Growing BioEnergy Opportunities in Canada

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REAP-Canada

- Providing leadership in the research and development of sustainable agricultural biofuels and bioenergy conversion systems for greenhouse gas mitigation
- 18 years of R & D on energy crops for liquid and solid biofuel applications
- Working in China, Philippines and West Africa on bioenergy and rural development projects

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Optimizing Bioenergy Development for Energy Security

To economically provide large amounts of renewable energy from biomass we must:

1. As efficiently as possible capture solar energy over a large area
2. Convert this captured energy as efficiently as possible into useful energy forms for energy consumers

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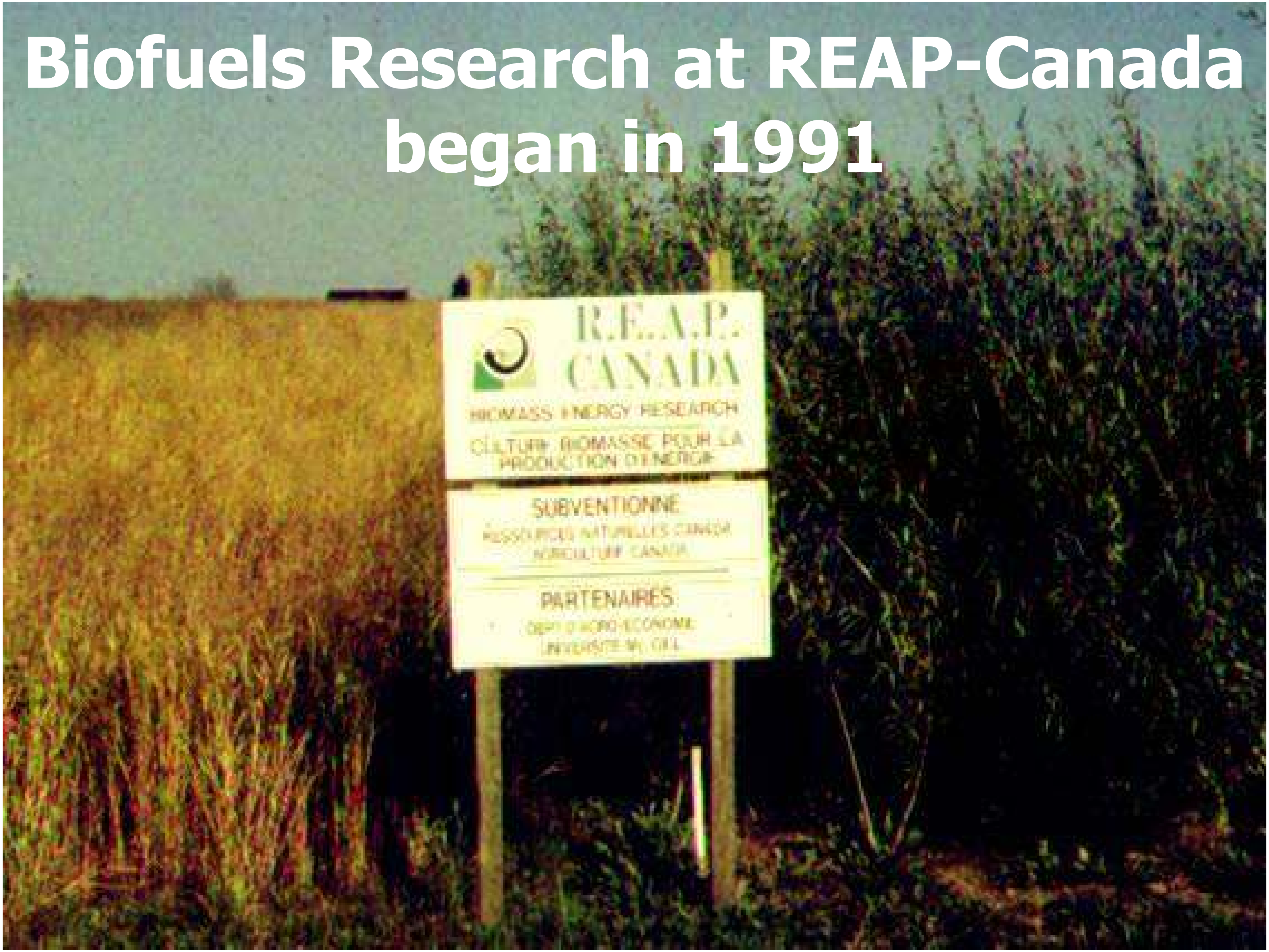
Biofuels Research at REAP-Canada began in 1991



Comparing C3 and C4 plants

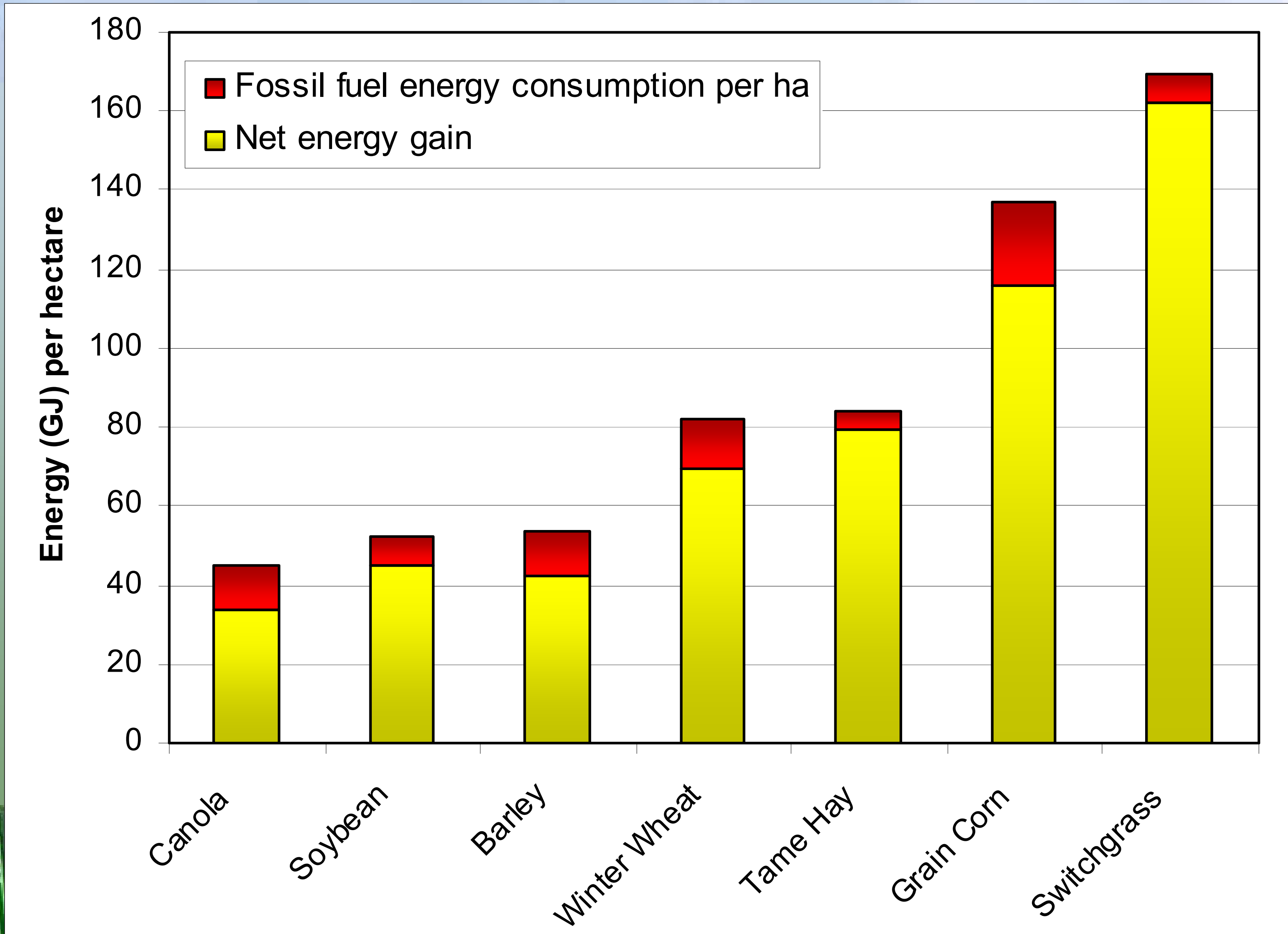
Cool season (C3) Plants

- Greater chilling tolerance
- Utilize solar radiation effectively in spring and fall

Warm season (C4) Plants

- Higher water use efficiency (typically 50% higher)
- Can utilize solar radiation 40% more efficiently under optimal conditions
- Improved biomass quality: lower ash and increased holocellulose and energy contents
- Responsive to warming climate

Solar Energy Collection and Fossil Fuel Energy Requirements of Ontario Crops/ha (Samson et al., 2005)



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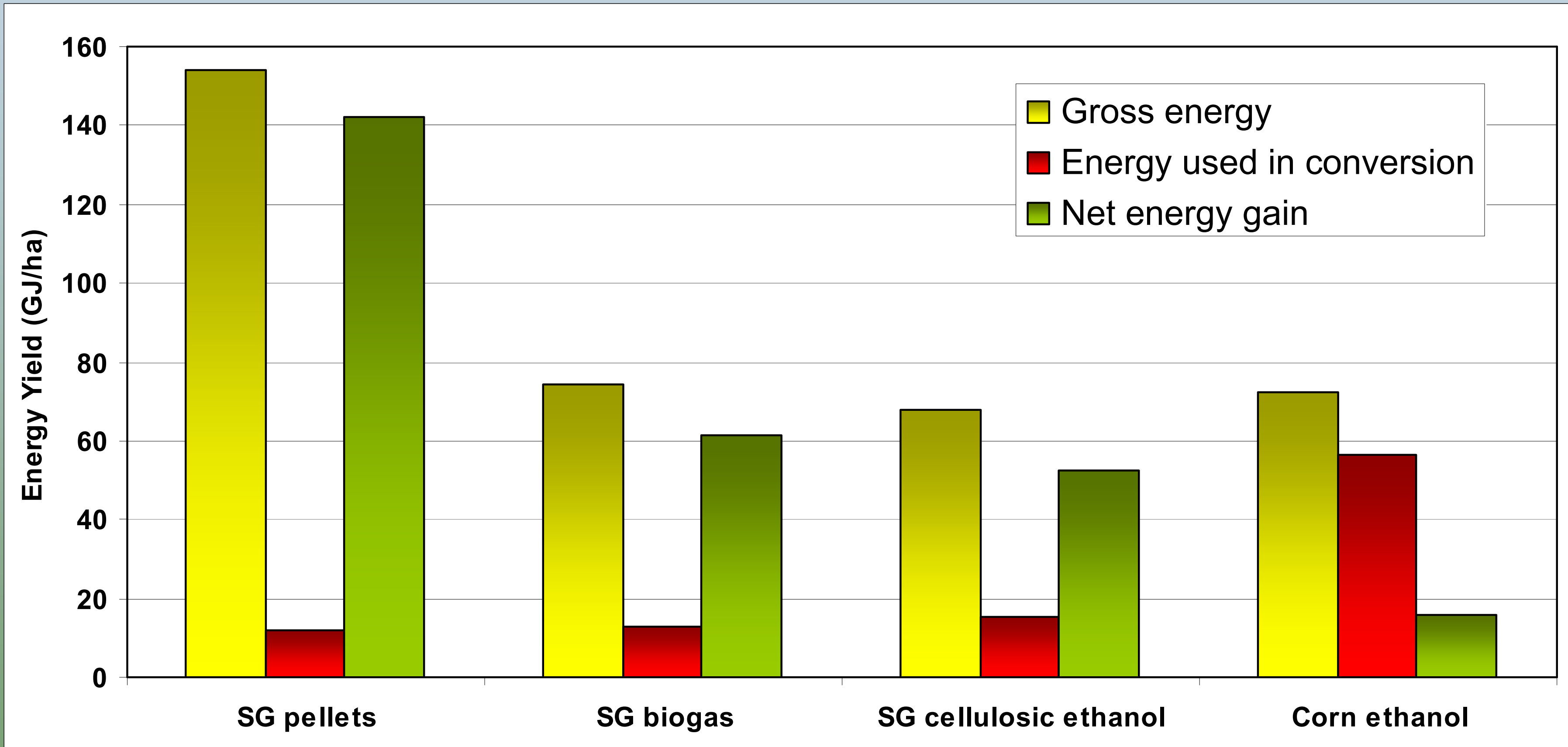
Thermodynamics of Switchgrass (SG) Energy Conversion Pathways



Samson et al., 2008

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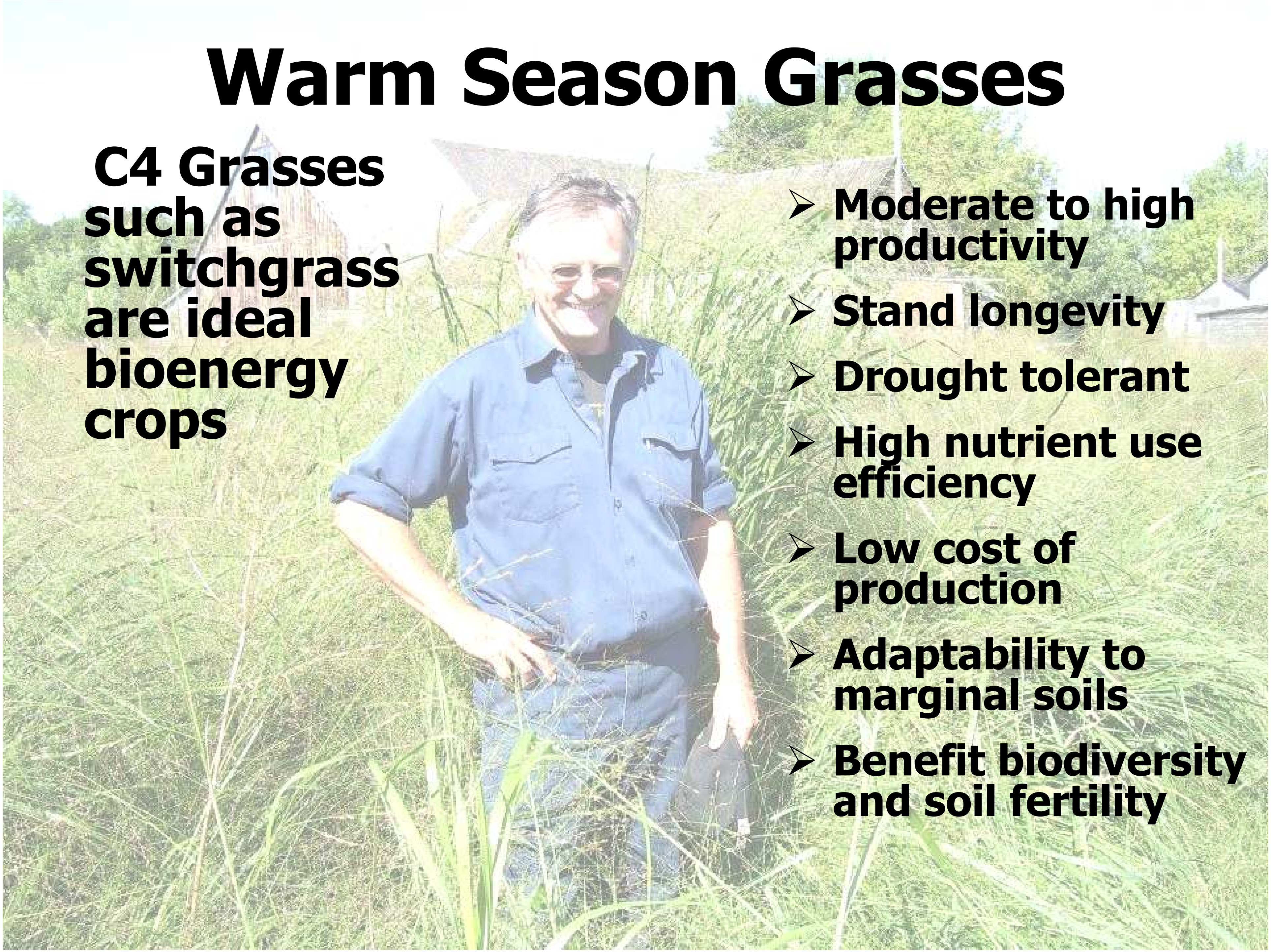
Sources of Agriculture Fuels for Combustion

- Field crop residues (soybean straw, rye straw, wheat straw, etc.)
- Feed grains (wheat, rye, barley etc.)
- Crop milling residues (oat hulls, wheat middlings, soybean hulls)
- Dedicated energy crops (warm season grasses)

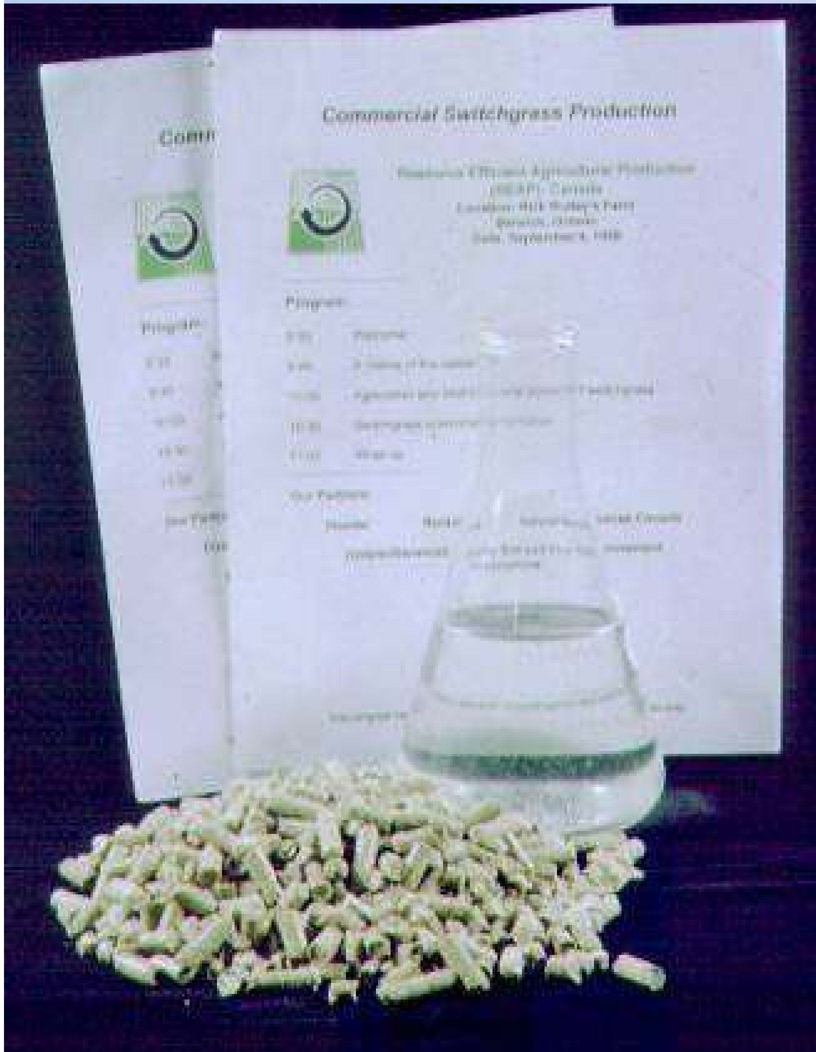
Warm Season Grasses



C4 Grasses such as switchgrass are ideal bioenergy crops

- Moderate to high productivity
- Stand longevity
- Drought tolerant
- High nutrient use efficiency
- Low cost of production
- Adaptability to marginal soils
- Benefit biodiversity and soil fertility

Switchgrass: a multi-use biomass crop



- Biofuel pellets and briquettes
- Biogas (CHP)
- Cellulosic ethanol
- Livestock bedding
- Paper
- “Straw bale” Housing

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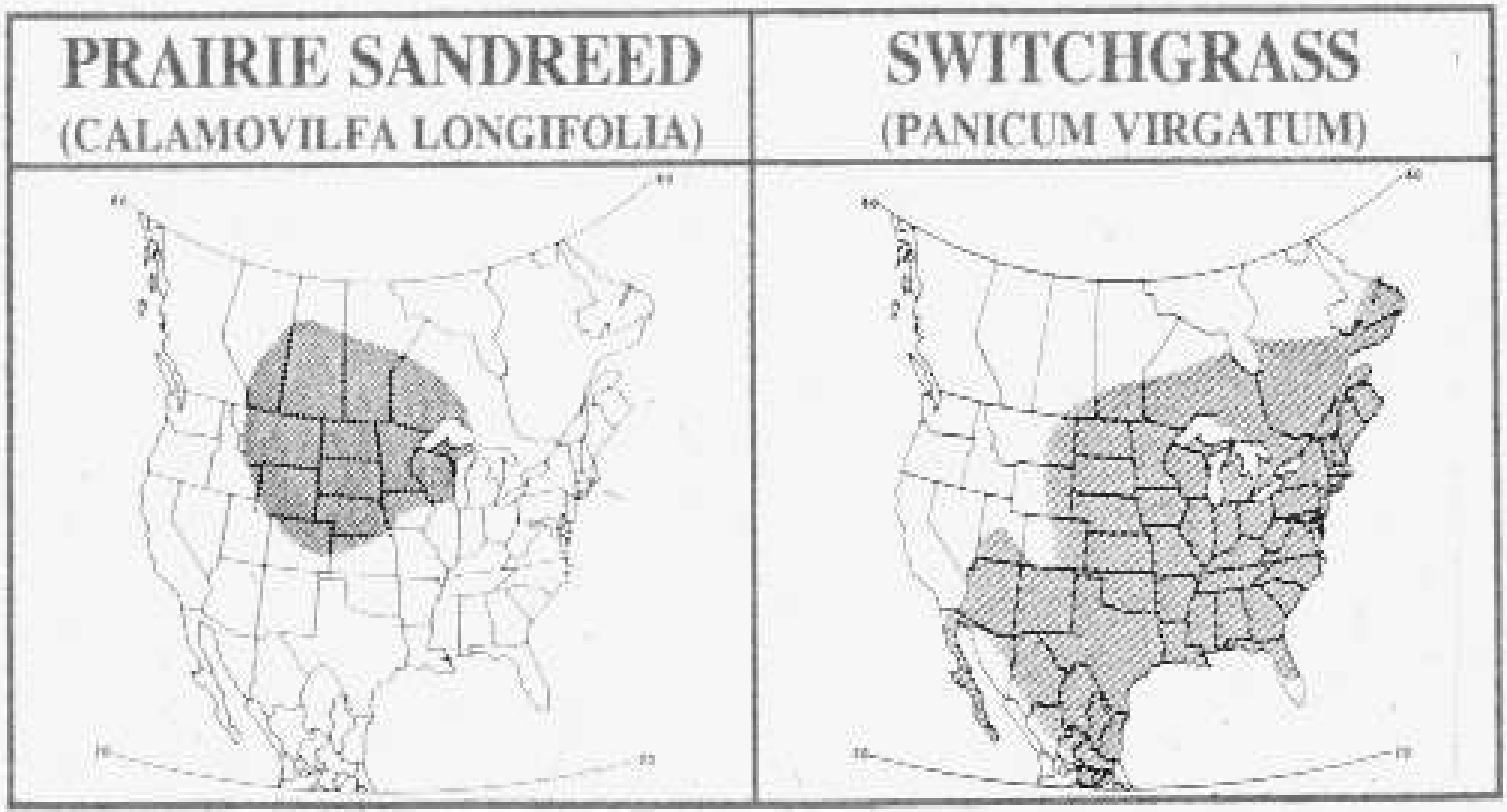
Native Range of Promising Warm Season Grass Biomass Feedstocks



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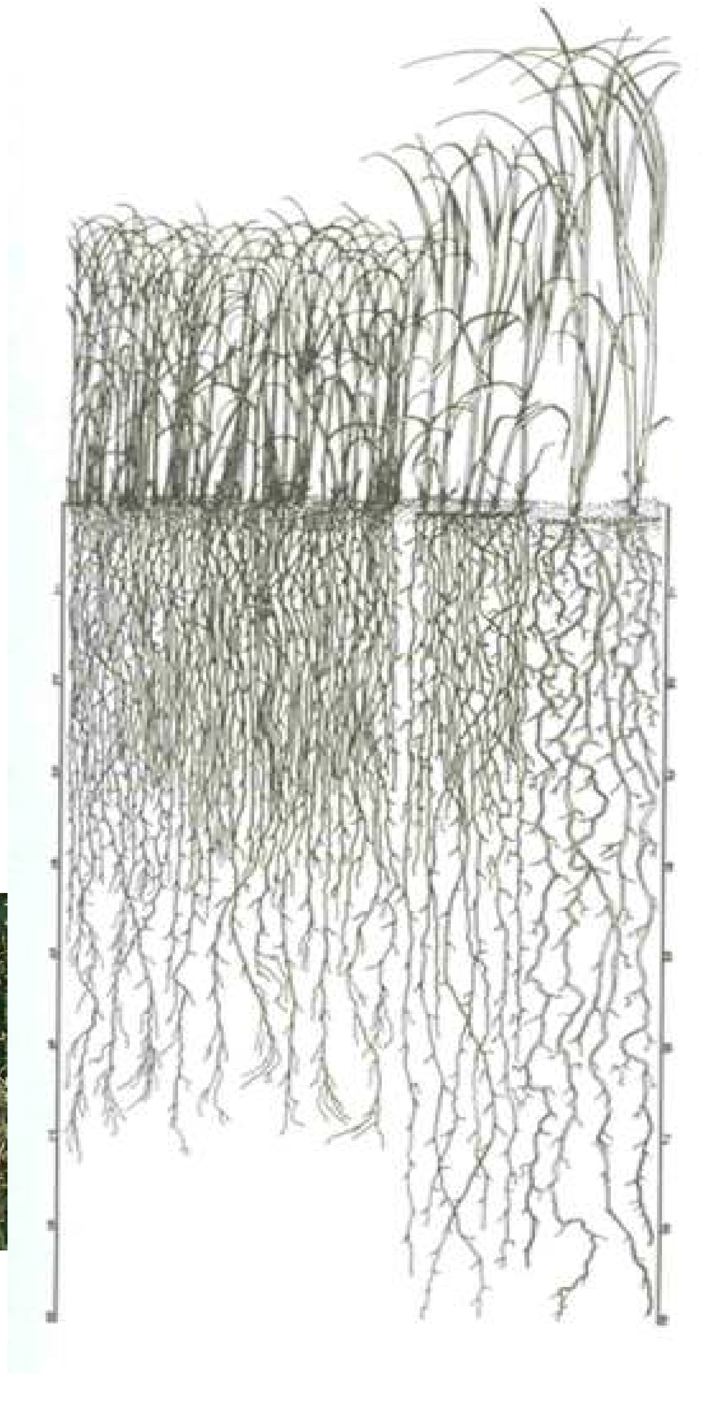
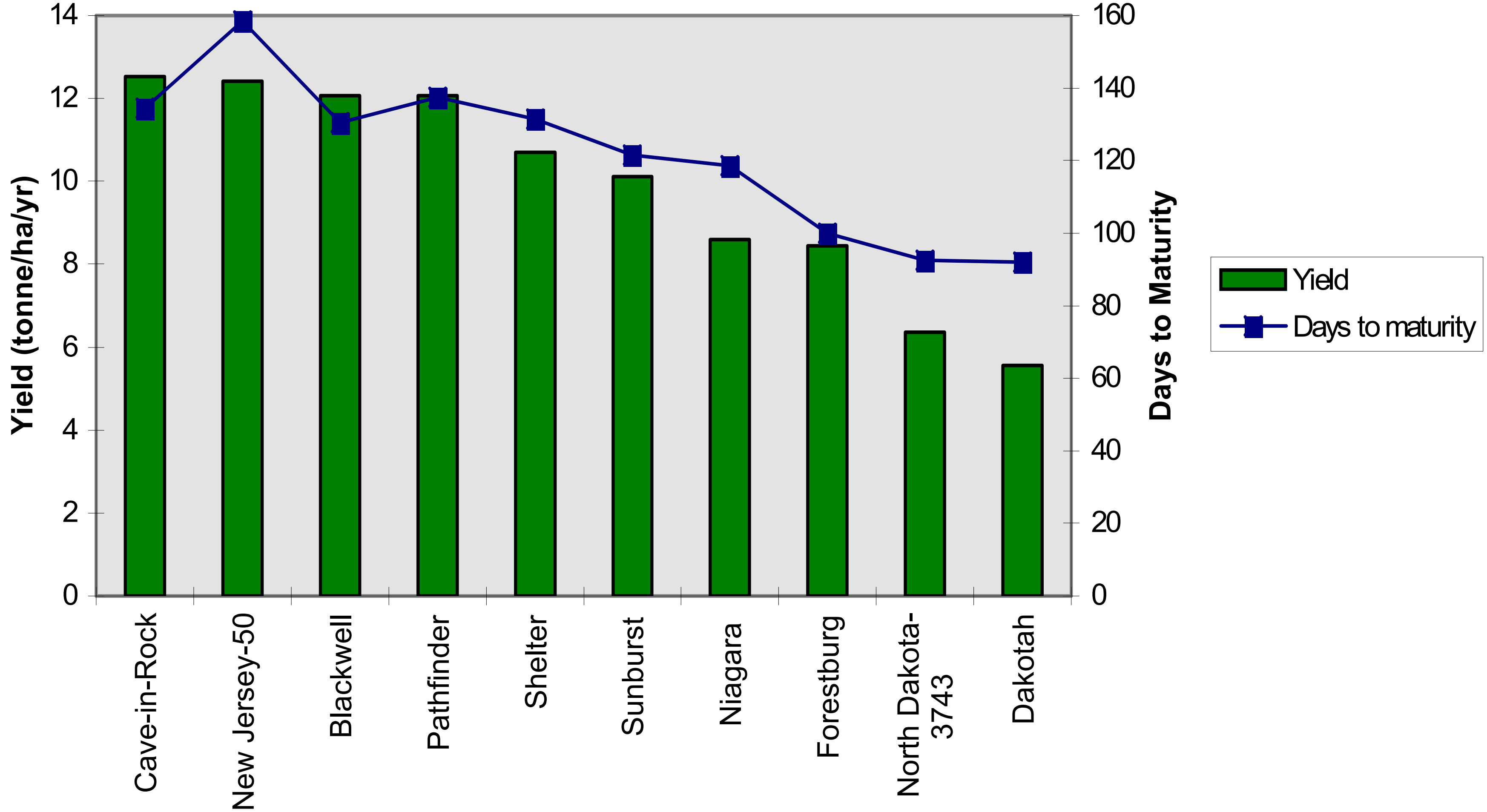
Switchgrass



Praire Cordgrass


Big Bluestem
in New York

Fall Yield of Switchgrass Cultivars at Ste. Anne de Bellevue, Quebec (1993-1996)



2009 Switchgrass Varieties for Canada

(guideline for hardiness and productivity)

Maturity	Days to Maturity	Cultivar name	Cultivar Origin (state, degree)	Corn Heat Unit (CHU) requirements
Very Early	95	Dakotah	N. Dakota (46)	2200
Early	100-105	Forestburg	S. Dakota (44)	2300
Mid	115-120	Sunburst Summer	S. Dakota (44) Nebraska (41)	2400
	125	Shelter	W. Virginia (40)	2500
Late	130	Cave in Rock	S. Illinois (38)	2600
Very Late	150	Carthage	N. Carolina (35)	2700

Northern lowland ecotypes (e.g. Kanlow) not fully tested in milder winter zones of Ontario but are hardy at Big Flats NY

SG Yield Data Comparison for Eastern Canada

Location	Cultivar Name	Days to Maturity	Yield (t/ha)
Harrington, PEI*	Trailblazer	130?	6.97
	REAP 922 (Blue Jacket)	120	7.25
Eastern ON, SW Quebec (3 locations)	REAP 922	120	8.9
	REAP 921(Tecumseh)	120	9.5

***Data from Agriculture and Agri-Food Canada (H. Tapani Kunelius, D. Lea, P. Boswall) based on 3yr means on a 2 cut system**

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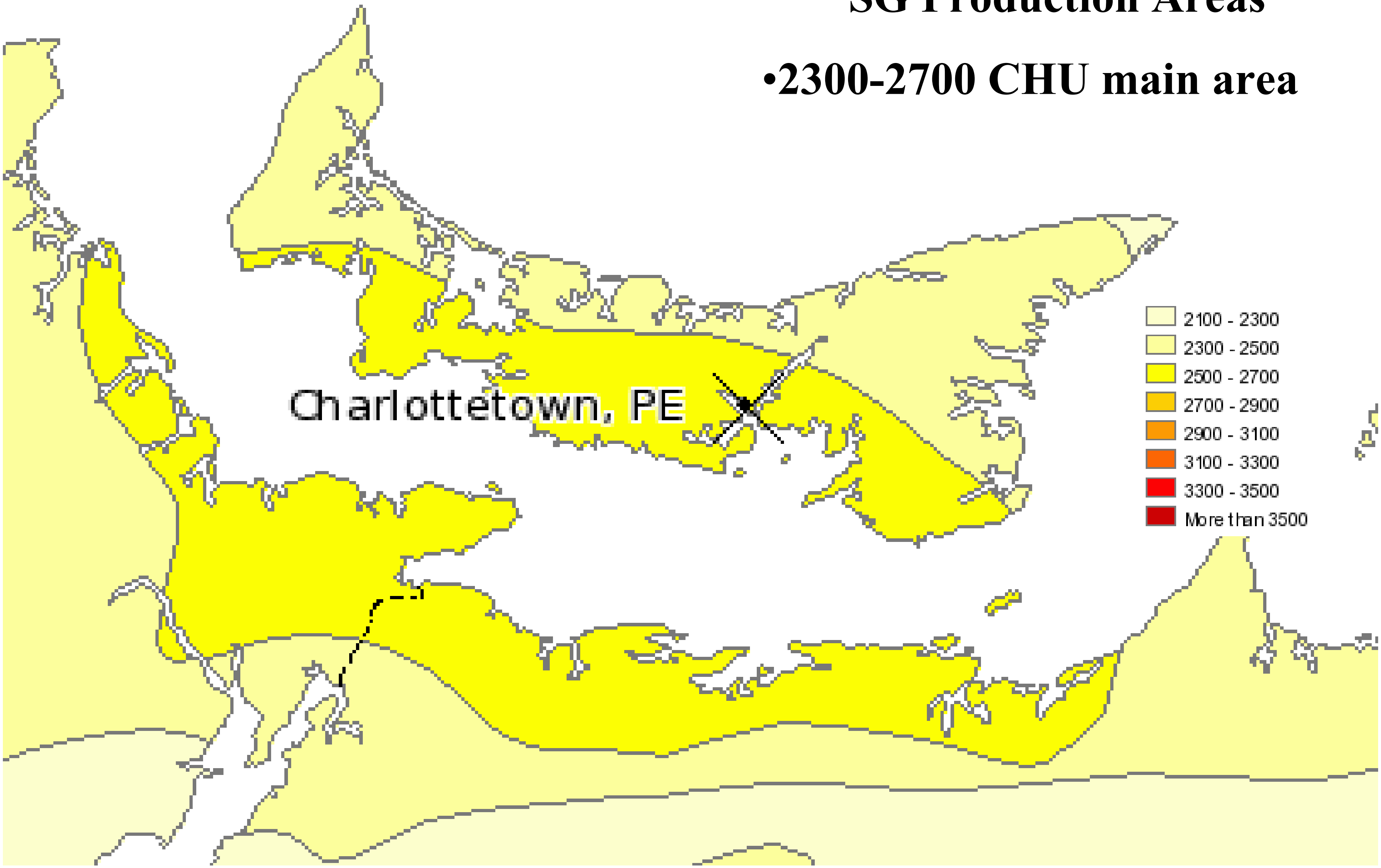
TECUMSEH SWITCHGRASS (115-120 days)

Identifying a Land Base

SG Production Areas

- **2300-2700 CHU main area**

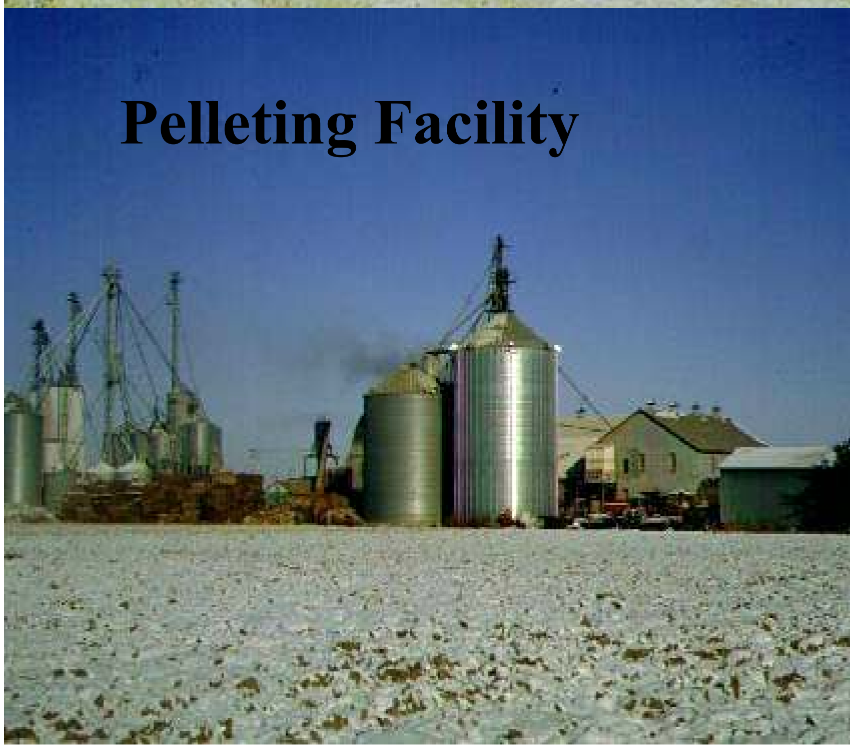


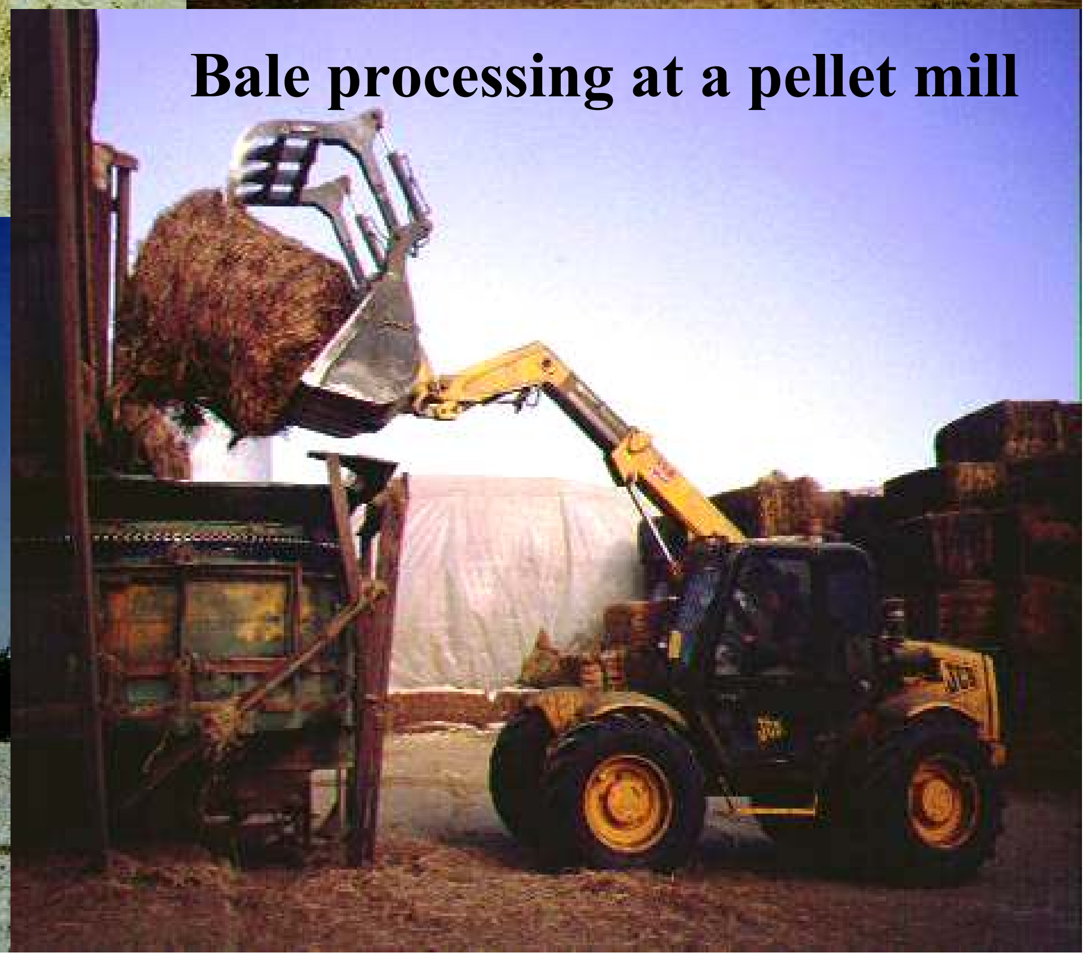
Switchgrass Management

- REAP SG Production guide
- Good site selection and weed control especially in northern locations, as you are mores susceptible to spring weed invasion in cool springs (i.e. quackgrass)
- Typically 50 kg N/ha and no P, K or lime
- Mow after senescence at 4” (10cm) to help ensure winter survival


Switchgrass Harvesting Operations


Bale Transport


Pelleting Facility


Bale processing at a pellet mill

Economics of Switchgrass Production in Ontario

Production Costs:

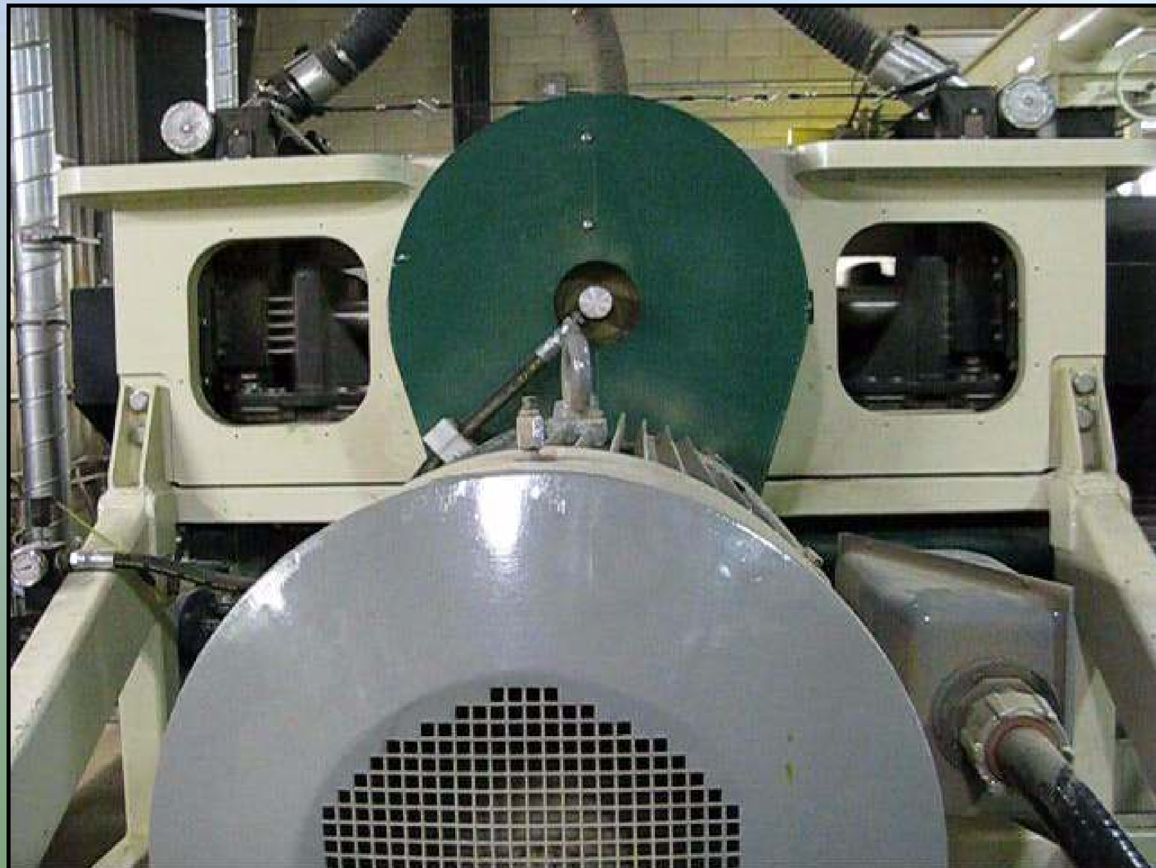
- Establishment-10%
- Land rental-40% (Variable 20%-40%)
- Crop maintenance-7%
- Harvest & delivery-43%

Spring Harvesting: $77-105/ODT

Reasons to Densify Herbaceous Biomass

- Convenient for handling and storage
- Increased energy density (smaller storage and combustion systems)
- Reduces fire risks
- More control over combustion
    - Higher efficiency
    - Lower particulate load

Energy Grass Densification



EkoFuel Technology 90 hp “Pellet mill”(2.5 T/h)

Developing Switchgrass Pellets for Energy

- Relatively easy crop to grow and produce into pellets for thermal energy
- Thermal energy from SG pellets is leading strategy to provide GHG offsets and energy security
- Main outstanding challenge has been how to burn without causing: 1) clinker and boiler corrosion, and 2) ambient air pollution

Residential Pellet Stove/Boiler

9kw Dellpoint Gasifier Pellet Stove

25kw Brandelle Biomass Pellet Boiler

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Grovewood Heat Boiler

75 KW heating a farm complex

Photo courtesy: Vince Court, President

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220 KW
Pelco Boiler
heating a 30,000
sq foot building
TOP Pelco TOP

Dekker Brand boilers

3 x 800 kw heating a 1.5ha greenhouse

Low aerosol forming pellets (i.e. low in K, Cl, Na and S) burn well and cleanly in multi-fuel coal/pellet boilers

Biomass Quality of Switchgrass vs. Wood Pellets and Wheat Straw

Unit	Wood pellets	Wheat straw	Switchgrass	
			Fall harvest	Overwintered Spring harvest
Energy (GJ/t)	20.3	18.6-18.8	18.2-18.8	19.1
Ash (%)	0.6	4.5	4.5-5.2	2.7-3.2
N (%)	0.30	0.70	0.46	0.33
K (%)	0.05	1.00	0.38-0.95	0.06
Cl (%)	0.01	0.19-0.51	n/a	n/a

Source: Samson *et al.*, 2005

Switchgrass Delayed Harvest Study

Location: 8 yr old Cave in Rock switchgrass field near Arnprior ~2650 CHU

Treatments: Fall mow & spring bale vs. spring mow & bale –side by side paired comparison with 6 reps

Main parameters assessed:

- Machine harvest yields, Unrecovered biomass residues, biomass quality changes

Fall Switchgrass Harvest


FALL
WINTER
SPRING

1. Fall Mow, Spring Bale

Mowed section was too wide for baler pickup so raking was used

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Fall Mowing: Biomass
losses were mainly a
result of raking losses in
dead furrows and wheel
tracks

2. Spring Mow & Bale

No raking was employed but shattering losses occurred during mowing which could not be harvested by baler

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Machine Harvested Recovered Yields

Treatment	Yield (ODT/ha)	Moisture Content (%)
Fall mow & spring bale	6.57*	6.0
Spring mow & bale	5.44	7.8

*Significantly different ($p<0.05$)

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Biomass Quality

Parameter	Control (Fall 2006)	1. Fall mow & spring bale	2. Spring mow & bale
Energy (GJ/t)	18.6	18.7	18.8
Ash (%)	4.63	5.20	4.30
N (%)	0.47	0.39	0.38
P (%)	0.08	0.05	0.04
K (%)	0.33	0.11	0.10

No major quality differences between fall and spring mowing. Main quality change was ~70% reduction in potassium from fall 2006 composite which was 0.33%K

Fall Mow & Spring Bale Advantages

- Reduction in switchgrass breakage over winter by season windstorms
- Promotes earlier soil warming (~2.8°C) and rapid early season re-growth
- No drying required prior to pelleting (~7% m.c.)
- Higher overall recovery of biomass than spring mowing & harvesting
- Improved biomass combustion quality
- Seems easier to pellet compared to fall harvested

Biofuel Options

Sector	Traditional Fuel		Alternative Fuel
Transportation	Gasoline	→	Ethanol
	Diesel	→	Biodiesel
Electrical Power	Coal Natural gas	→	Wind energy Straw pellets Biogas
Heating	Coal Natural gas LNG	→	Switchgrass/Wood pellets

LNG-liquefied natural gas

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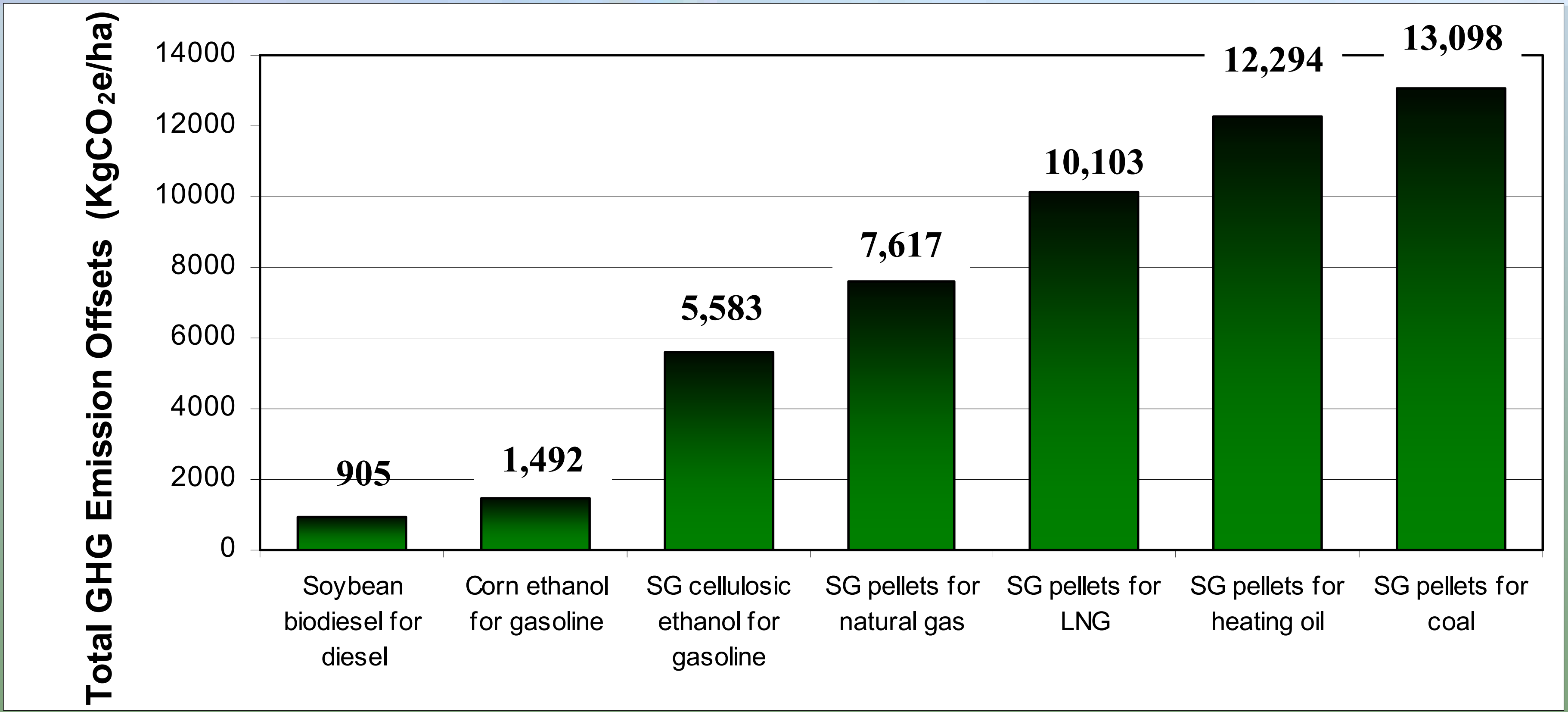
Heat Generation GHG Offsets

Fossil Fuel		Renewable Fuel		Net offset (%)
	kg CO_2e/GJ		kg CO_2e/GJ	
Coal	93.4	Switchgrass pellets	8.2	91
LNG	87.9	Switchgrass pellets	8.2	90
Natural gas	61.6	Switchgrass pellets	8.2	87

Samson and Bailey Stamler, 2009

GHG Offsets From Ontario Farmland Using Biofuels



SG= switchgrass; LNG= liquified natural gas

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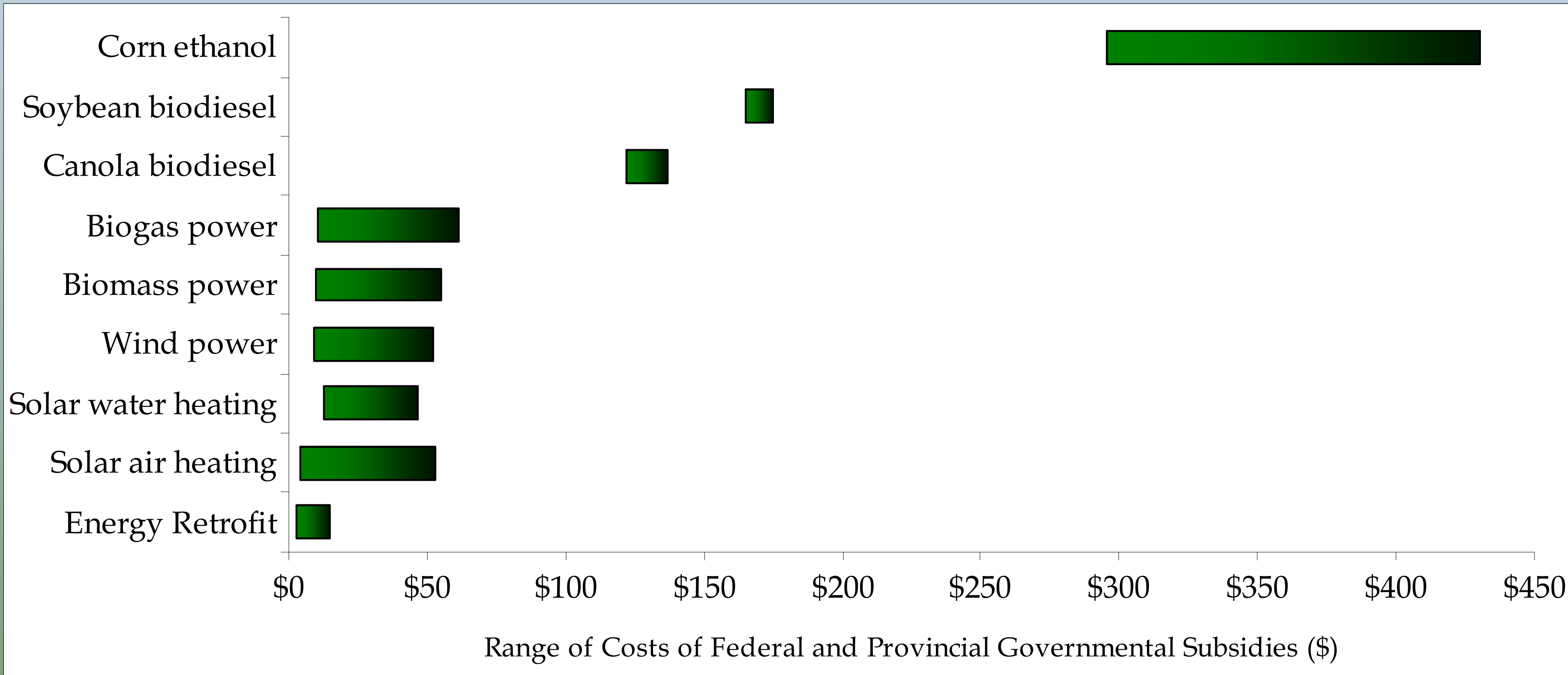
Costs required to offset 1 tonne CO_2e with current Provincial & Federal Incentives



Currently no incentives for SG or Wood pellets

Samson and Bailey Stamler, 2009

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Summary and Conclusions

- Warm season grasses represent the most resource efficient way to capture solar energy through crop production
- WSG biomass quality for combustion can be improved through cultural management and breeding
- Biggest emerging application is thermal energy to replace coal, natural gas and LNG

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Summary (Continued)

- There are no technical barriers to develop the grass pellet industry
- There is a need for renewable energy subsidy reform to enable the most efficient renewable energy technologies to emerge

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Thank You!

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