

A Regional Bioeconomy:

Harvesting *Typha* for Nutrient Capture, Bioenergy, Phosphorus Recovery and Carbon Offset Credits



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North America



US Dept of State Geographer
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image IBCAO
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Google earth

⤴ Tour Guide

56°42'57.71" N 79°18'09.52" W elev 42 m eye alt 8785.35 km

The Lake Winnipeg Watershed

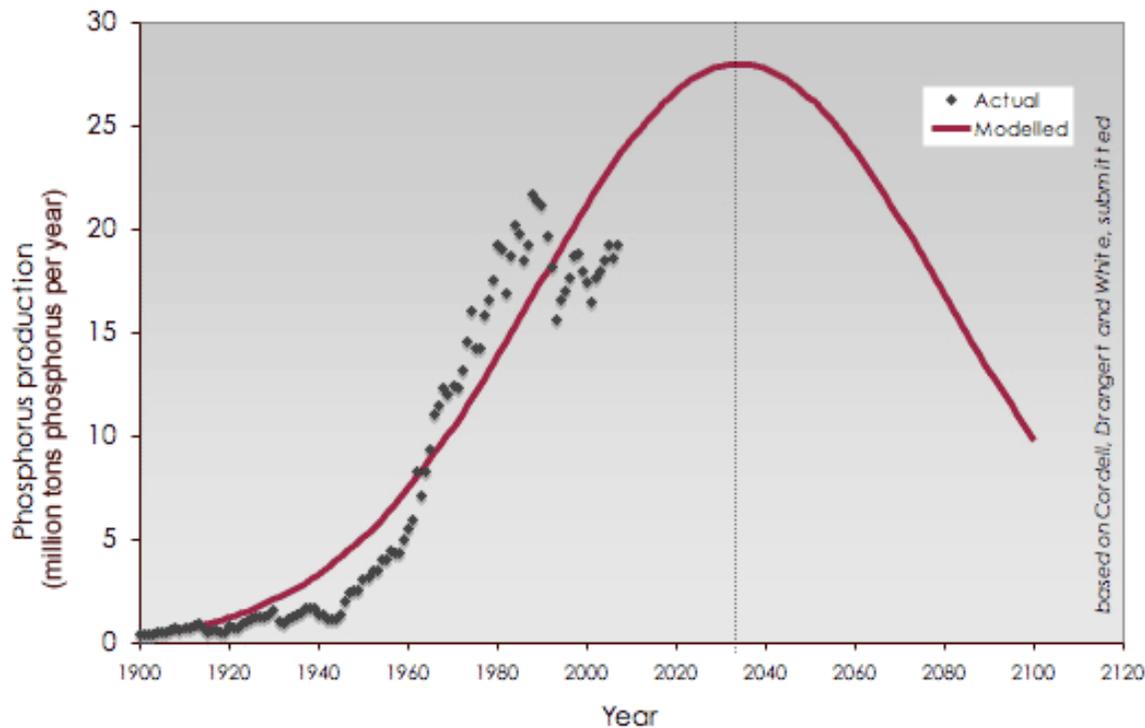


An abundance of water and nutrients



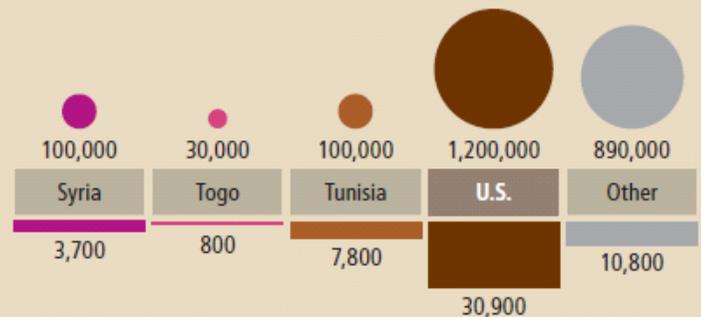
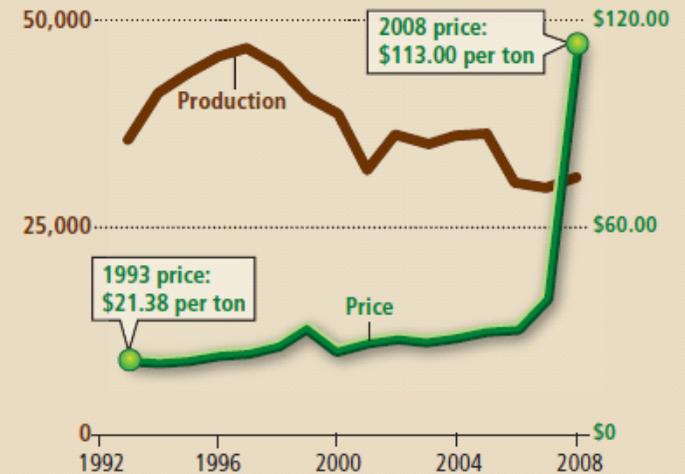
Meanwhile...that noxious pollutant is actually a scarce and strategic resource: the Peak Phosphorus story

Phosphorus production: When will it peak?



U.S. PRODUCTION IN DECLINE AS PRICE SOARS

Phosphate Rock Production (millions of metric tons)

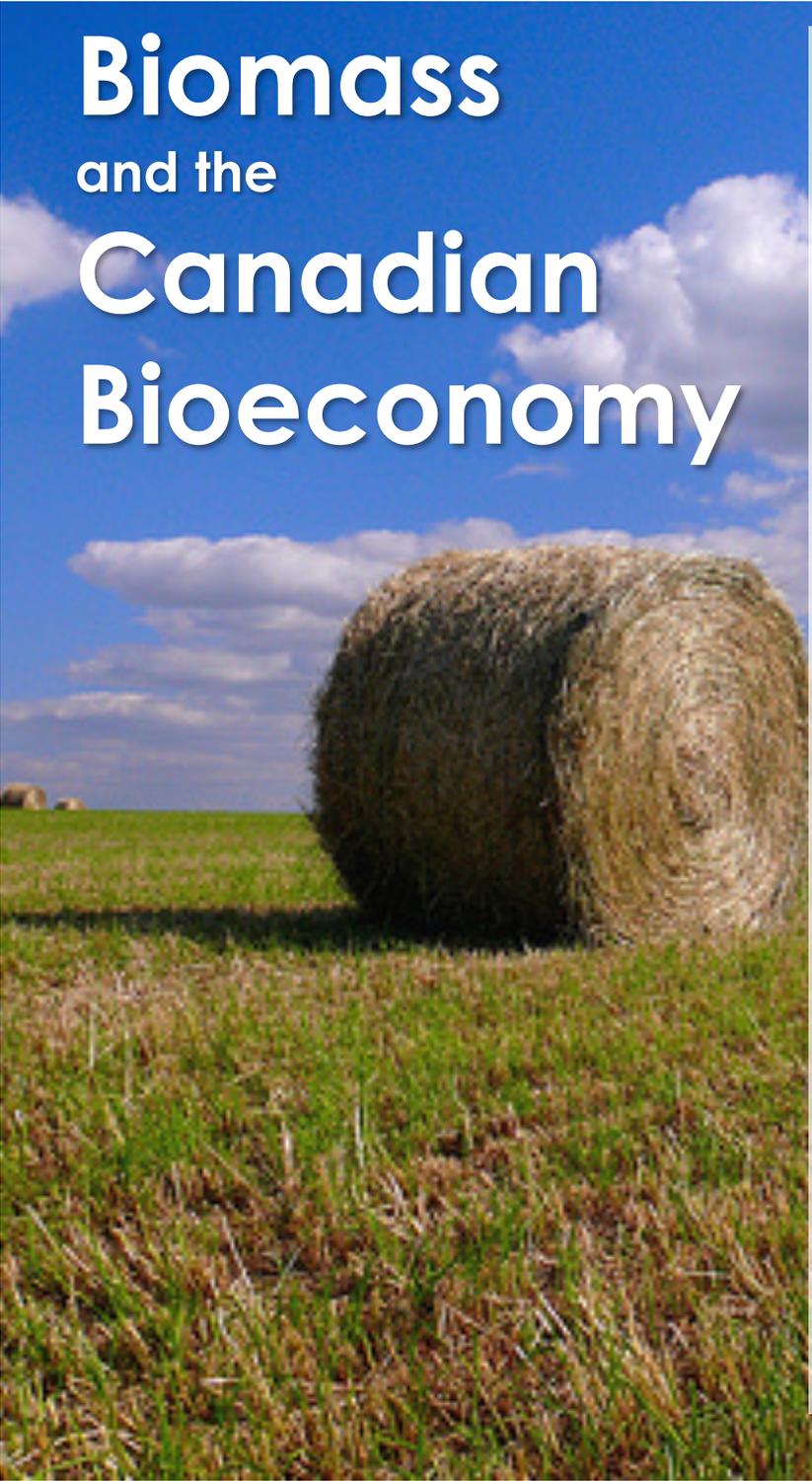


Lake Winnipeg and The Manitoba Bioeconomy

- Lake Winnipeg - one of the most eutrophic large lakes in the world
- Flooding and nutrient loading issues provide economic opportunity through innovative solutions
- Phosphorus - the noxious pollutant fouling Lake Winnipeg is a valuable strategic recourse



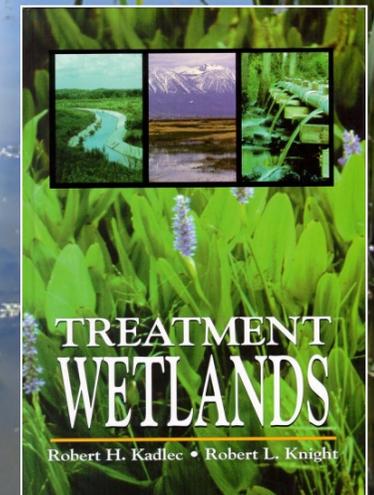
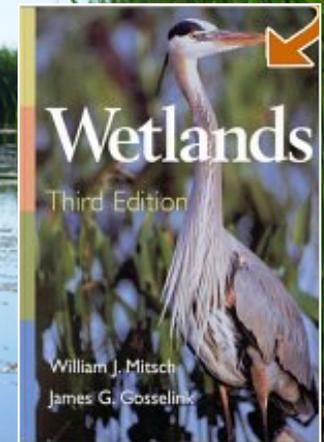
Biomass and the Canadian Bioeconomy



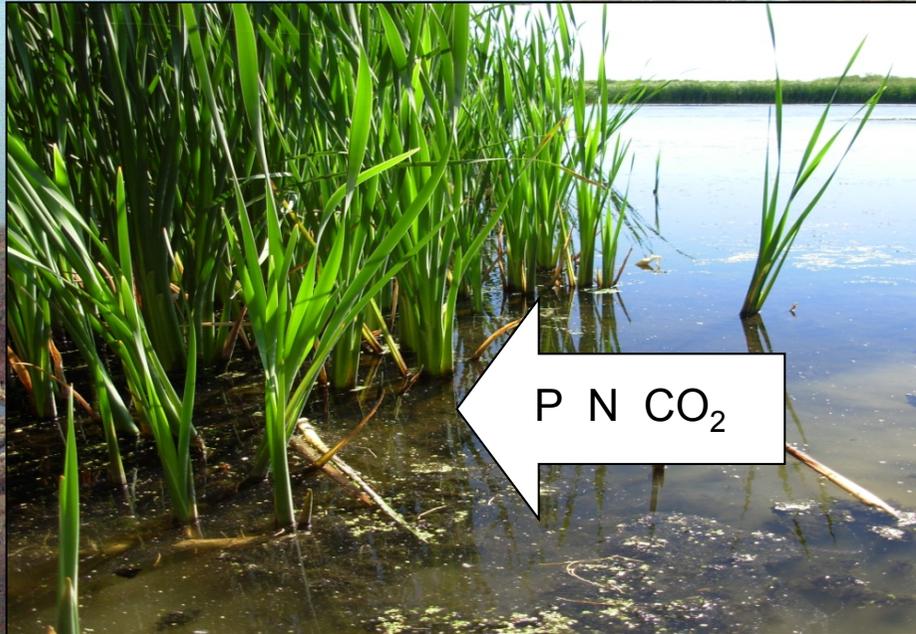
- **Lack of Feedstock sustainability and economic viability** is a significant risk to the biofuel industry
- **Biomass industry** receiving growing attention for its potential as a significant source of renewable energy within the Canadian Bioeconomy
- Need to expand portfolio of **sustainable biomass sources**.
- Opportunity to explore alternative feedstocks that combine benefits: i.e. nutrient management, bioenergy, flood storage:
 - *Typha*
 - *Willows*
 - *Agr. Residue (i.e. straw, stover)*
 - *Forestry residue*

Wetlands - Nature's Kidneys

- Wetlands are a critical part of a healthy watershed
- Effectively store nutrient rich runoff water preventing downstream flooding
- Store and remove significant amounts of nutrients and toxins from the water before reaching rivers and lakes
- Nutrients are buried in wetland sediments
- Plants take up nutrients from litter and sediment – incorporated into biomass
- Nutrient rich material re-enters ecosystem from decaying vegetation – **intercept with harvesting**



Netley-Libau Nutrient-Bioenergy Project



- *Typha* plants absorb nutrients – phosphorus (P) and nitrogen (N)
- Sequester carbon from the air (CO₂)
- Harvest nutrient-rich cattail biomass:
 - ❑ captures stored nutrients (P)
 - ❑ novel biomass feedstock
 - ❑ Combines bioremediation with habitat renewal and GHG emission reductions
 - ❑ **a sustainable biomass for bioenergy and higher value bioproducts**



Netley-Libau Nutrient-Bioenergy Project

Typha biomass for nutrient capture and bioenergy

- *Typha* biomass harvesting and combustion for nutrient capture and bioenergy - **an approach that intercepts, sequesters, recovers stored nutrients**
- Nutrient management combined with upland surface water management and novel biomass feedstocks - **create new value chains and economics**
- Sustainable renewable biomass harvested for bioenergy and biomaterials - **key mechanism for intercepting phosphorus before it enters Lake Winnipeg**
- **Phosphorus recycled** - fertilizer for crop production
- Fundamental concept - **we're turning a waste/pollution stream into an input for sustainable biomaterial production – key building block of the Bioeconomy.**



Typha biomass harvesting

Spring harvest



Summer harvest



Summer harvest – 100 m² plots

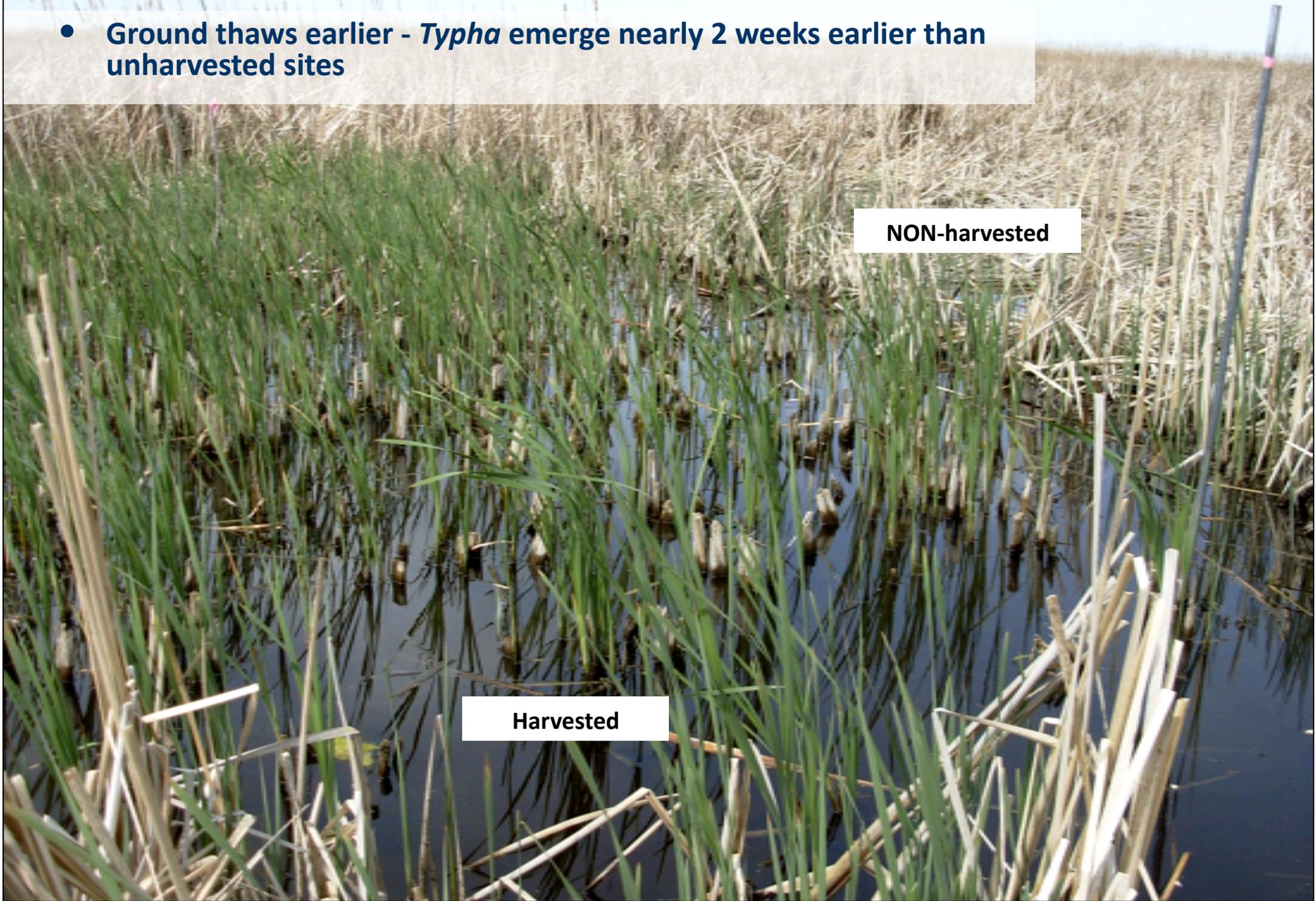


Winter/Spring harvest – 100 m² plots



Harvesting Effects - Harvested sites vs. non-harvested

- Ground thaws earlier - *Typha* emerge nearly 2 weeks earlier than unharvested sites



NON-harvested

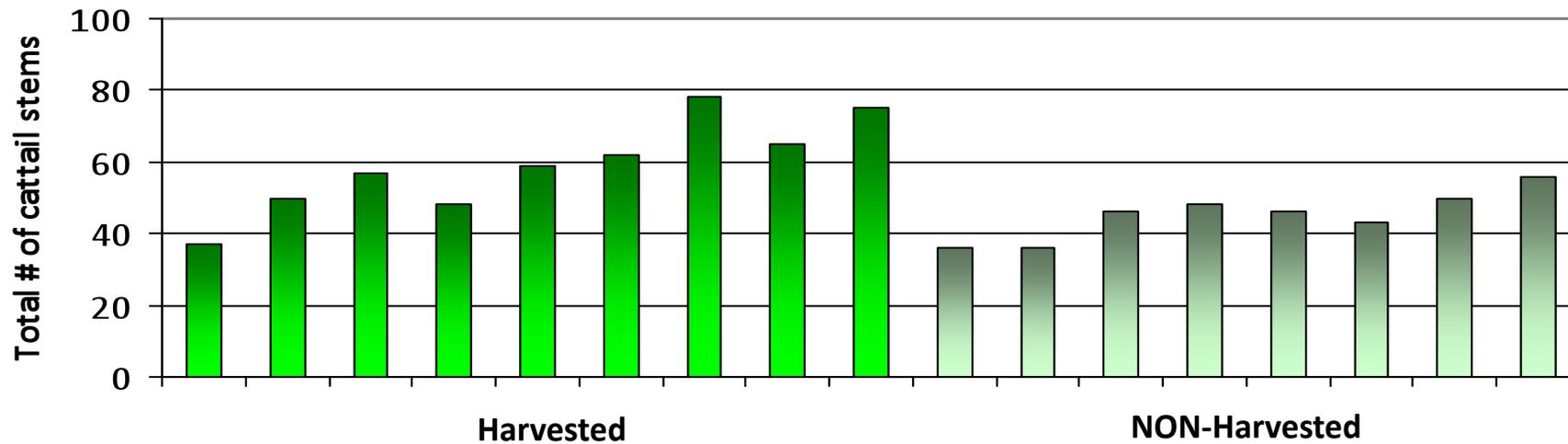
Harvested

Harvesting Effects - Harvested sites vs. non-harvested

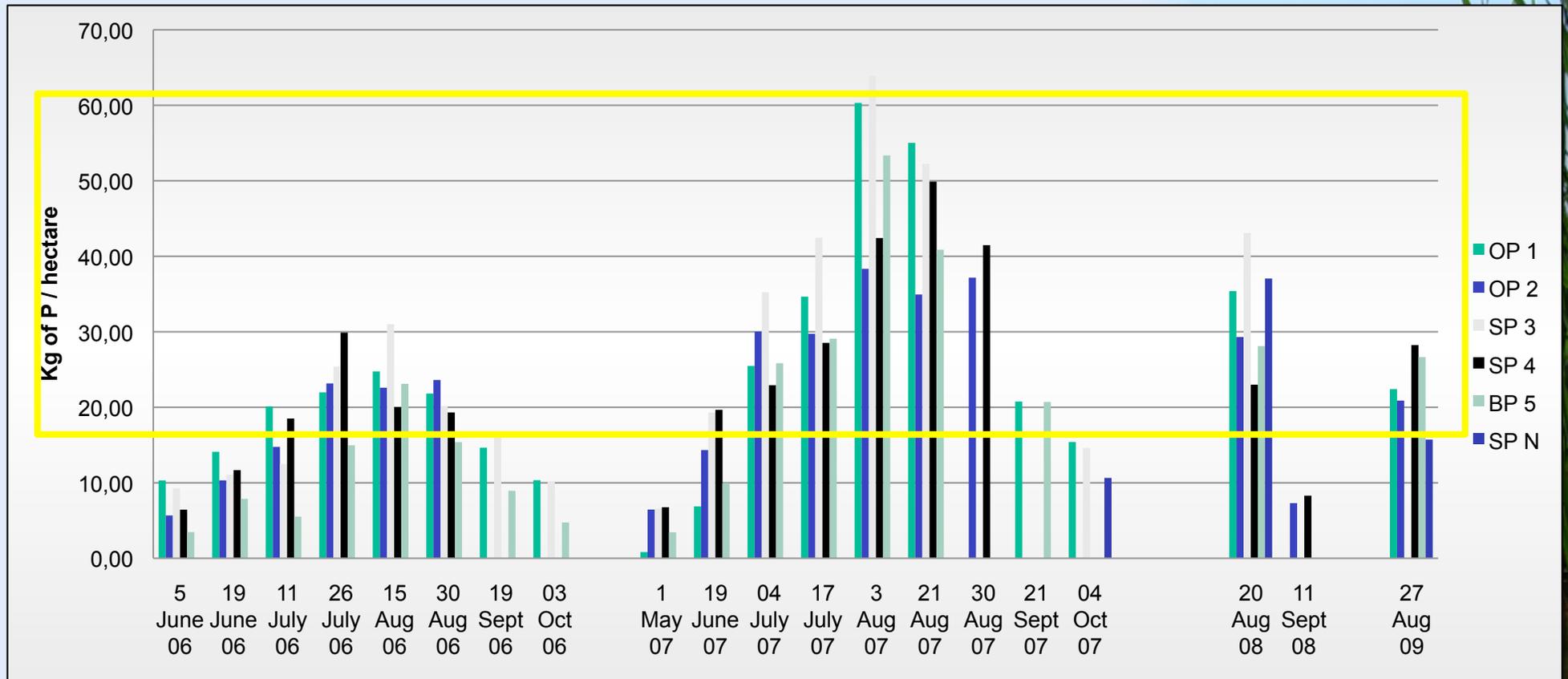
- *Typha* density increases following harvest and clearing of deadfall



Cattail Density - Large harvest plots - harvest year 2



Phosphorus captured (kg/hectare) in harvested *Typha*



20 to 60 kg of P

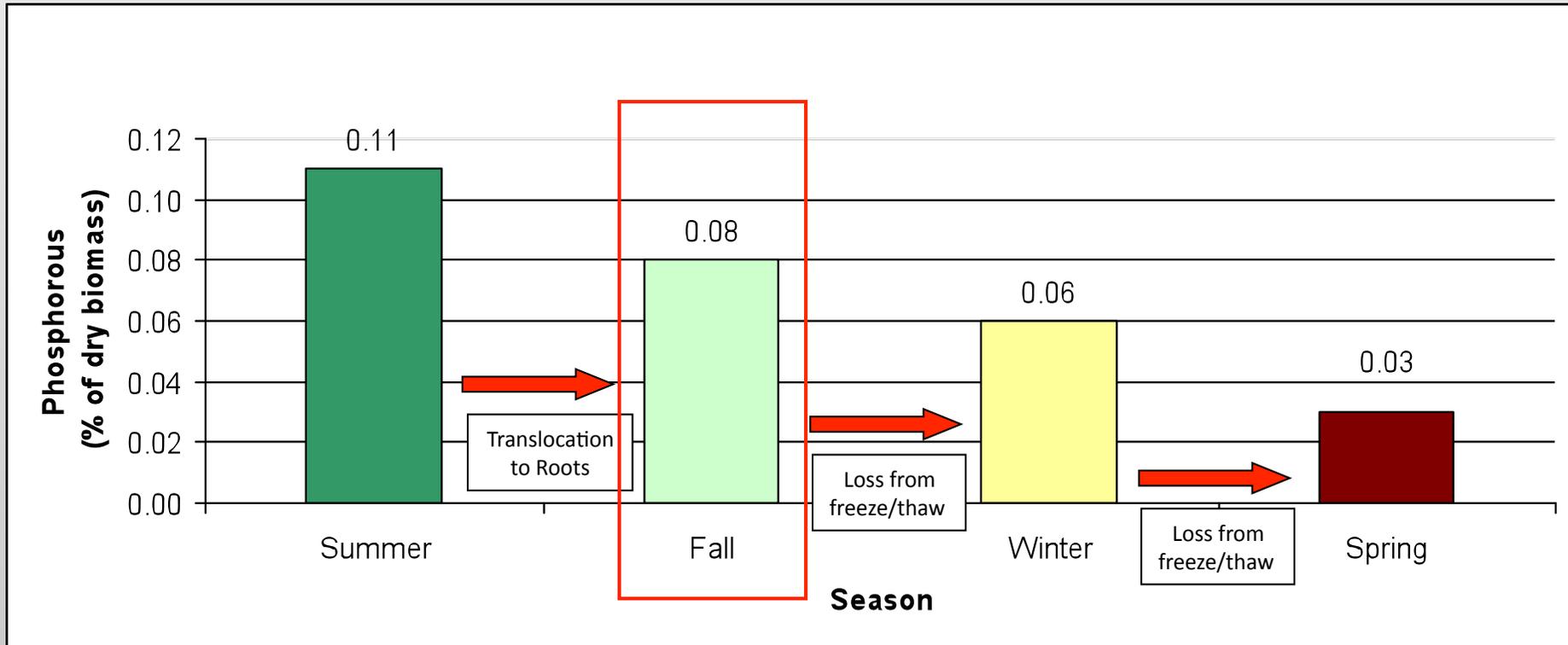
per Hectare of *Typha*

1 to 2 kg of P

per 400 kg round bale



Seasonal Phosphorus Loss in *Typha*



Typha Biomass Bioenergy

- *Typha* spp. can produce considerable biomass within a single growing season
- Extremely competitive – primary aquatic plant for nutrient removal in engineered wetlands and **wastewater treatment** wetlands
- **ZERO inputs** for nutrients and planting
- **Valuable biomass** feedstock
- Harvesting *Typha* biomass offers **greatest feasibility if combined for multiple purposes** and EGS – bioenergy, habitat management, nutrient removal, flood control, erosion reduction...



TABLE 1: *Typha* biomass characteristics and phosphorus content.

	Average
Biomass yield	15 to 18 tonnes
Moisture	6 - 15 (% dry matter)
Phosphorus content	0.10 - 0.25 (% dry matter)
Phosphorus capture	20 - 60 (kg/hectare = 1-2 kg/bale)
Ash content	5.5 - 7.5 (% dry matter)
Phosphorus in ash	2 – 3 (% dry matter)

TABLE 2: *Typha* biomass general characteristics.

Biomass	Average Yield (T/ha)	Days to Maturity
<i>Typha</i>		
<i>IISD (2006-2009)</i>	14.7 to 18.8	90
<i>Canada (hybrid)</i>	35	90
<i>North Carolina, USA (2009)</i>	16 (42 max)	
<i>Minnesota, USA (1980)</i>	25	
Wheat straw	1.8 - 2.4	90-100
Corn stover	5.1	110-120
Flax residue	1.2	99-110
Switchgrass	9.1 - 13.5	3 years
Miscanthus	6.3 - 48.3	3 - 5 years
Willow	7 - 10	3 years
Poplar	7 -10	6 - 12 years
Alfalfa	5.6	6 years



Biomass Densification – cubes and pellets

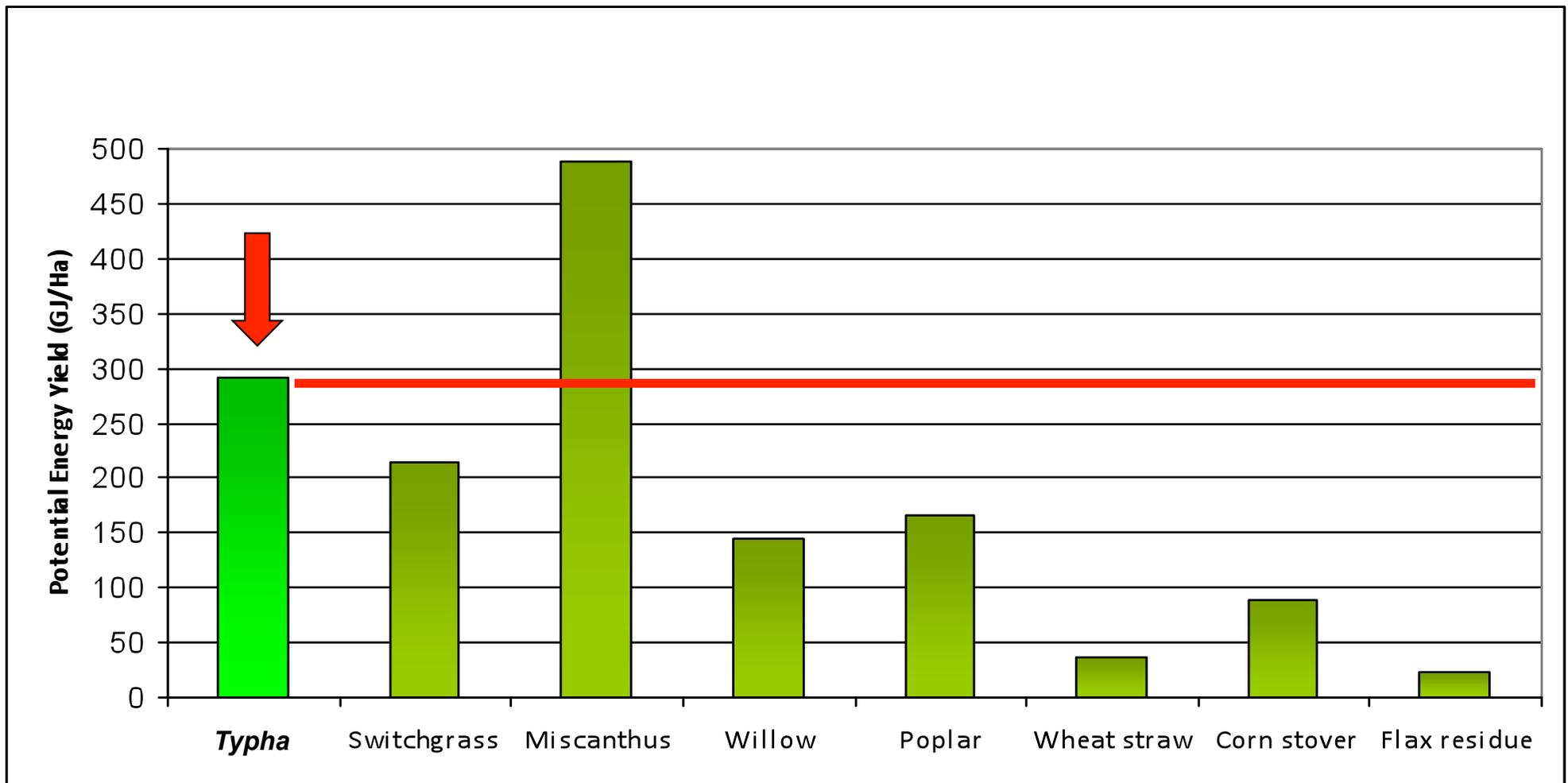


- Created densified fuel cubes and pellets for use in bioenergy systems
 - Easily stored and transported - is a universal feedstock
 - Current market for fuel pellets – European, Canadian, USA markets
 - Cubes for use in larger burners – Canadian market
- Comparison of *Typha* as a feedstock to other biomass feedstocks

TABLE 5: Energy value and proximate analysis (% dry basis) of cattail biomass & densified fuel pellets, comparison to standard wood pellets and common biomass feedstocks and fuel sources.

Biomass	Calorific Value MJ/kg	BTU /lb	Volatile Components (%)	Fixed Carbon (%)	Ash Content (%)
<i>Typha (various studies)</i>	17.29 to 18.2	7739 - 7837	64 to 76	16.82 - 30	5.47 – 7.64
<i>Typha pellet (no binder)</i>	19.89 ± 0.15	8551	64.52 ± 0.11	28.94 ± 0.14	6.54 ± 0.03
<i>Typha pellet (starch binder)</i>	16.80 ± 0.03	7223	68.54 ± 0.69	25.25 ± 0.74	6.21 ± 0.05
Wood pellets (standards)	16.9 - 18.0	7266 - 7739	-	-	< 0.5 - 3
Wood chips	10.4	4471	> 70	-	0.6 to 1.5
Wheat Straw (dry)	17.3	7438	72.9	-	8.3
Wheat Straw (20 % mc)	13.74	5907	-	-	4
Flax Straw (dry)	19.97	8586	-	-	-
Flax Straw (20 % mc)	15.43	6634	-	-	-
Corn cobs	18.8	8083	-	-	1.36
Corn stover	17.6	7567	-	-	5.58
Alfalfa	16.1	6922	-	-	7.94
Sunflower hulls	19.7	8469	-	-	2.86
Propane	46.37	19936	-	100	0
Natural Gas	48	20636	-	100	0
Fuel Oil	37	15907	-	-	-
Coal (anthracite)	29.5	12683	-	-	10.5
Coal (Bituminous)	20.9 to 33.4	10748	-	-	6 to 9.8
Coal (lignite)	15.31	6582	-	-	7.3

Typha Biomass – potential energy yield



Typha Cube Burn Trial Fall

2009

Blue Flame Stoker
Biomass Burner





**Nutrient
Capture and
Removal**

***Typha* Harvesting for Nutrient Removal and Bioenergy Production**

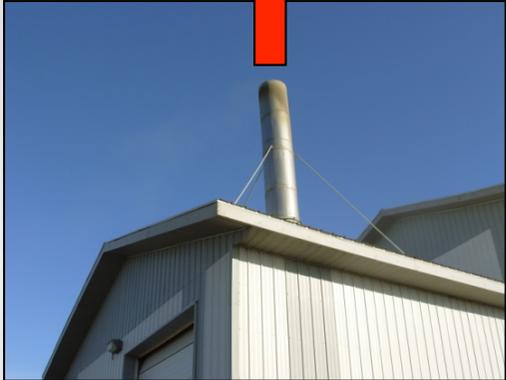
***Typha* Biomass
Harvest**

Bioenergy

Emissions out



**Biomass Transport
(Baled)**



Heat Energy



**Biomass
Densification
(cubes, pellets)**

P Recovery

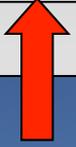
Ash OUT

**Biomass IN
P IN**



**88%
Phosphorous
Recovery**

***Biomass* Burner**



Current harvesting 2012



Current harvesting 2012



Current harvesting 2012



Harvesting technology for 2013?

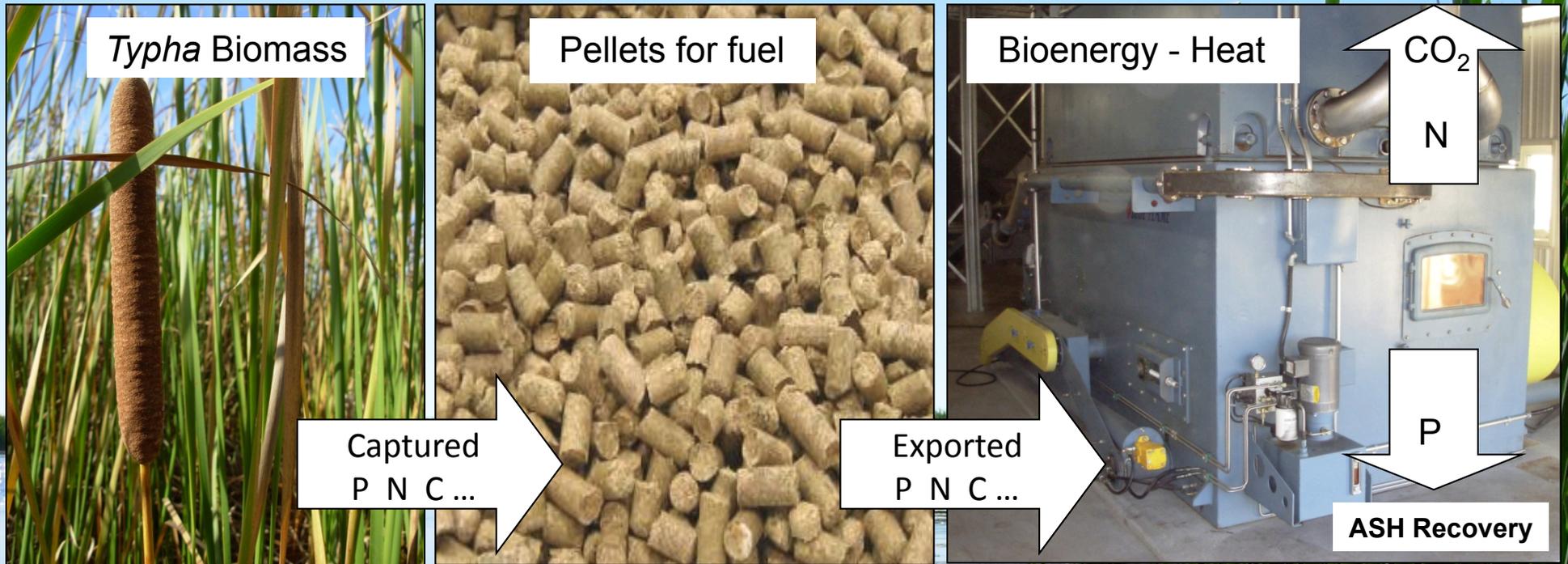


Baling technology for 2013?



Higher value products – biocarbon, biofuels, biocomposites, bioplastics,

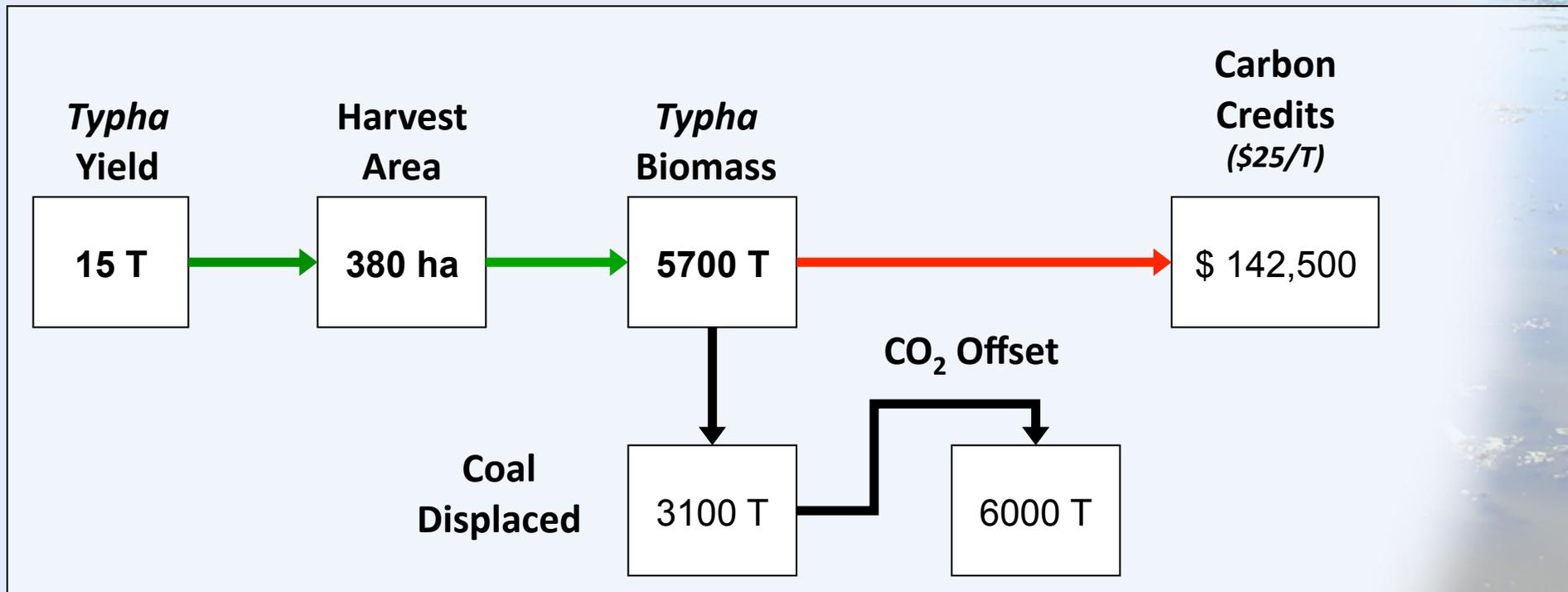




- Harvesting *Typha* captures stored nutrients
- Further benefit gained as a **bioenergy** feedstock to displace fossil fuels (coal) used for heating or electricity
- **Carbon credits** from production of “low carbon” bioenergy, while reaping benefits of Phosphorus (P) capture from Lake Winnipeg – “**Lake Friendly**” biomass
- **Recover P** (pre or post combustion) - being explored for use as fertilizer
- Diversify rural economic activity by providing a value towards wetland restoration
- **An example of innovative integrated systems for the Bioeconomy**

Typha carbon offsets & GHG emission credit potential displacing coal (*bituminous*)

Biomass	Yield (T/ha)	Energy Content (MJ/T)	Energy Content (MJ/T) at 80% efficiency	Emissions (T CO ₂ /T biomass)	CO ₂ offset per T
<i>Typha</i>	15	17500	14000	0.5	1.05
coal	-	25800	-	2.44	-



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durable



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**NSERC
CRSNG**



TABLE 3: Elemental analysis of cattail biomass with comparison to other biomass feedstocks.

Biomass	Carbon (%)	Hydrogen (%)	Nitrogen (%)	Sulphur (%)	Oxygen (%)	Aluminum (%)	Silica (%)
Cattail	38.8 - 43.6	5.39 - 5.74	0.83 - 1.28	0.14 - 0.30	37 - 43.3	0.90	0.11
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	80		0.90	0.70			
<i>Anthracite</i>							
<i>Bituminous</i>	52.5 to 81.7		1 to 1.5	1 to 1.5			
<i>Lignite</i>	40.1		0.70	1			
Natural Gas	75	24	0.9	0	0.9		

TABLE 4: Cellulose and lignin content of cattail (% of dry biomass August to September).

	Cellulose	Hemicellulose	Lignin
Leaves			
<i>Saskatchewan (1979)</i>	20 to 29	24 to 36	15
<i>Minnesota (1980)</i>	31 to 33	19 to 20	-
<i>North Carolina (2009)</i>	28.7	23.4	10.1
Rhizomes			
<i>Saskatchewan</i>	10 to 21	-	-
<i>Minnesota</i>	22 to 40	-	-