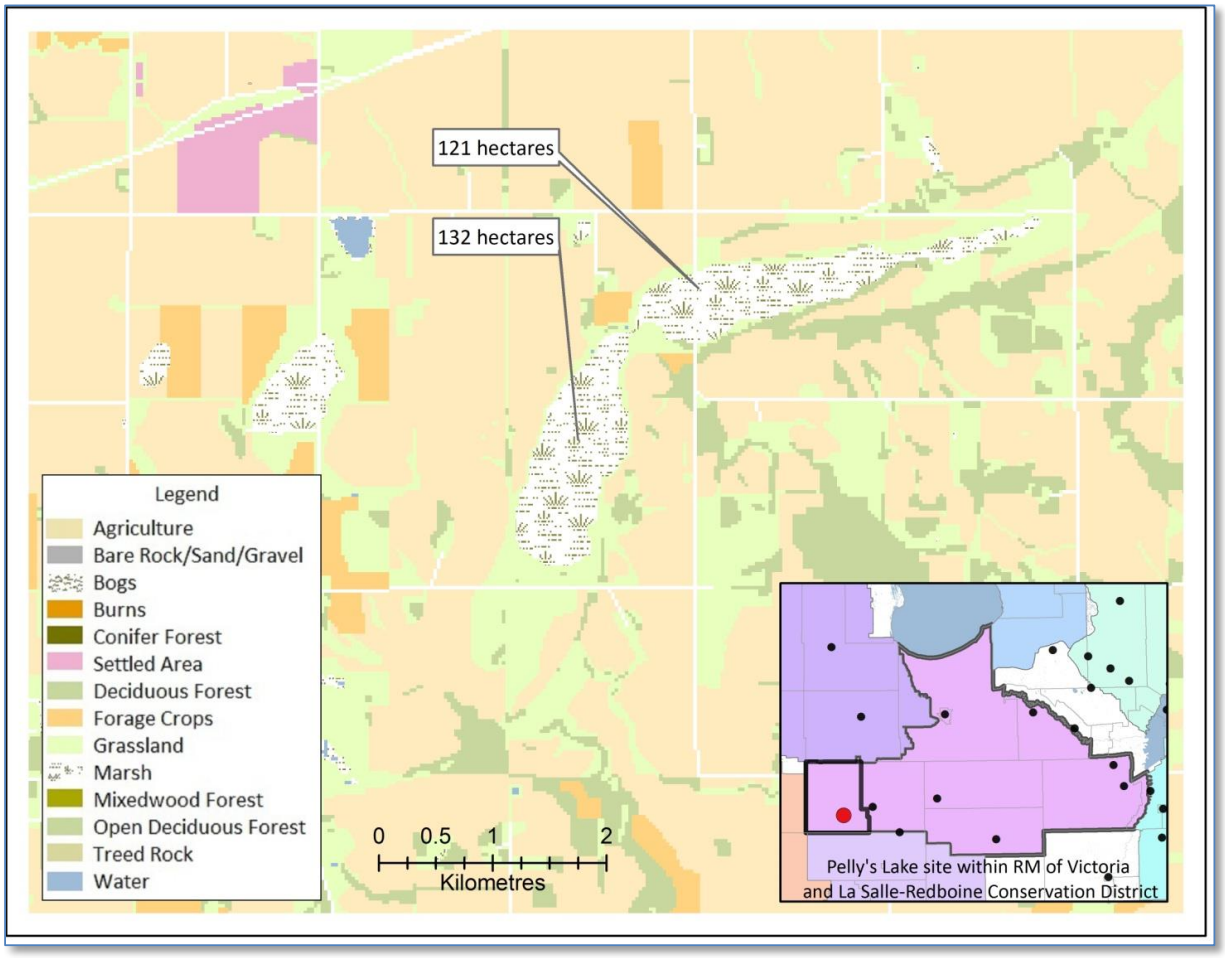

FIGURE 12. Location of Pelly's Lake project in the La Salle Redboine CD. Cattail and other biomass resource opportunities will be explored on this private marginal agricultural land.

4.2 Resource assessment – Cattail Biomass Potential

Interest in the cattail harvesting concepts for combined flood storage, nutrient management and biomass bioenergy for the Lake Winnipeg watershed has grown significantly, which has expanded the scope of IISD's nutrient-bioenergy project beyond Netley-Libau Marsh. A resource assessment will be carried out for several potential cattail harvest sites in different landscapes and land-use areas to evaluate the opportunities for combined upstream flood storage, nutrient capture, and biomass for bioenergy. Initial resource assessments of the Netley-Libau Marsh and Pelly's Lake project sites are provided as examples below.

Initial assessments include:

1. Cattail biomass yields
2. Nutrient capture (phosphorus uptake)
3. Carbon sequestered in the cattail biomass
4. Carbon displaced from bioenergy production and replacement of coal
5. Carbon offsets produced

TABLE 5. Initial resource assessments (based on research from Grosshans et al., 2011b)

PARAMETER	AVERAGE
Cattail biomass yield (tonnes) per hectare (T/ha) Potential total cattail biomass yield based on average calculations of cattail yield per hectare of cattails	15 T/ha of cattails
Nutrient capture – phosphorus uptake (kg/T) Potential total phosphorus stored and captured in harvested cattail biomass based on average phosphorus per hectare of cattails	2.2 kg/T of cattails 33 kg/ha of cattails
Carbon sequestered in cattail shoot biomass Total carbon stored in harvested cattail biomass, based on average calculation of carbon content (avg. 40 per cent carbon)	6 T/ha
Coal displaced by replacing coal use with cattail use (T/T) What is the total amount of coal displaced for the amount of harvestable cattail biomass. Based on average calculations of 1 tonne of cattail biomass replaces 0.54 tonne of coal	0.54 T/ T of cattails
Carbon offsets displaced by replacing coal use with cattail use (T) What is the total amount of CO_2 displaced and CO_2 offsets produced for the amount of coal displaced by cattail biomass. Based on average calculations: 1 tonne of cattails produces 1.05 tonnes of CO_2 offsets.	1.05 tonnes of CO_2 offsets

Netley-Libau Marsh (St. Clements RM) – Resource Assessment

Potential cattail harvest sites have been identified on the Libau side of Netley-Libau Marsh in the RM of St. Clements on primarily private and Crown land (Figure 13). Total potential harvestable cattails is based on site surveys, yields, elevation data and transportation logistics. Potential harvestable area includes 60 ha of private land, and approximately 230 ha of Crown land. Potential harvest sites will be surveyed in 2012.

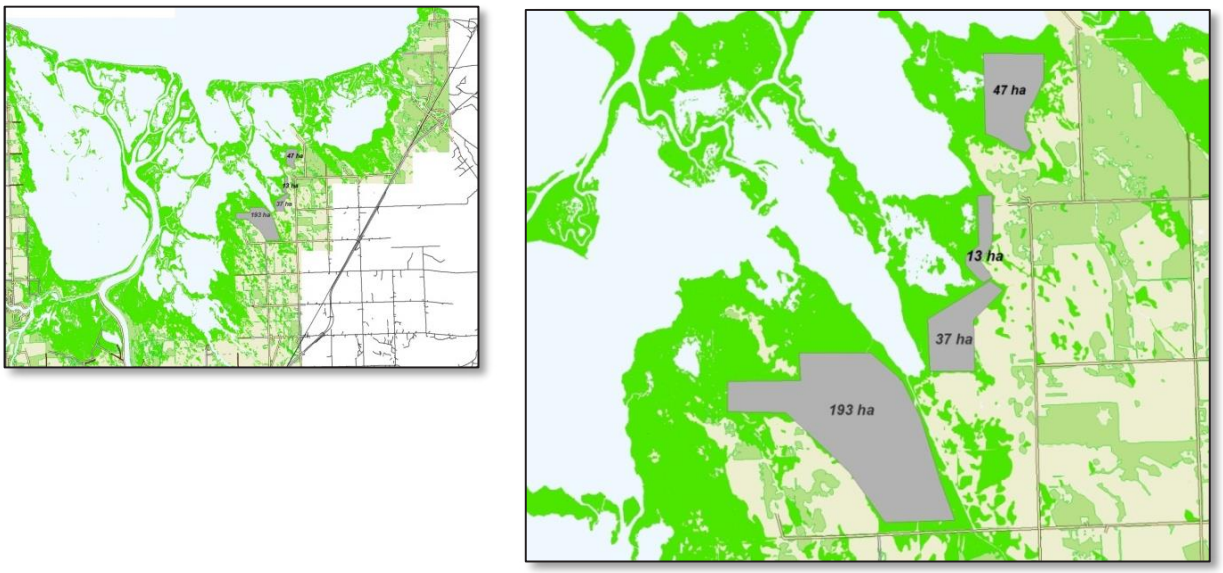

FIGURE 13A. Netley-Libau Marsh at the south end of Lake Winnipeg. Dark grey areas show potential harvestable cattail areas for 2012 on private and Crown land with the area of each site given in hectares (ha). Road access is shown.

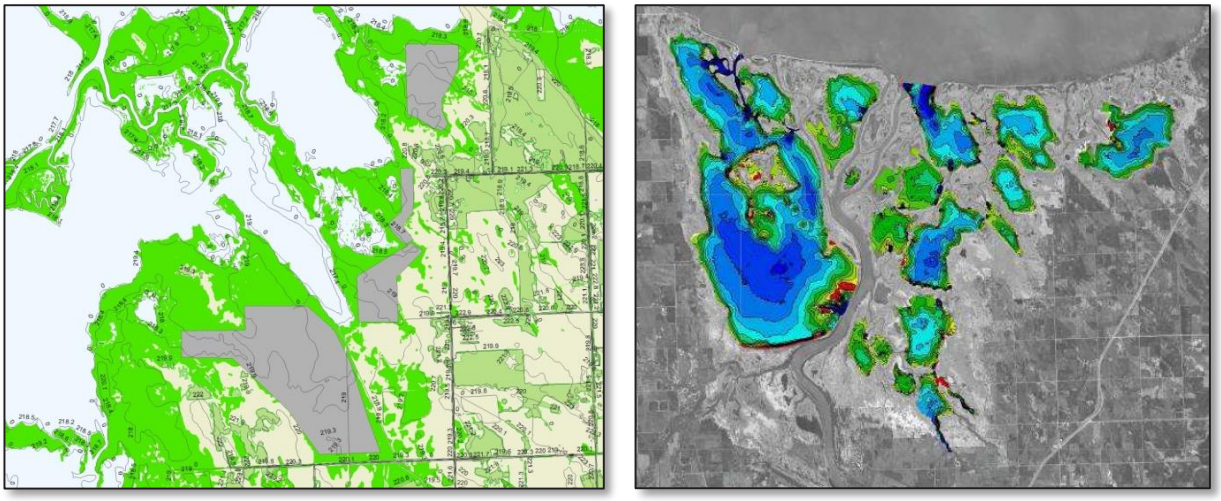

FIGURE 13B. Left: Dark grey areas show potential harvestable cattail areas for 2012 on private and Crown land. Road access is shown, as well as contour elevation lines. Right: Bathymetry from 2011 will be utilized for harvest site selection.

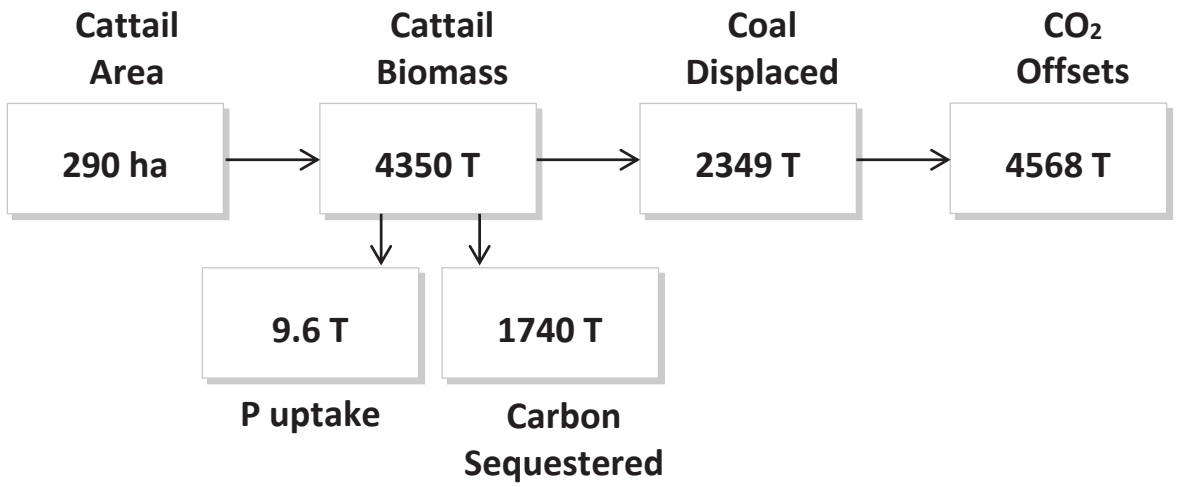

FIGURE 14. Coal displacement and CO_2 offset credits Note: P= phosphorus

TABLE 6. Netley-Libau Marsh resource assessment

PARAMETER	AVERAGE
Total harvestable cattail area	290 ha
Cattail biomass yield *(avge 15 T/ha)*	4350 tonnes cattails
Nutrient capture (P uptake) *(2.2 kg /T of cattails)*	9.6 tonnes P
Carbon sequestered – cattail shoot biomass	1740 tonnes C
Coal displaced – replacing coal use with cattail *(0.54 T/T)*	2349 tonnes C
Carbon offsets – displaced by replacing coal *(1 T = 1.05 T CO_2)*	4568 tonnes of CO_2

Pelly's Lake Project - Resource Assessment

TABLE 7. Pelly's Lake resource assessment

PARAMETER	AVERAGE
Total harvestable cattail area	254 ha (627 Acres)
Cattail biomass yield *(avg 15 T/ha)*	3795 tonnes of cattails
Nutrient capture (P uptake) *(2.2 kg /T of cattail)*	7.6 tonnes P
Carbon sequestered – cattail shoot biomass	1524 tonnes C
Coal displaced – replacing coal use with cattail *(0.54 T/T)*	2050 tonnes C
Carbon offsets – displaced by replacing coal *(1 T = 1.05 T CO_2)*	3985 tonnes of CO_2

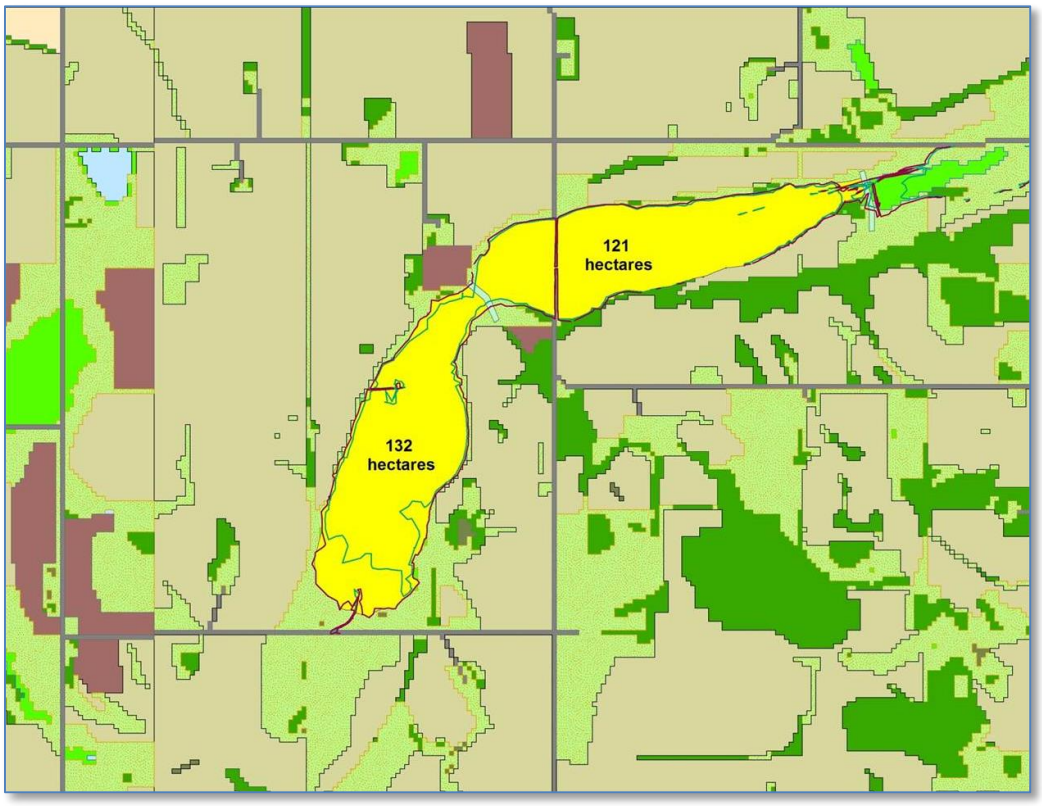

FIGURE 15. Pelly's Lake Project in the La Salle Redboine CD. Yellow areas show potential harvestable cattail areas for 2012 on private land with area of each site given in hectares (ha). Road access is shown.

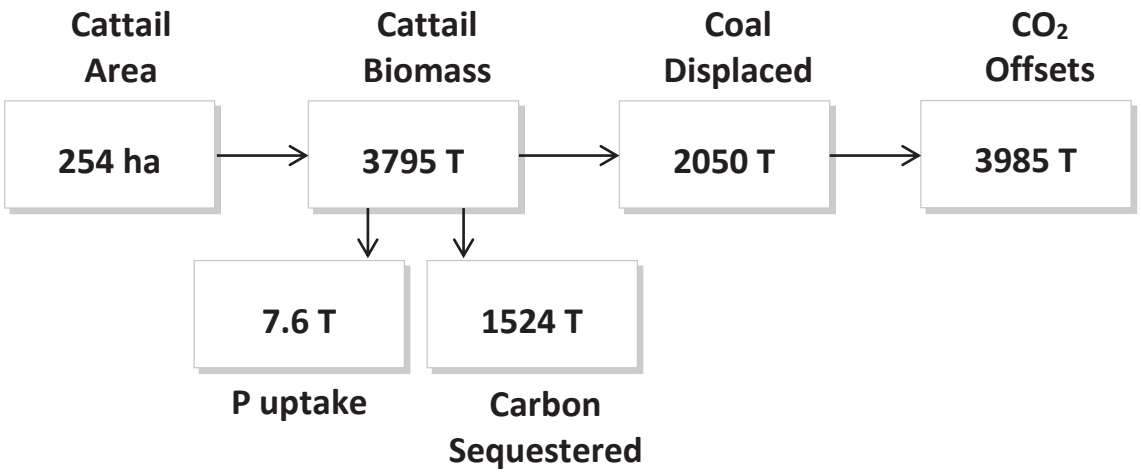

FIGURE 16. Coal displacement and CO_2 offsets

4.3 Demand Analysis

A GIS survey aided with ground surveys and GPS locations will identify heating loads and end-users surrounding potential cattail harvest sites, and will identify potential biomass storage and processing facility locations. Processing facilities, such as the carbonizer facility at the Rock Lake Hutterite Colony in Grosse Isle, MB, will undergo a demand analysis to identify potential harvest sites within a 25, 50, 75, and 100 kilometre radiuses for economic analysis, as demonstrated in Figure 17.

Netley-Libau Demand Analysis – Potential Heating Loads and End-Users

Potential heating loads and end-users within the Netley-Libau area include: Selkirk and its industries; Hutterite colonies; greenhouses and other district heating; industry (i.e., Graymont); provincial facilities, where biomass heating or conversion to co-firing is feasible; and South Beach Casino, which currently heats their facility with tanked propane gas.

Pelly's Lake Project – Demand Analysis

The Oakridge Hutterite Colony near Pelly's Lake could be the primary end-user for harvested cattails. They have expressed an interest in upgrading their current coal burner to be used with biomass material.

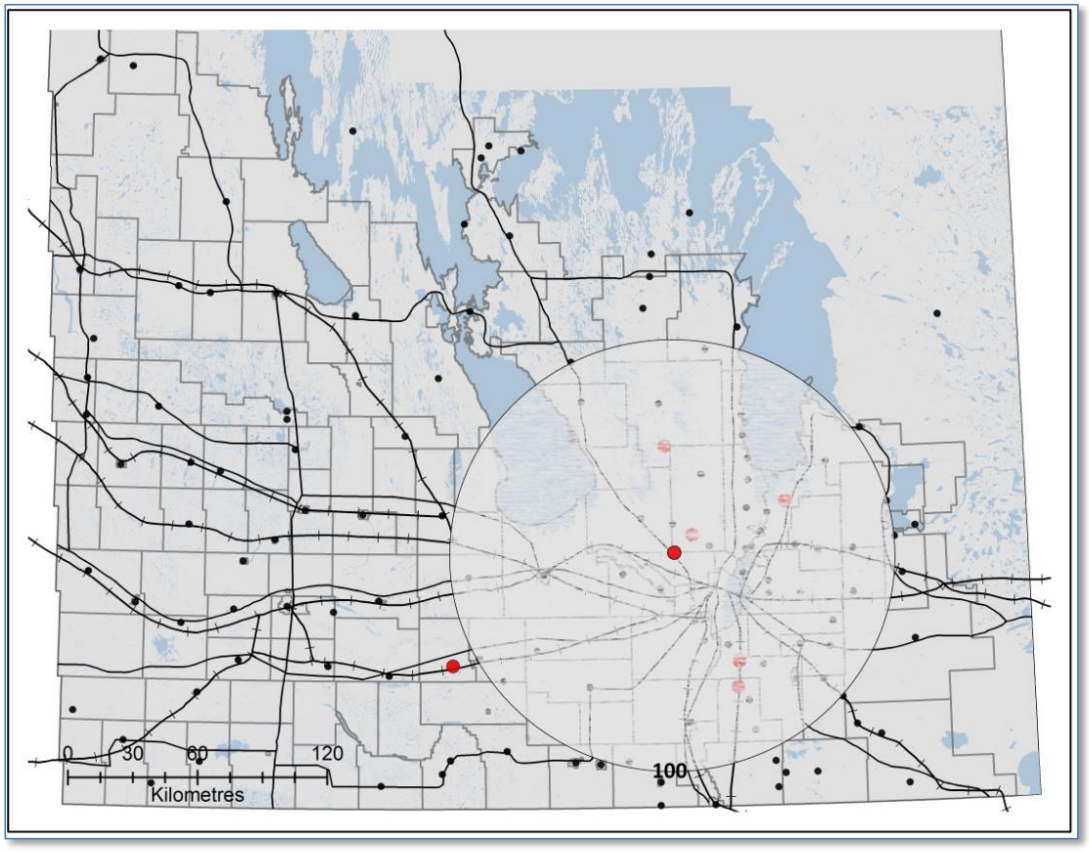

FIGURE 17. Demand analysis showing the 100-kilometre region surrounding the carbonizer facility at Grosse Isle, MB. Current and potential harvest sites are located within this region, except the Pelly's Lake project.

5.0 The Harvest Plan – Commercial-Scale Cattail Harvesting

5.1 Harvest Outline

The goal is to harvest several 1,000 dry tonnes of cattail biomass in wet environments from several project sites in southern Manitoba, to demonstrate sustainable large pilot-scale commercial harvesting opportunities for this innovative sustainable biomass feedstock. Feasibility for several end-uses of the biomass will be evaluated, and a harvest protocol and certification for carbon offsets and GHG emission credits will be established.

TABLE 8: ACTIVITIES AND OUTPUTS OF THE HARVEST PLAN.

	ACTIVITIES	OUTPUT
SPATIAL LOGISTICS		
Cattail harvest site survey	Continue to build partnerships and identify new harvest sites Visit potential cattail harvest sites Selection and assessment of potential harvestable areas	Sites identified in the field and on the map GPS locations and delineations Resource assessments
Monitoring for fall harvest parameters	Fall sample collection from harvest sites • Cattail shoots • Cattail roots • Soil and litter	Samples collected, dried and processed for analysis • nutrients • biomass, moisture, starch • heavy metals and toxins analysis
GIS Survey	Resource assessment Demand analysis	GIS spatial analysis and maps with sites identified and logistics Identify heating loads and end-users within 50, 75, and 100 kilometre radiuses from project sites Identify densification/ biochar/ processing facilities within 50, 75, and 100 kilometre radius from project sites
HARVEST LOGISTICS		
Cattail pilot harvester design, construction	Identification of potential harvesters Modification for use in wet environments Demonstration harvest of cattail biomass	Low-impact harvester Demonstration harvests
Biomass harvest, processing and storage	Cattail biomass harvests Processing of cattail biomass • shredded • bales Storage of cattail biomass on or off site Densification—cubes, pellets, etc.	Large-scale harvests of cattails Processing, transportation and storage options Densified products evaluated

Conversion of cattail to bioenergy	Thermal Conversion Demonstration burns of biomass • Providence College • Graymont • Sturgeon Creek Colony • Oakridge Colony • Rock Lake Colony Thermochemical Conversion Biocarbon – with Manitoba Hydro • Produce up to 500 t of biochar • Demonstration burns of biochar Biochemical Conversion • Gasification • Anaerobic digestion	Demonstration burns Evaluate coal displaced, heat produced, and bioenergy potential Biocarbon evaluated Evaluate coal displaced, heat produced and bioenergy potential Demonstration burns and evaluations Demonstration digestion and evaluations
CARBON BROKERAGE		
Value as certified carbon offsets	Certification of cattail biomass for carbon offsets and trading Certification of cattail biocarbon for carbon offsets and trading	Cattail biomass certified Cattail biocarbon certified
Carbon market	Biomass carbon model evaluation—provincial and federal	Carbon market evaluation
NUTRIENT CAPTURE AND RECOVERY		
Phosphorus reduction and recovery	Phosphorus capture and recovery Fertilizer value of cattails, ash and biocarbon Ecosystem service co-benefit assessment as a Lake Friendly biomass • P reduction to Lake Winnipeg, P value	Phosphorous captured and recovered Fertilizer and soil amendment experimental trials with the University of Manitoba P displaced from watershed by harvesting—economic value of P

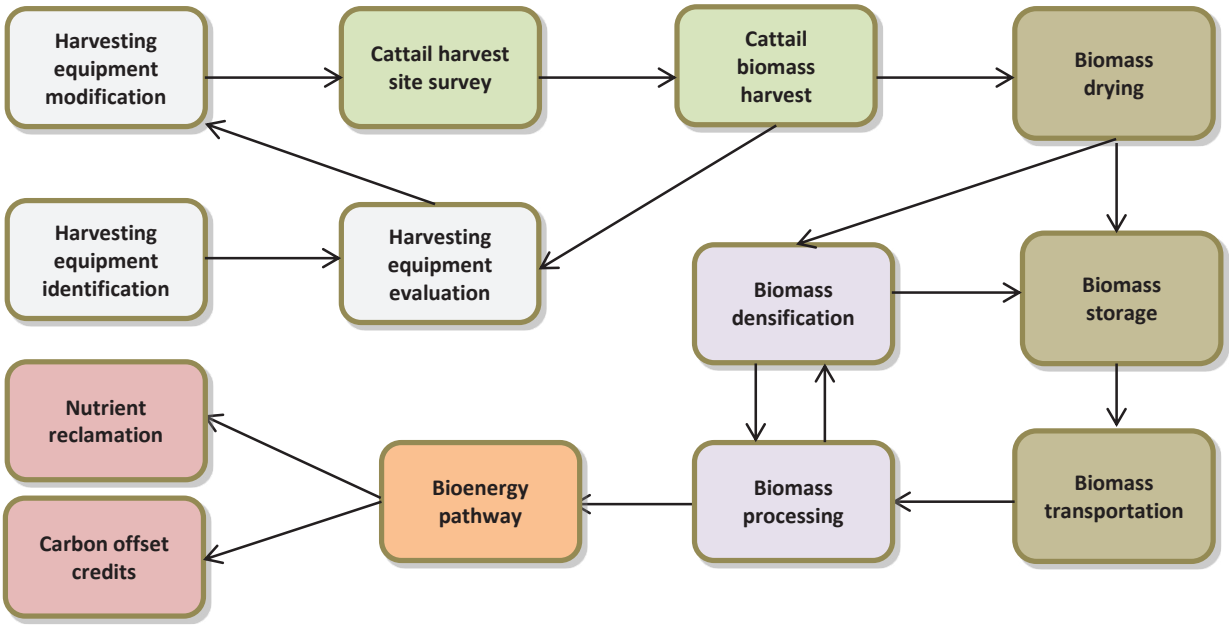

FIGURE 18. The harvest plan: steps towards cattail biomass harvesting. Bioenergy Pathway is expanded in detail in section 5.6 End-Uses.

5.2 Harvest Site Survey

Potential harvest sites will be visited to identify and map by GPS access points, harvestable areas of cattails, resource assessments and logistics of equipment movement. While gathering resource data, additional data will be gathered by interviewing managers and landowners on their attitudes towards cattail harvest, wildlife habitat and invasive species implications, logistical considerations and other recommendations.

Objectives:

1. Identify cattail harvest areas and identify access points for equipment
2. Locate areas and map by GPS for GIS integration potential harvestable cattails
3. Estimate total area coverage of cattail sites in RMs of St. Andrews and St. Clements, East Interlake CD, La Salle Redboine CD, City of Winnipeg
4. Perform Resource Assessments and Demand Analyses, given the availability of commercial boilers in the study area and the economics of harvesting, densification, transportation and storage of the feedstock.

5.3 Monitoring of Harvest Parameters

Samples and data will be collected in summer and fall from cattail harvest sites in cooperation with collaborative research with researchers from the University of Manitoba and Ducks Unlimited Canada. Samples of plants, roots, soil and litter will be collected to monitor biomass yield, harvesting impacts, nutrient capture and carbon sequestration.

Other samples and analysis considered by collaborating research projects are for pore water; surface water; wildlife surveys; cattail starch, lignin and cellulose; and GHG emissions.

5.4 Harvesting Equipment and Technology for Wet Environments

An essential component of this project will demonstrate commercial-scale agricultural equipment for harvesting cattail from wetlands and wet environments and possible integration of technologies from Europe (Wichtmann et al., 2009). Harvesting in wetlands presents some serious logistical challenges, particularly if the goal is to minimize ecological impact and maintain the sustainability of the marsh plant community. Because of soft wetland soils rich in organic matter, typical heavy machinery intended for harvesting causes rutting and damage to soil-plant roots. Equipment traction, weight ratio and flotation are major considerations for wetland harvester design. European harvesters have been designed and built for harvesting in wetland conditions. These tracked harvesters, or those fitted with large balloon tires, can negotiate soft terrain without sinking, and have low weight ratios and ground pressure, less than 50 grams per square centimetre (Wichtmann et al., 2009).

Several designs exist for collection of the harvested material. Some harvesters chop the plant material into pieces, blowing it into an attached hopper or collecting trailer similar to an agricultural forage harvester. Others cut and place them in swaths, which are collected and baled in an attached baler.

Cattail Pilot Harvester Identification, Design and Modification (with PAMI)

For the purpose of this pilot-scale demonstration project, IISD in partnership with the PAMI will identify, lease and modify agricultural harvesting and transportation equipment suitable for low-impact harvesting in wet environments to demonstrate large-scale commercial harvesting of cattail biomass. Equipment to be explored and tested are a low-impact tracked or wheeled vehicles with a PTO attachment, pull-behind-type forage or corn silage harvesters, self-propelled forage or silage harvesters, and self-propelled swathers (Figure 19).

Additional biomass collection vehicles will be required, including trucks for hauling biomass and front-end loaders for moving biomass. Tracked vehicles, such as those owned by Manitoba Hydro through its Fleet Services, could be used with some minor modifications to storage boxes as collection vehicles in wet environments (Figure 19).

FIGURE 19. Clockwise from upper left: pull-behind forager harvester with PTO attachment; self-propelled forage harvester with rotary corn silage header; tracked collection vehicle with dump box; and self-popelled swather.

Objectives:

1. As appropriate, modify harvesting equipment for use in wet environments and to harvest cattails as sustainably as possible without destroying ground cover.
2. Demonstrate large-scale harvesting and processing of cattail biomass.
3. Measure and report on harvester performance and harvesting parameters, including: harvested volumes, total area harvested, time and labour requirements, fuel consumption, costs of harvesting, harvester and harvester head performance.

Identification of Potential Future Harvesters – Wetland Harvesters from Europe

Experience gained from this project will lead towards future development of low-impact equipment suitable for harvesting cattails and other emergent plants in wet environments, and the integration of European harvesting equipment for use in Canada. Several equipment manufacturers in Europe offer equipment that would be well suited for harvesting cattails in wet environments, and would need to be tested in Manitoba conditions.

Tracked forage harvester Pisten Bully GreenTech 300

Manufactured by:

Kässbohrer Geländefahrzeug AG
Kässbohrerstraße 11, 88471 Laupheim
Phone: +49 (0) 7392/900-0
Fax: +49 (0) 7392/900-445
www.pistenbully.com
E-Mail: info@pistenbully.com

Cutting and swathing header mounted on Pisten Bully

Manufactured by:

PRONAR Sp. z o.o.
ul. Mickiewicza 101 A, 17-210 Narew, Poland
Export Department tel. +48 (85) 68 27 109,
Fax: +48 (85) 68 27 302
www.pronar.pl/EN/ENfirma/___kontakt__.html

Tracked baler attachment

Manufactured by:

PRONAR Sp. z o.o.
ul. Mickiewicza 101 A, 17-210 Narew, Poland
Export Department tel. +48 (85) 68 27 109,
Fax: +48 (85) 68 27 302
www.pronar.pl/EN/ENfirma/___kontakt__.html

Softrak low ground pressure tracked vehicle – "Cut and collect system"

Manufactured by:

Loglogic
United Kingdom
EX15 1RW
Telephone : +44 (0) 1884 83 99 99
Fax: + 44 (0)1884 839 993
www.loglogic.co.uk/cutandcollect.php

Seiga reed harvester

Manufactured by:

Loglogic
United Kingdom
EX15 1RW
Telephone : +44 (0) 1884 83 99 99
Fax: + 44 (0)1884 839 993
www.loglogic.co.uk/cutandcollect.php

Pisten Bully wetland harvester

Custom built by research group in Germany

Wichtmann, Tanneberger & Bärisch et al. (2012)

5.5 Processing and Storage

Biomass Collection and Processing

Collection of the harvested cattails will be evaluated through several collection pathways, determined on logistics for biomass collection, harvesting equipment, economics, moisture and drying issues, transportation and storage. Harvesting and collection equipment will look at shredding (i.e., forage-type harvester) or swathing and baling.

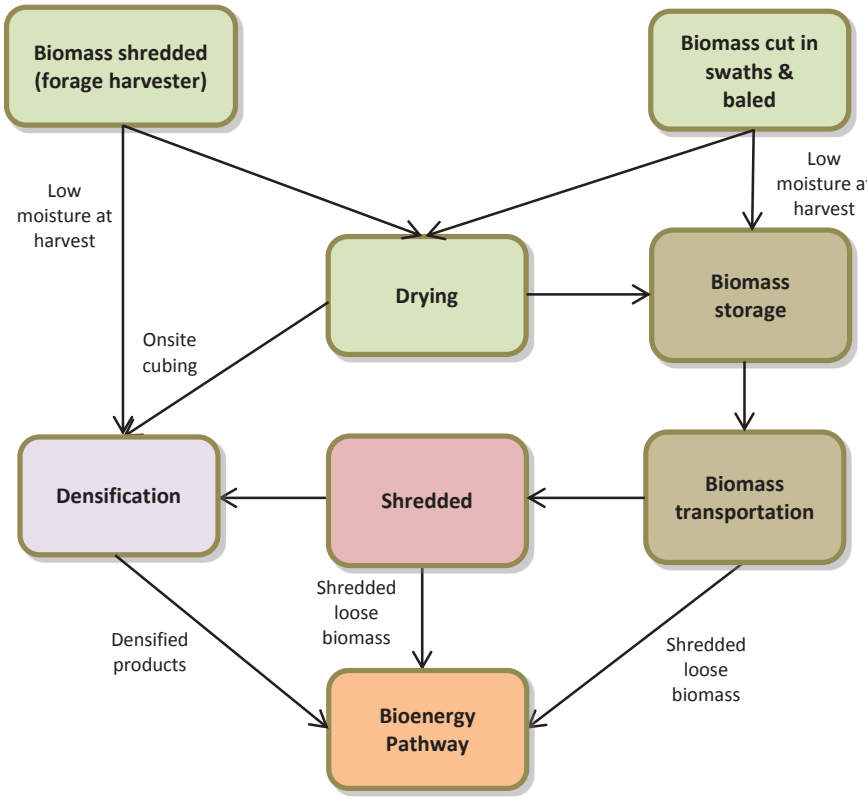

FIGURE 20. The above flow-chart tracks the potential pathways for harvesting cattail biomass

Biomass Drying and Storage

Facilities will be identified for storage of large volumes of harvested biomass, either close to harvest sites or at the processing facility. Biomass will need to be sun and or air-dried either onsite or at that processing facility. One component of Manitoba Hydro's Biocarbon Demonstration Project could include biomass drying technologies from the United States. This drying technology will be evaluated for use with high moisture feedstocks like cattail.

Densification

Our previous research evaluated densification of cattail biomass through two different processes to create compressed cubes and pellets (Grosshans et al., 2011b). They were analyzed for their energy value and potential as a feedstock with comparisons to traditional industry standard biomass fuel sources—agricultural straw residues were compared primarily to the cubes and wood with the pellets. Densified biomass is of interest because it is easily stored and transported, it is a universal biofuel that can be produced from numerous biomass sources in a single biorefinery and there is a well-established European market for fuel pellets.

Several solid fuel suppliers operate in Manitoba, and interest in investing in Manitoba is growing.[12] Densification of cattail biomass will be examined for commercial-scale quantities. Feasibility of onsite densification will be evaluated using PAMI's mobile cuber. Several other companies are being explored to produce small quarter-inch fuel pellets and larger products.

5.6 Conversion of Cattail Biomass

Several conversion pathways and end-uses of the cattail biomass have been identified. The harvested biomass will be evaluated for its use and feasibility through these end-uses.

End-Uses:

1. Use as a solid fuel source for heat production in solid fuel burners
2. Produce biocarbon for soil amendment, activated charcoal and as a coal replacement for use in solid fuel burners
3. Evaluate for lingocellulosic ethanol production—third-generation biofuels
4. Co-feed with manure for anaerobic digestion and methane gas production
5. Potentially test cattails as feedstock for use in a new gasifier system in Manitoba for CHP
6. Use as a green manure for agricultural crop fertilization
7. Recapture and re-use of nutrients through use as a fertilizer—from green manure, cattail biocarbon and ash post-combustion

[12] Vorus announced March 15, 2012 they are interested in building two biomass plants in Manitoba; see: http://www.canadianbiomassmagazine.ca/content/view/3217/57/

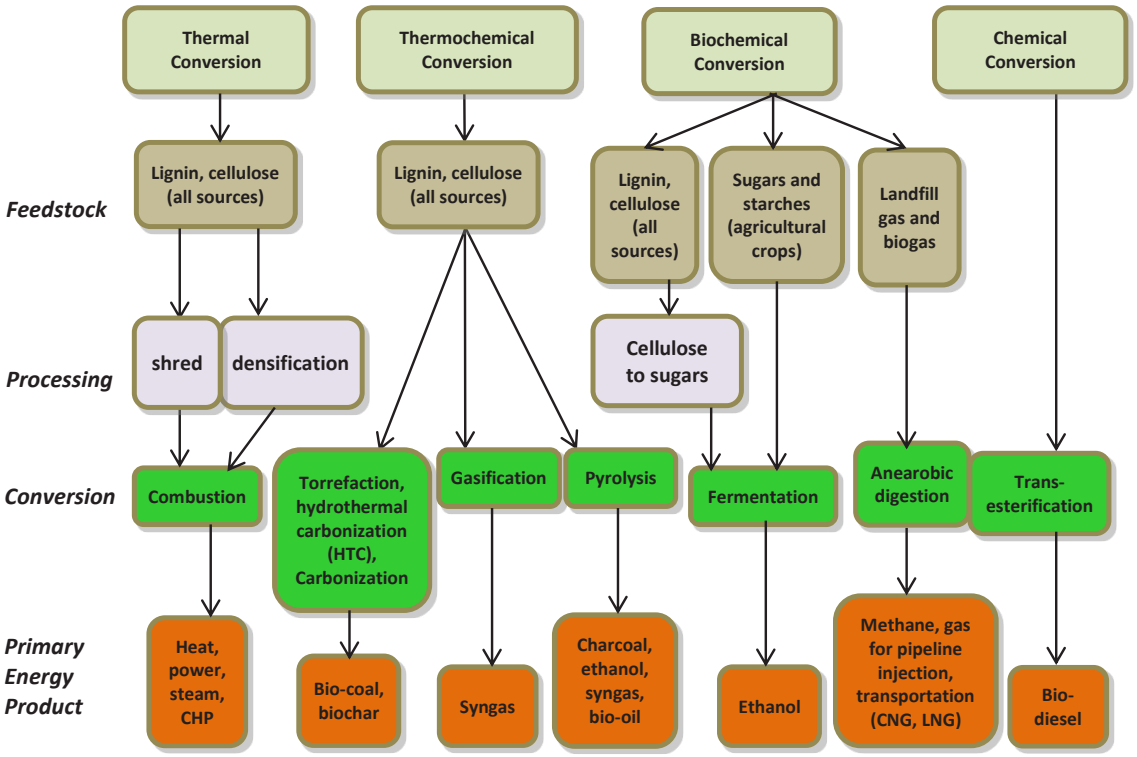

FIGURE 21. Several conversion pathways and end-uses of cattail biomass can be identified (combined heat and power [CHP], compressed natural gas [CNG], liquefied natural gas [LNG])

Combustion for Space Heating – Thermal Conversion

Several examples of biomass used for space heating exist in Manitoba. Vanderveens Greenhouses in Carman, Pineland Nurseries near Hadashville, Providence College south of Winnipeg, and over 25 Hutterite Colonies in Manitoba have all converted from coal to burning biomass to meet their primary energy needs for heating. If the purpose is to harvest cattail biomass for bioenergy production as well as nutrient management in aquatic systems, it is critical to ensure that the biomass conversion technology employed is sustainable, efficient and does not redeposit unwanted elements (i.e., phosphorus) by air dispersion back into the ecosystem. The retaining of nutrients and other heavy metals in residual ash is essential.

Blue Flame Stoker

The thermal conversion bioenergy technology used in this project will be the Blue Flame Stoker, a solid fuel burner, manufactured in Manitoba, and in operation in many facilities in Manitoba. Thermal combustion test sites include Providence College, Sturgeon Creek Hutterite Colony, and Rock Lake Hutterite Colony. These stokers are designed to ensure efficient combustion of biomass fuels while maintaining low emissions (Figure 22). The specially designed chain grate system allows for efficient burning of various biomass fuels and collection of residual ash and particles

(Blue Flame Stoker, 2011). The multi-cyclone dust collector removes the smallest dust particles or fly-ash, up to 90 per cent that is generated from solid fuel combustion, with emissions comparable to natural gas. Most of the new models of Blue Flame Stokers have moved away from densified biomass and are now designed to handle loose biomass.

FIGURE 22. The Blue Flame Stoker biomass burner in use at the Sturgeon Creek Hutterite colony for cattail biomass burn trials (Grosshans et al., 2011a).

Biocarbon – Thermochemical Conversion

IISD's new Cattail Biocarbon Project is a new component of the Netley-Libau Nutrient-Bioenergy Project and a partnership with Manitoba Hydro. Manitoba Hydro's current biocarbon demonstration project is supported by the Clean Energy Fund and is focused solely on the use of wood chips as a feedstock for biocarbon. The potential to evaluate alternate biomass sources such as cattails and crop residues could offer a means to lower cost for producing biocarbon. The Cattail Biocarbon Project will explore biocarbon as a viable end-use for harvested cattail, and further develop commercial opportunities.

IISD will conduct trials on the use of alternative, readily available, low-cost feedstocks for production of biocarbon and an evaluation of environmental benefits associated with biocarbon in agricultural soils. Beyond the application as an alternative to fossil coal for energy production, biocarbon has excellent potential to improve fertility and offer carbon sequestration and storage in agricultural soils. Carbonization trials will be conducted on cattail biomass and agricultural residue into biocarbon at Manitoba Hydro's biocarbon production facility at the Rock Lake Colony near Grosse Isle, MB. Methodology will be based on protocols established during initial phases of the "wood chip to biocarbon" phase of the demonstration project. Depending on initial results and acceptance by the host combustion sites, up to an additional 500 tonnes of biocarbon will be produced from alternative feedstocks. The biocarbon will be run through an additional set of combustion trials to analyze energy performance.

Fertilizer growth trials will be conducted in partnership with researchers at the University of Manitoba to evaluate biocarbon for soil condition and fertility, cattails as a green manure, fertility of ash post-combustion and potential recovery of phosphorus. Ash produced during trial demonstration burns of biocarbon and cattail in solid fuel burners

will be analyzed to determine fates of elements and recovery of captured nutrients. These enhancements are anticipated to more clearly define the options for producing biocarbon in a cost-effective manner and identify markets for non-energy-grade biocarbon.

Objectives:

1. Examine alternative feedstocks for the production of biocarbon
2. Harvest up to 2,000 dry metric tonnes of cattails
3. Use the cattail biomass to produce up to 500 tonnes of biocarbon
4. Evaluate feasibility of cattails as a feedstock for biocarbon
5. Test use of biocarbon as a means to improve soil fertility, carbon sequestration and carbon storage in agricultural soils
6. Test fertilizer value of: cattails as a green manure, biocarbon, cattail ash post-combustion and biocarbon ash post-combustion
7. Modify harvesting equipment for use in wet environments
8. Demonstrate large-scale harvesting and processing of cattail biomass
9. Measure and report on harvester performance and harvesting parameters

Advanced Biofuels – Biochemical Conversion

IISD is currently collaborating with Richard Sparling and David Levin at the University of Manitoba to investigate the potential of cattail biomass for the production of advanced biofuels and third-generation biofuels (i.e., ethanol). Cattail samples are being analyzed for lignin and cellulose content, and will be analyzed for their potential for third-generation biofuel production. A complete life-cycle analysis for cattails will be conducted for lingocellulosic ethanol production.

Gasification – Biochemical Conversion

Gasification is a process that converts organic plant biomass into a combustible synthetic gas, or syngas made up of CO_2, carbon monoxide and hydrogen. This is achieved by reacting the material at high temperatures (>700°C), without combustion, with a controlled amount of oxygen and/or steam (Rezaiyan & Cheremisinoff, 2005). Resulting syngas is much more efficient to burn than direct burning of the original biomass, and can be burned to produce direct heat energy and boil water for steam heating. High temperature combustion of the biomass and burning of the syngas instead of the original biomass is considered a sustainable fuel, and leaves behind chemicals and nutrients in the ash and slag, resulting in cleaner emissions and gas production, and potential for recovery of nutrients from the ash.

IISD is currently in discussions with a company in Winnipeg, MB, to test the use of cattail biomass as a feedstock in their gasification processes. A gasifier unit is being installed in a greenhouse facility west of Winnipeg, and there was interest in cooperating to evaluate cattail as biomass feedstock.

5.7 Phosphorus Recovery Potential – Nutrient Recycling and Reuse Feasibility

Phosphorus is a scarce and strategic natural resource. Phosphorus can be recovered from cattail biomass and ash post-combustion (Grosshans et al., 2011b), and the feasibility of developing this additional revenue stream will also be examined in the course of this project.

Phosphorus Ash Recovery (Experiments with the University of Manitoba)

Fertilizer growth trials will be conducted in partnership with researchers at the University of Manitoba to evaluate: cattails as a green manure, fertility of ash collected post-combustion, biocarbon and biocarbon ash post-combustion, and potential recovery of phosphorus from these sources. Biocarbon will also be tested for soil condition and fertility. Ash produced during trial demonstration burns of biocarbon and cattail in solid fuel burners will be analyzed to determine fates of elements and recovery of captured nutrients. These enhancements are anticipated to more clearly define the options for producing biocarbon in a cost-effective manner and identify potential markets for non-energy-grade biocarbon.

5.8 Coal Displacement and Carbon Offset Potential of Cattail Biomass

A further economic and environmental benefit can be gained when cattail biomass is used to displace the use of coal or natural gas through the use of carbon markets, which greatly enhances the value of harvesting cattail biomass. Preliminary calculations based on coal emission data obtained from the literature (IPCC, 2010) estimate that displacing coal[13] with one tonne of cattail biomass, to be used as a feedstock for bioenergy production, would generate 1.05 tonnes of CO_2 offsets. At a conservative average harvest rate of 15 tonnes per hectare (dry weight), 350 hectares of harvestable cattail would yield approximately 5,250 tonnes of cattail and directly displace 2,835 tonnes of coal. Potential GHG emission offsets estimate this could displace 5,513 tonnes of CO_2 emissions, without considering methane reduction, and capture up to 10 tonnes of phosphorus.

With current volunteer carbon offset market values of $10 to $25 per tonne of offsets (see Section 6), this could potentially produce $55,130 to $131,250 in carbon offset credits to be sold for cost recovery. This carbon price is given for illustrative purposes and fair market value should be considered. Further research is needed to confirm and quantify potential additional carbon sequestration associated with wetland restoration as a result of incentives from cattail biomass production, and methane reduction credits associated with harvesting plant material that could otherwise decompose anaerobically. Additionally, cattail biomass also has much lower sulphur content in comparison to coal, thereby reducing emissions (Tampier et al., 2004).

[13] These calculations assume the coal replaced is Alberta bituminous. Substituting with other types of coal would yield different results.

TABLE 9. Cattail carbon offsets and GHG emission credits displacing coal (Alberta bituminous) for heat production (IPCC, 2010).

BIOMASS	YIELD (T/HA)	ENERGY CONTENT (MJ/T)	ENERGY CONTENT (MJ/T) AT 80% EFFICIENCY	EMISSIONS (T CO_2/T BIOMASS)	EMISSIONS PER UNIT ENERGY	P CONTENT (KG/T)	CO_2 OFFSET PER T
Cattail	15	17,500	14,000	0.5	0.0357	3.5	1.05
Coal	-	25,800	-	2.44	0.0945	0.5	-

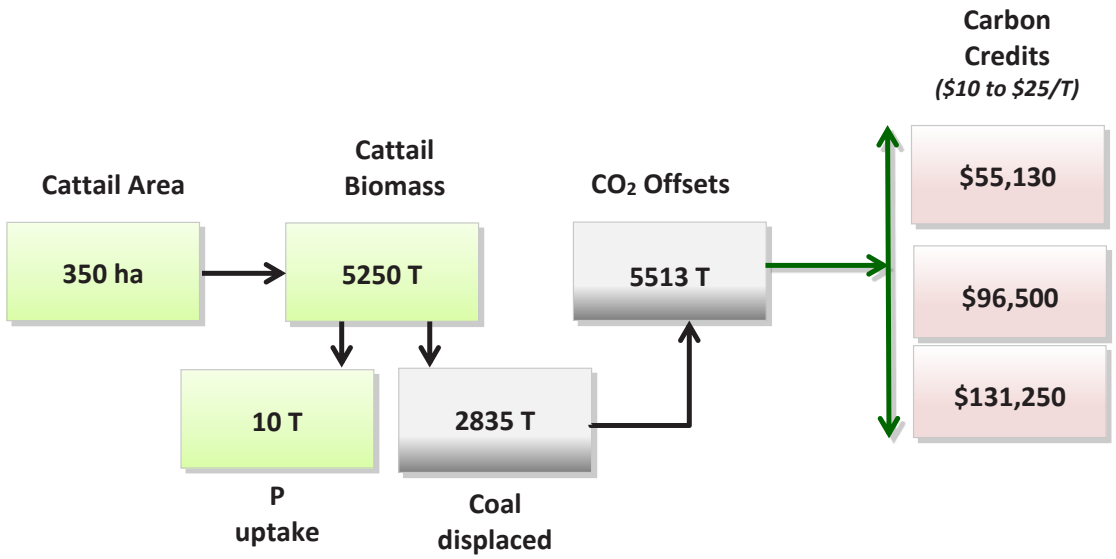

FIGURE 23. COAL DISPLACEMENT AND CO_2 OFFSETS

Coal displacement = (energy content of cattail /energy content of coal)

CO_2 offsets = Coal displacement x (coal CO_2 emissions – cattail CO_2 emissions)

6.0 Carbon Offset Market Opportunities and Certification

6.1 Market Opportunities for Cattail-Based Biomass and Bioproducts

As commercial-scale harvesting opportunities for cattail are explored, there is a need to examine existing and projected markets to determine potential demand for various benefits derived from this value chain. As Figure 24 illustrates, economic opportunities can be derived through 1) nutrient management and reduction in lake eutrophication, 2) habitat improvement and related benefits including recreation and tourism, 3) biomass for bioenergy and bioproducts, 4) carbon offsets for greenhouse gas mitigation and 5) phosphorus recovery for fertilizers and water quality trading.

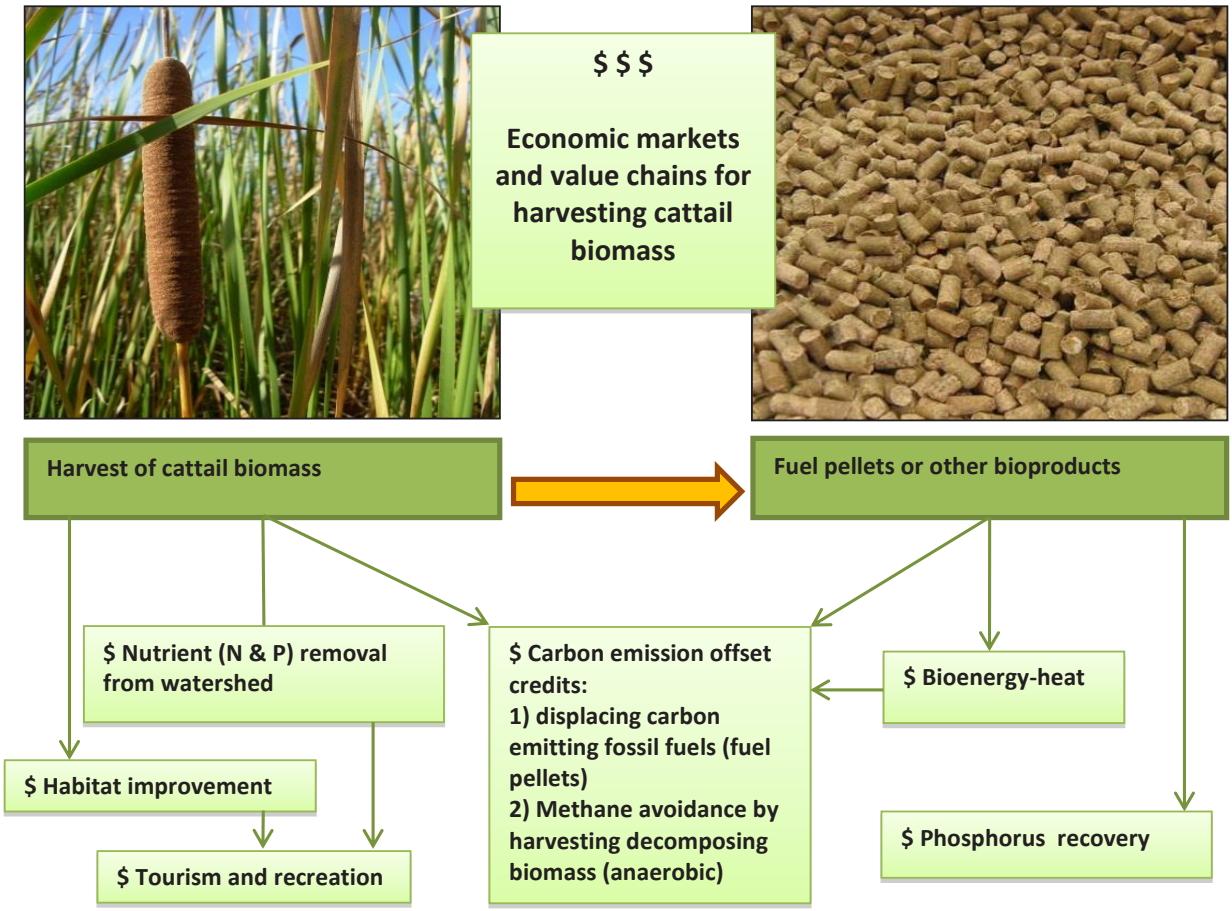

FIGURE 24. Economic value-chains derived from cattail biomass harvesting.

A study of current and projected market demand will ensure these value chains can be realized to optimum potential and market adjustments might be informed in the best possible manner. An initial step in the study of markets and market demands for products and by-products of these value chains is a preliminary scoping of opportunities that exist for carbon offsets, regionally and nationally, in Canada.

6.2 Offset Opportunities in Canada

The Potential for Offsets to Help Meet Canadian GHG Targets

IISD conducted a preliminary study of the potential for offsets to help Canada meet its 2020 emission reduction target, showing that offsets can be a significant contributor to emission reduction. A preliminary analysis by IISD in *Mind the Gap: The State-of-Play in Canadian Greenhouse Gas Mitigation* (Sawyer, 2011) revealed that domestic offsets alone have the ability to contribute as much as 26 Mt of reductions annually in 2020 at a price of $25 per tonne in the sectors of agriculture, waste, buildings and transport. This represents as much as 12 per cent of the reductions needed to meet the Canadian government's 2020 target of 17 per cent below 2005 levels. While these numbers are only an initial modelling, and therefore must be taken with a degree of caution, they are illustrative of how offsets could contribute to emission reductions targets in Canada.

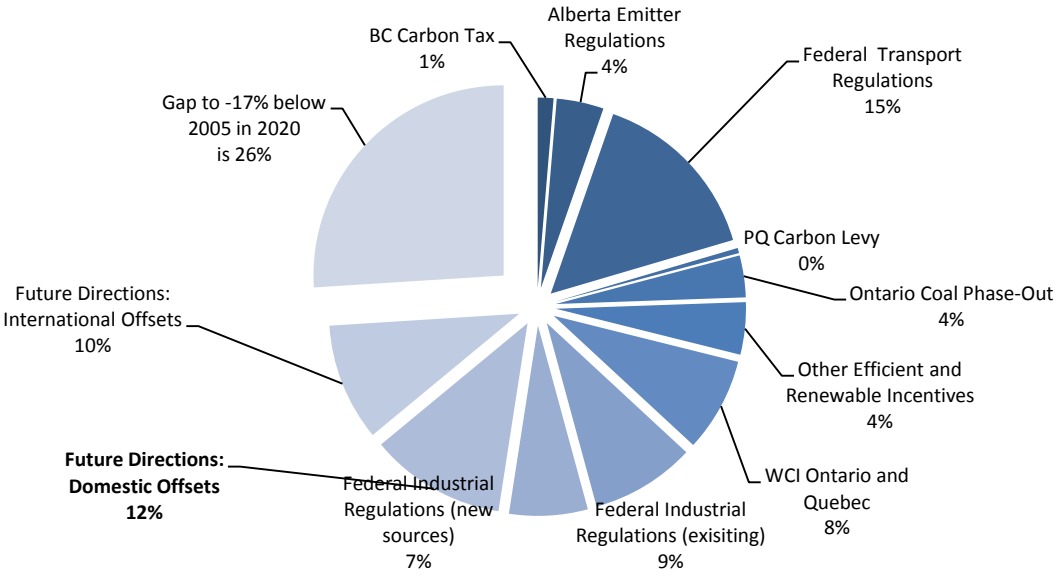

FIGURE 25. Current, planned and possible actions to reduce GHG emissions in Canada: Composition of Canada's target of 17 per cent below 2005 levels in 2020 (Saywer, 2011)

Mind the Gap proposes that an offsets system could either be a form of flexibility for emitters to reduce compliance costs, or a standalone government fund that purchases reductions itself for retirement against the national GHG reduction target (Saywer, 2011). While such a system has yet to move forward, the potential for offsets to contribute to national targets in a significant way makes it an attractive option.

The Canadian Offsets Market

There is currently no national strategy or market for offsets for GHG mitigation at the federal level in Canada. The current role of offsets in Canadian GHG mitigation is based on a patchwork of approaches, without a clear guiding strategy at this level.

Efforts have been made to propose the development of an offset system for GHGs in Canada. The last of these proposals, in 2009 (Environment Canada, 2009), included incentives for reductions in sectors uncovered in other approaches to GHG mitigation (i.e., cap and trade, sector performance regulations). Credits for offset action would then be purchased

and utilized by entities in covered sectors that had offset flexibility as part of their compliance regime. The initial goal was to include actions such as methane capture and destruction, afforestation, soil management and renewable energy. Steps in an offset project approval would have included: (i) creation of a quantification protocol for the project type; (ii) registration of the project; (iii) implementation of the registered project and monitoring of data; (iv) reporting and verification of reductions from the registered project; and (v) certification of reductions and issuance of offset credits by Environment Canada.

6.3 Provincial Offset Systems

In the absence of a federal system, several provinces have taken to developing their own offset regimes with varying levels of coverage, standards and pricing. A summary of some of the prominent provincial approaches are included here.

Manitoba

A good starting point for a potential market for carbon credits for Manitoba-based cattail harvesting would be from Manitoba-based offset purchasers. Currently in Manitoba, domestic offsets have been piloted through the Manitoba Sustainable Agriculture Practices Program (MSAPP), which is currently under review for renewal (Manitoba Agriculture, Food and Rural Initiatives, 2012). The MSAPP operates as a single-purchaser offsets program to help the province achieve its climate change objectives and its transition to a low carbon and green economy with a focus to reduce GHG emissions in the agriculture sector. The MSAPP has three components:

- Beneficial management practices (BMP)
- Research and development
- Extension

The BMP program (currently fully subscribed and not accepting applications) enabled farmers to adopt practices such as improved manure storage, reduced tillage and pasture management planning, that would achieve GHG reductions.

The MSAPP has created a market for agricultural offsets in Manitoba at the price of $24 per tonne, covering 180 projects for a total payout of $2 million (Government of Manitoba, 2010). To date, this has resulted in 82,000 tonnes of emission reductions that the province (as purchaser of the offsets) can claim towards its provincial emission mitigation target. The program is currently scheduled to run until March 31, 2012, with its long-term future currently unclear.

There is potential that future iterations of an MSAPP program could be expanded to include projects such as IISD's cattail harvesting program, given its GHG reduction (via energy fuel switching and methane mitigation) and nutrient management benefits. Once the long-term lifespan of the MSAPP is determined, a review of acceptable projects would be a useful exercise to expand opportunities.

Highlights of Some Other Provincial Protocols

Alberta has the most mature offsets regime within Canada, due in part to the strength of its GHG mitigation strategies. The structure of Alberta's climate change plan, including the Climate Change and Emissions Management Amendment Act and the Specified Gas Emitters Regulations have developed three methods through which covered entities can meet their compliance requirements:

- Improve the efficiency of operations (meet intensity targets directly)
- Purchase offset credits through the in-province offset system
- Make payments into a provincially managed fund (Climate Change and Emissions Management Fund [CCEM]) designated for technology improvements at $15 per tonne of CO_2 equivalent (tCO_2e)

The presence of the CCEM and the offset system serve as flexibility mechanisms to enable compliance at reasonable cost. The CCEM sets a carbon price within the system, setting a price point that the offsets regime can work with. As of late 2011 Alberta had collected more than $250 million through CCEM fund payments (Alberta Environment and Water, 2012a), while the offset registry has 96 projects registered accounting for over 16 million tCO_2e in emission reductions (Carbon Offset Solutions, 2012a)

Alberta developed its own in-province Offset Credit System Protocols (Alberta Environment and Water, 2012a) covering the types of projects accepted[14] and third party verification. The system is operated and managed by a Crown corporation through the Carbon Offset Solutions website (Carbon Offset Solutions, 2012b).

British Columbia and Quebec have both taken steps towards the development of an offset regime under the Western Climate Initiative (WCI). **British Columbia** developed an emission offset regulation that informs how measurement and removals of GHGs are to be expressed, as well as reporting and verification requirements (Government of British Columbia, 2008). Initially intended to help the public sector become carbon neutral, the intention was eventually to have the offset regime operate as part of the provincial cap-and-trade program under WCI, which was to start January 1, 2012 (Ministry of Environment. 2012). Currently, launching cap and trade has been delayed in the province, but the offset regime still has delivered significant reductions to both the B.C. government and private sector clients through voluntary purchases. Pacific Carbon Trust, a Crown corporation of the B.C. government established in 2008 to facilitate GHG reductions through B.C.-based offsets, offers credits for purchase at $25 per tonne (Pacific Carbon Trust, 2012a). Pacific Carbon Trust also offers advice and market assistance to offset project developers and delivered nearly 750,000 tonnes of carbon offsets to clients in 2010 (Pacific Carbon Trust, 2012b).

Through its involvement in the WCI, **Quebec** has also considered offsets for compliance and the launch of the WCI emission trading system in Quebec on January 1, 2012, gives added weight to the commitment. WCI developed essential elements for an offsets system (WCI, 2010) as well as reviewed existing offset protocols against their own criteria (Det Norske Veritas, 2010). Recommendations included areas such as: ownership, use, geographic limits (offsets from non-WCI jurisdictions may be used), quantification, leakage, permanence, eligibility, verification and additionality. Importantly, only protocols approved through the WCI protocol review process may be used. Protocols that WCI reviewed include soil sequestration, manure management, rangeland management, forestry, landfill gas and waste treatment.

6.4 The Voluntary Market

With the offset market disjointed in Canada, many entities are relying on the voluntary market for offsets. Much of this market relies on targets imposed internally, not by government regulations, but by shareholding management or ownership groups imposing internal reduction targets.

[14] There is a protocol for biomass combustion within the Alberta system, both related to the avoided GHGs from switching to biomass from fossil fuels as well as avoided GHGs by combusting biomass versus undergoing anaerobic decomposition. This protocol, with some amendment, could be used as a basis on which to build an offset protocol for the cattail harvesting project. This biomass protocol is available via the Alberta Environment website at: http://environment.gov.ab.ca/info/library/7908.pdf

For the Netley-Libau cattail harvesting project, like other projects in stages of development that have GHG mitigation opportunities, the presence of a voluntary market serves as an outlet to gain a crediting benefit while they wait for a regional compliance market to form (i.e., WCI) or just as a way to derive a funding or cost-recovery source for a project with a GHG mitigation benefit. A relevant example is in the case of fuel switching from coal to biomass for heat generation where the biomass is more expensive, but becomes economically competitive with an offset credit.

Standards

There are a series of regionally and globally accepted standards that operate in place of jurisdictional standards (i.e., Alberta or WCI's system) in the voluntary market. Some, such as the Gold Standard and VER+, are based on the Clean Development Mechanism (part of the Kyoto Protocol) but designated for use on the voluntary markets. Others are developed by specific groups, such as the VCS, which was developed by The Climate Group, the International Emissions Trading Association and the World Business Council for Sustainable Development. There are also standards specifically for developing countries such as the Gold Standard, which is only for projects developed in countries without Kyoto Targets, and those for use anywhere in the world, such as the VCS.

Overall, the VCS is one of the most commonly used standards around the world, with the largest market share (Peters-Stanley et al., 2011). It is also a viable option, at least upon initial review, for the IISD cattail project to look at bringing its offset potential to the voluntary carbon market. For this reason, it is the model that we will focus on in terms of how a project gets accredited.

Developing a VCS-Approved Project and Selling Credits

Getting accredited and issuing credits in the form of Verified Carbon Units (VCUs) with the VCS is a multi-step process for project developers. The VCS website offers a step-by-step process for project development (Verified Carbon Standard, 2012), but the basic steps are as follows. Given its worldwide applicability, highly respected and accepted standards, and competitive price points, it is likely that the VCS will continue to be a leading offset standard in Canada for the foreseeable future. Pending the development of a more structured and expansive offset system in Manitoba, with its own set of regulations, the VCS also serves as a suitable model to follow in studying the potential of developing standard-approved offset credits for the IISD cattail project.

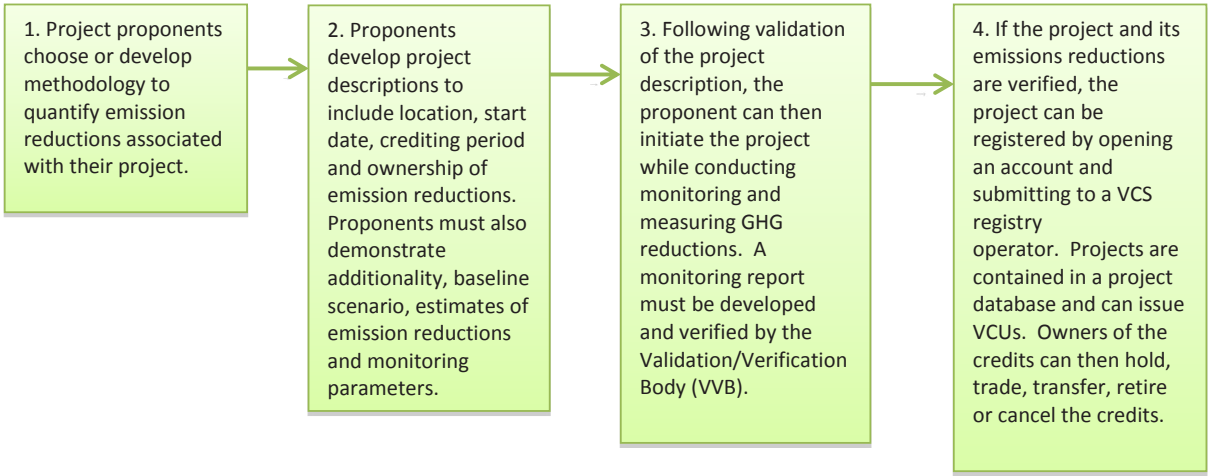

FIGURE 26. Methodology of the VCS voluntary market process.

7.0 Regulations and Legislation

IISD has recently conducted a legislative and regulatory review for cattail (*Typha* spp.) harvesting in Manitoba. This survey and analysis is vital to the lawful, sustainable and beneficial harvesting of cattails in Manitoba. The harvest of cattails is not currently included in any federal or provincial legislation, policies or programming and the purpose of this study was to understand the current and potential position of cattail harvesting in Manitoba. Two management scenarios were explored that include legislation, policies and programming:

1. Private benefit harvesting scenario scheme based on other resource extraction schemes similar to for-profit activities like wild rice harvesting. This could be conducted on both Crown and private lands.
2. Publicly funded land management assistance scenario, where private corporations can be contracted to harvest cattails in areas of concern. This scenario can be used on Crown lands in this way, or for private lands using incentives such as those used for agricultural BMPs or other tax credits to land owners.

Although the scenarios are different, when cattail harvesting becomes realized, the management framework may be a combination of these two scenarios. Regardless of funding sources and benefit scenario, an adaptive management framework is recommended in order to fully understand the multiple co-benefits to humans and the environment that the harvest of cattails does have. In addition, it is recommended that legislation is drafted to include cattail harvesting into the Manitoba Bioproducts Strategy and the Manitoba Biomass Energy Support Program list of approved biomass sources.

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