An Invitation To Success: Growing Grass for Fuel Pellets

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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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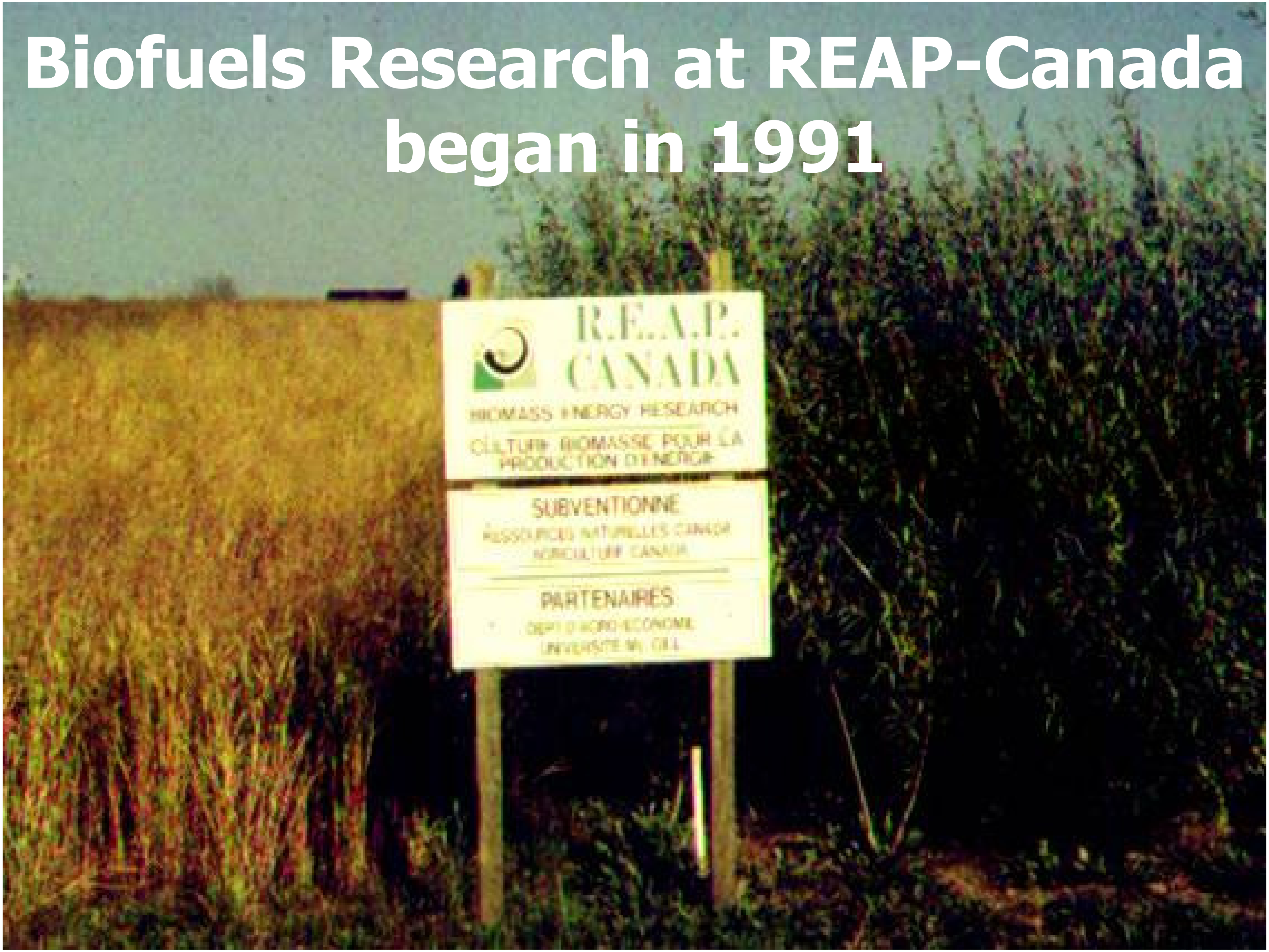
Biofuels Research at REAP-Canada began in 1991



Comparing C3 and C4 plants

Cool season (C3) Plants

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

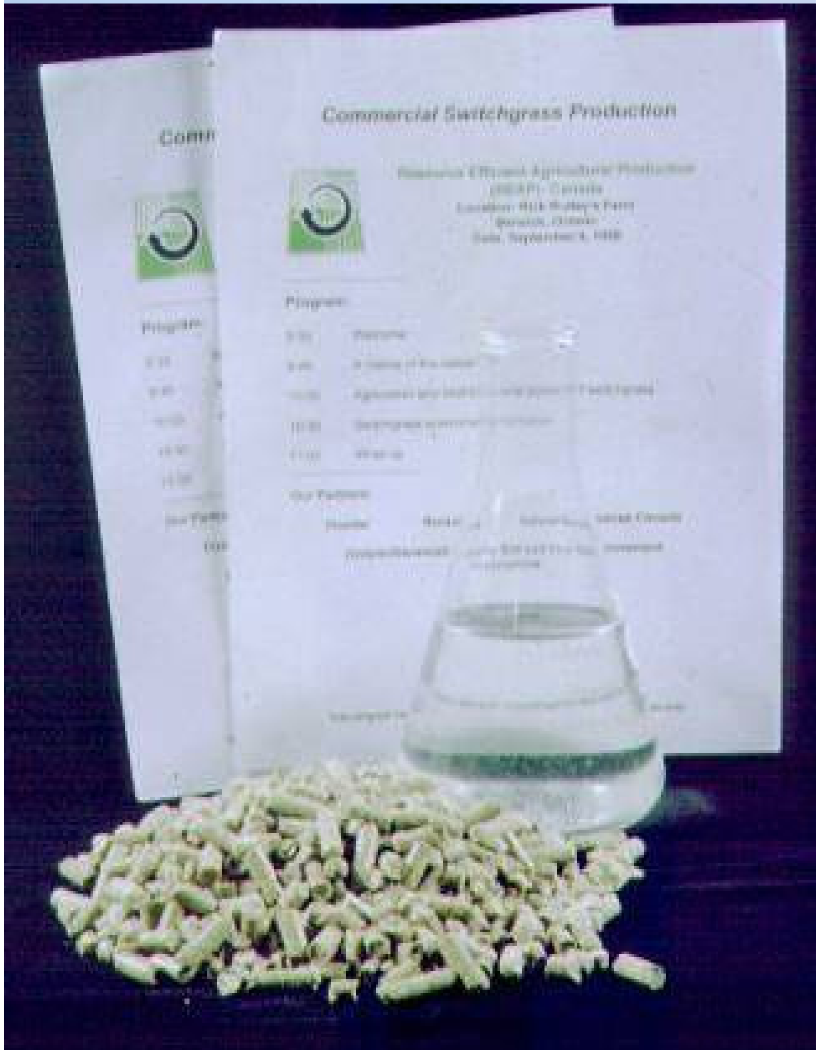
Warm season (C4) Plants

- 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

Warm Season Grasses

C4 Grasses such as switchgrass are ideal bioenergy crops because of their moderate to high productivity, stand longevity, high moisture and nutrient use efficiency, low cost of production and adaptability to marginal soils.

Switchgrass: a multi-use biomass crop



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

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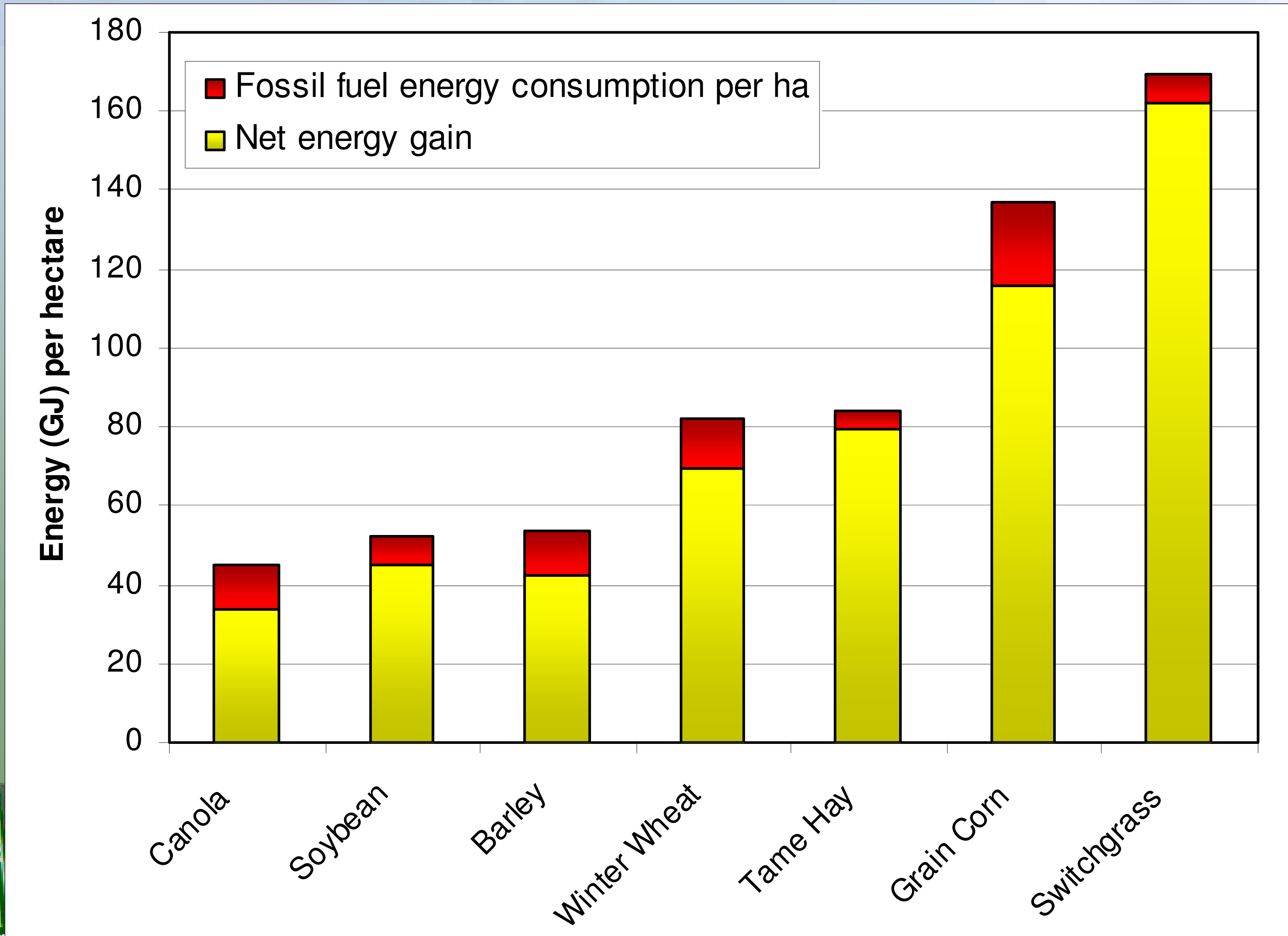
Solar Energy Capture and Net Energy Gain of Ontario Field Crops (Samson et al., 2008)



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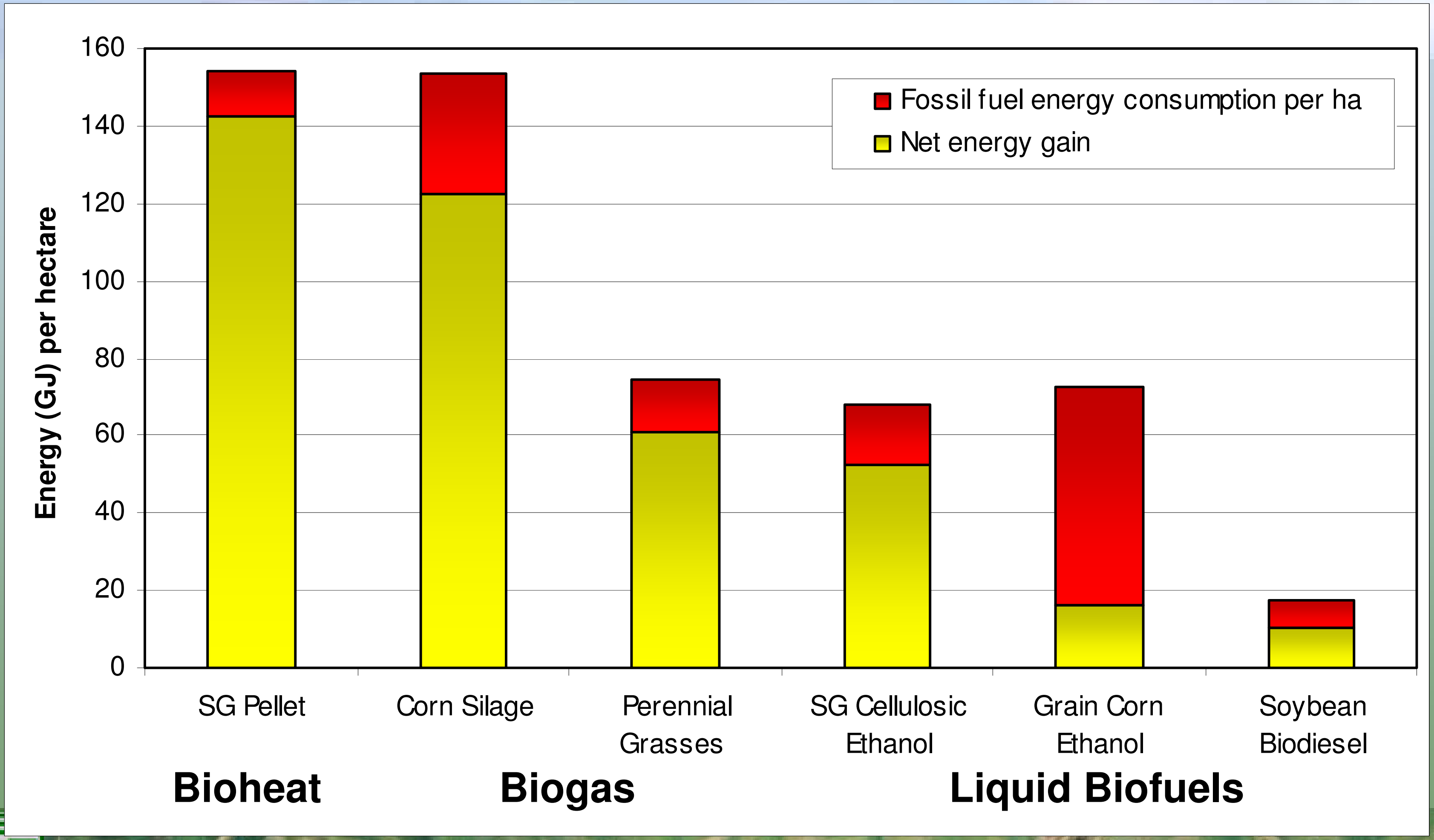
Harvesting Energy from Ontario Farmland for Biofuel Applications (Samson et al., 2008)



SG=Switchgrass

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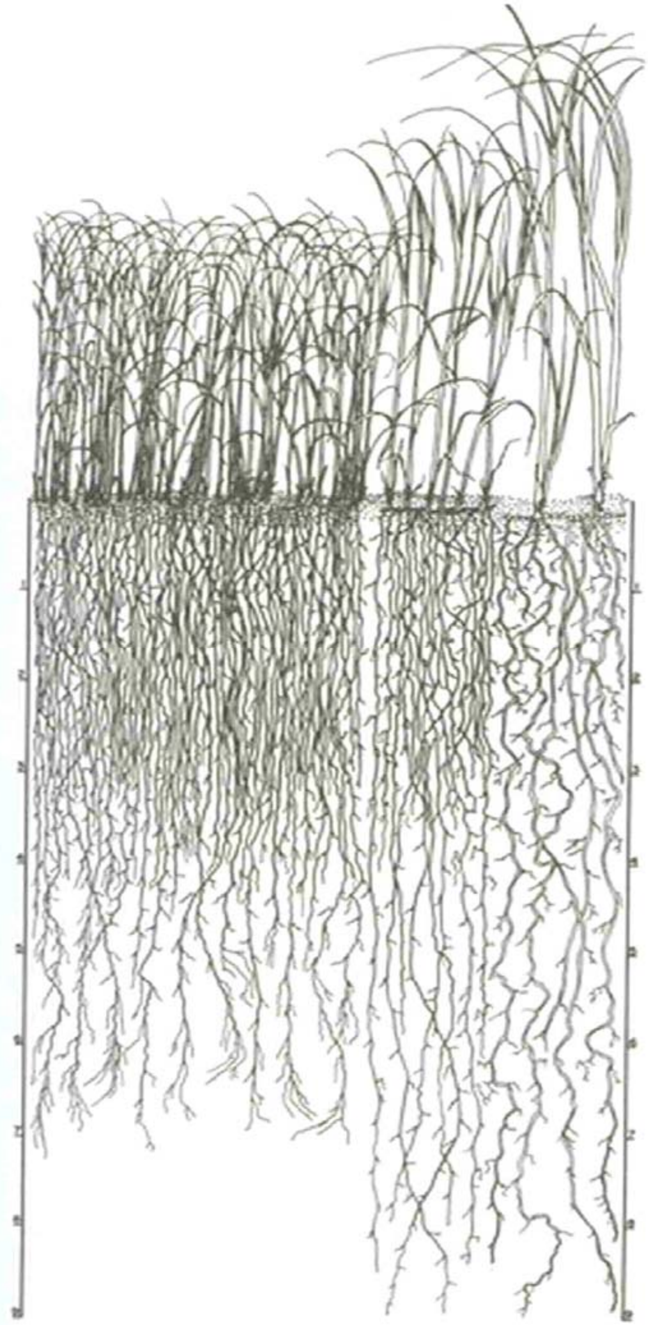
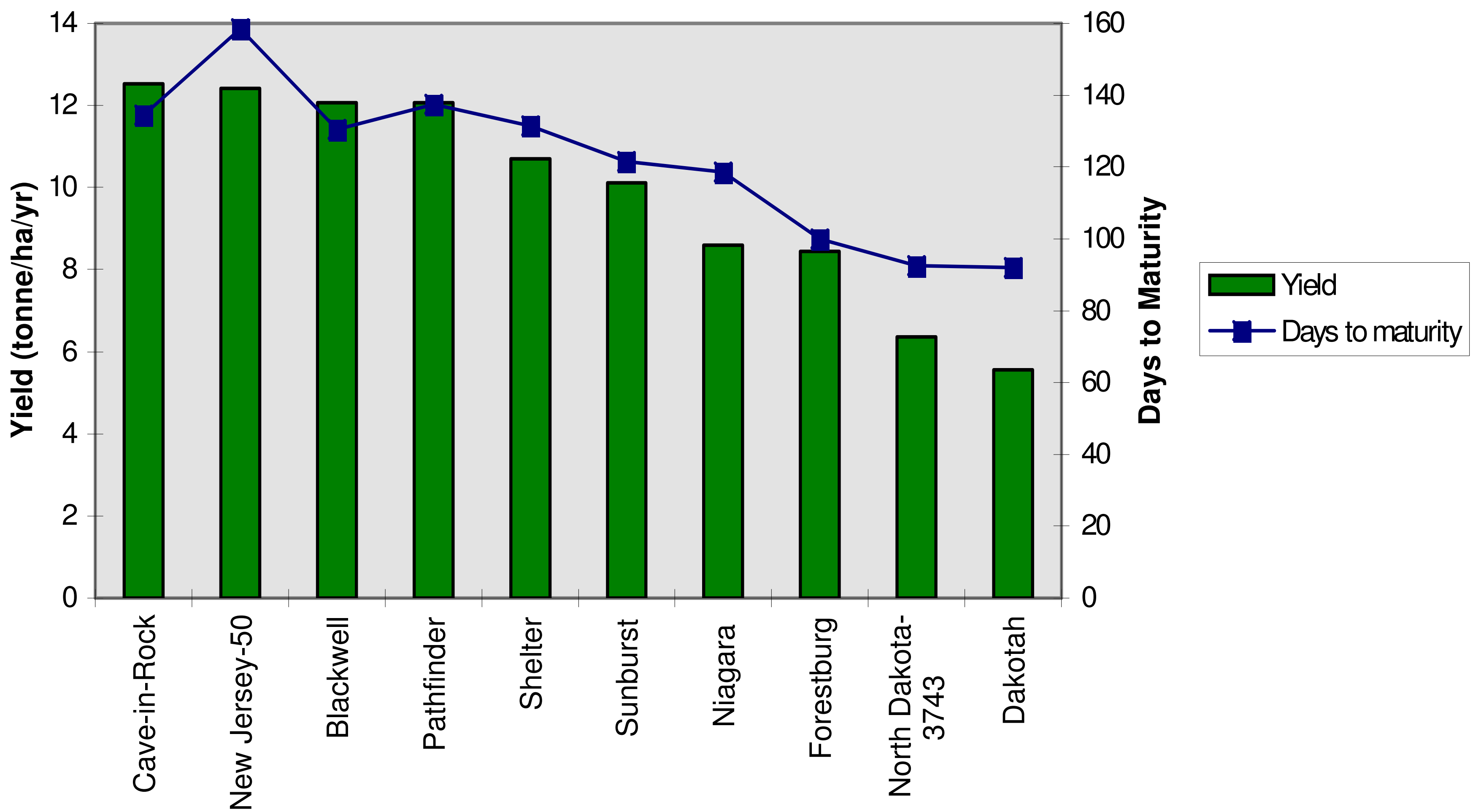
Switchgrass

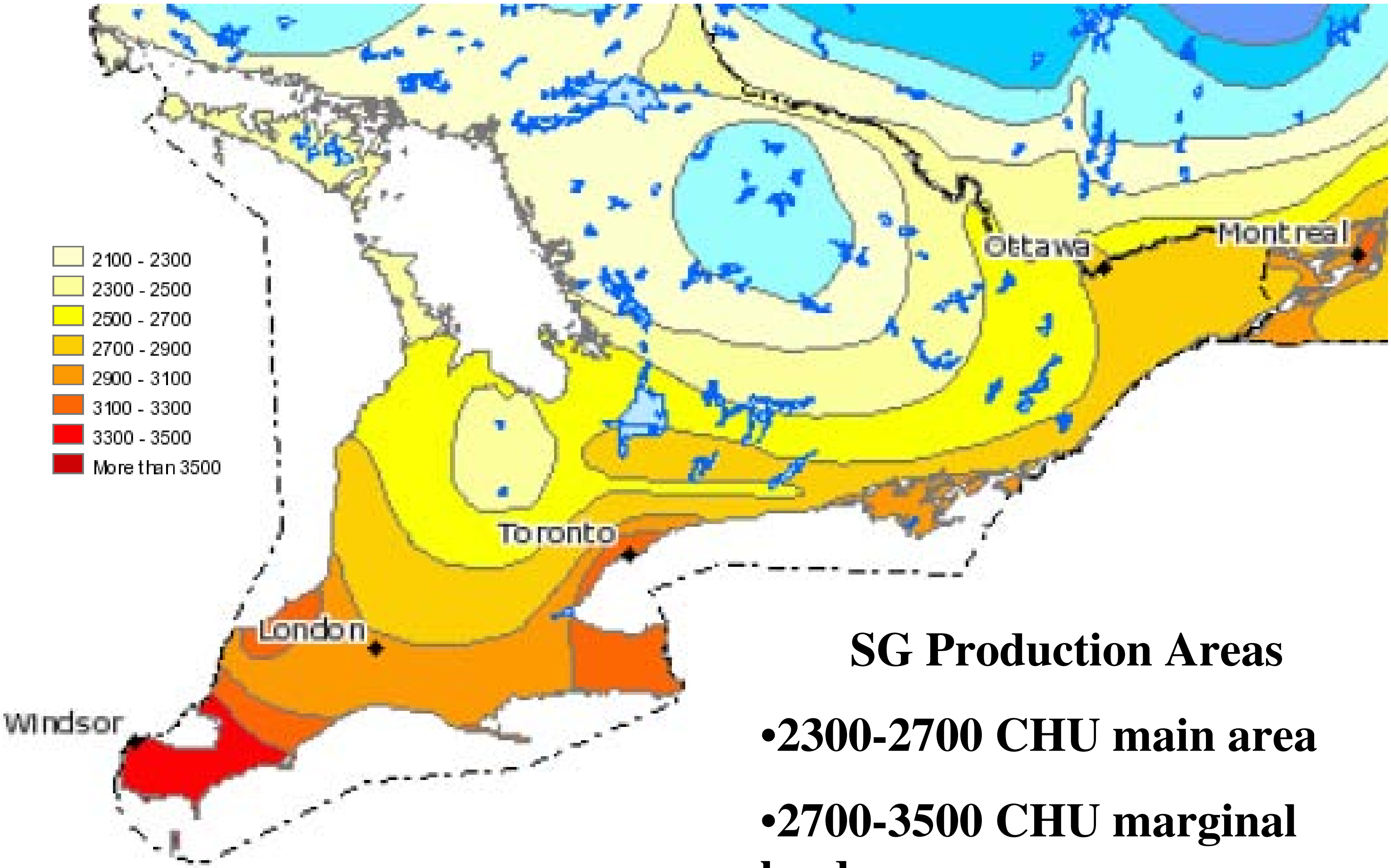


Praire Cordgrass

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



Identifying a Land Base



SG Production Areas

- **2300-2700 CHU main area**
- **2700-3500 CHU marginal lands**

Switchgrass Varieties Options for Atlantic 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, Bluejacket Tecumseh	S. Dakota (44) (bred from Sunburst) (bred from Summer)	2400
	125	Shelter, Summer	W. Virginia (40) Nebraska (41)	2500
Late	135	Cave in Rock	S. Illinois (38)	2600


TECUMSEH SWITCHGRASS (115-120 days)
% Yield of sunburst on sandy soils in E.Ont and SW. QC.


Big Bluestem

WSG Biomass Quality and Combustion

Problem:

- Main historic barrier with grasses has been high potassium (K) & chlorine (Cl)
- Causes clinker (agglomeration) problems and corrosion in boilers

Solution

- Use warm season grasses under delayed harvest management to leach chemicals
- Use advanced boiler & stove technology

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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

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Delayed Harvest Cause Important Losses

- SG Research in Quebec (Girouard and Samson 1997) and Pennsylvania (Adler *et al.,* 2006) indicated recovered spring biomass is 46% and 49% of fall biomass using a mower conditioner and baling system

Losses come from:

- Loss of cell solubles (~7-10%)
- Field breakage (~20-25%)
- Harvest system losses (~20-25%)

Where Are We Primarily Losing Biomass Through Overwintering?

Botanical Component	Fall yield (kg/ha)	Spring yield (kg/ha)	Net loss (kg/ha)	Net loss (%)
Head	1,363	364	999	73%
Leaf	2,725	924	1,801	66%
Leaf sheath	1,613	1,253	360	22%
Stem	5,199	4,459	740	14%
Total	**10,900**	**7,000**	**3,900**	**36%**

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Fall Switchgrass Harvest

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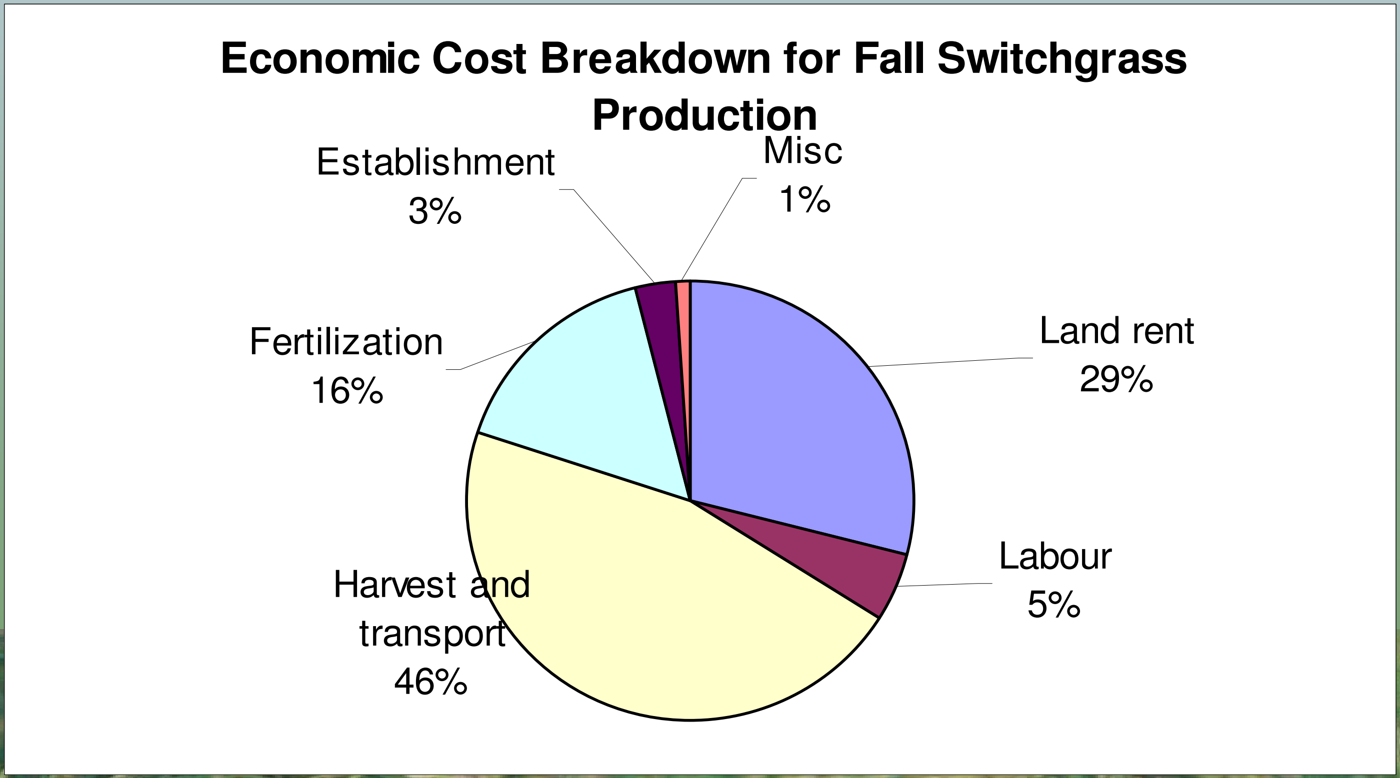
FALL
WINTER
SPRING

Economics of Switchgrass Production in Eastern Canada

- Present delivered cost for spring harvest ~$80-$100/tonne



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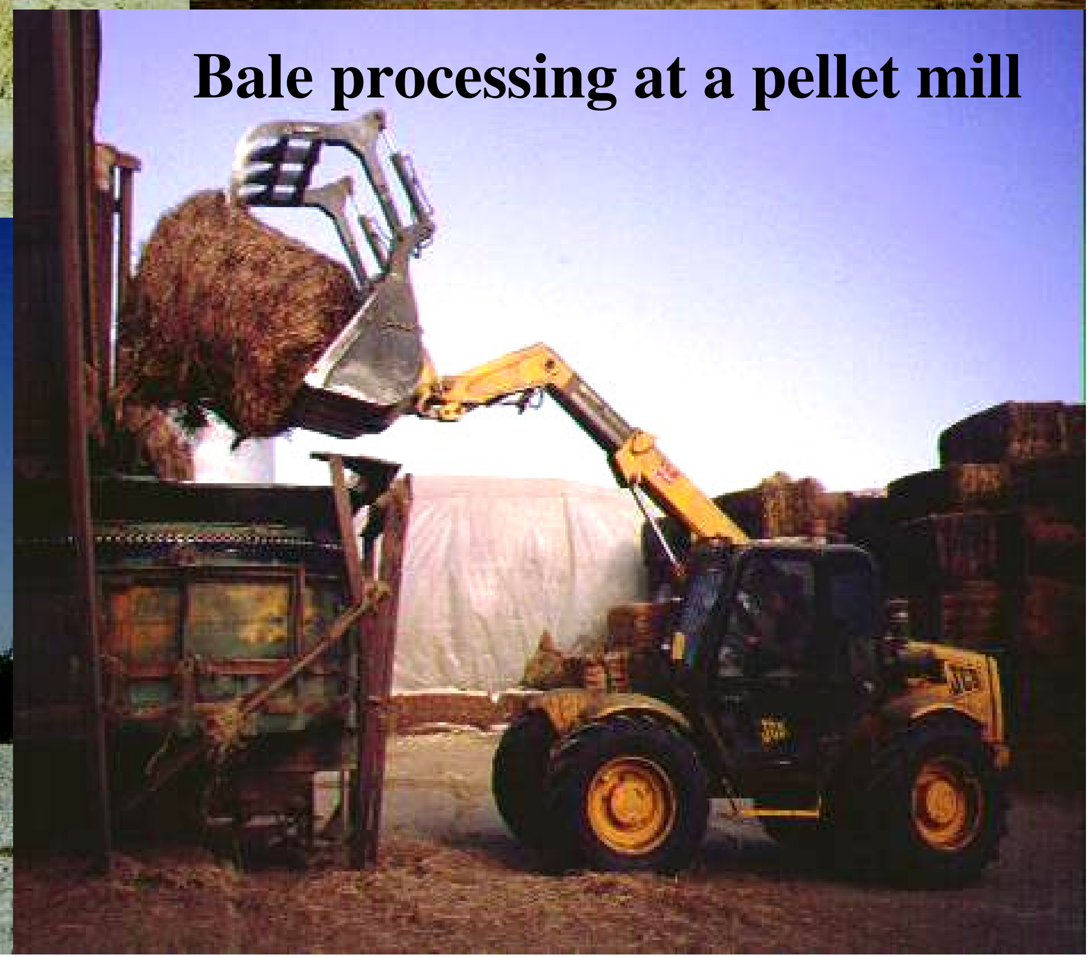
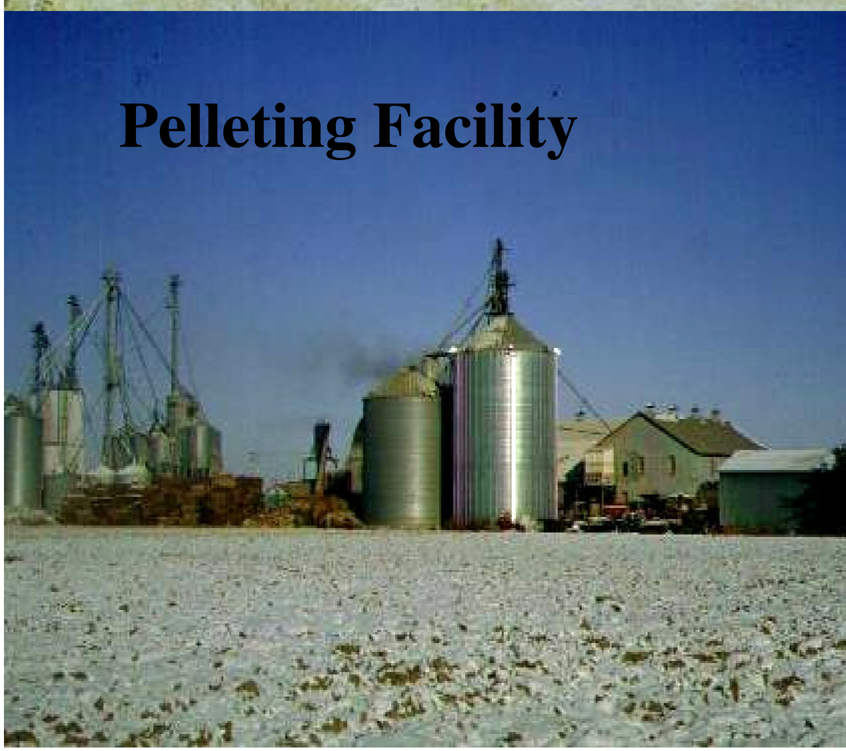
Switchgrass Harvesting
Operations


Bale Transport


Bale processing at a pellet mill


Pelleting Facility

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 process
  - Higher efficiency
  - Lower particulate load

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Producing Rural Energy in Eastern Canada at $ 7-8/GJ

- Energy grasses grown for $85/tonne or $4.75/GJ
- Densification at $40/tonne or $2.25/GJ
- On-farm fuel at $125/tonne or $7.00/GJ (range ~ $125-$150)
- Commercial Pellets ~$150-$160/tonne
- Residential Pellets ~$225-250/tonne


Dekker Brand
3 x 800 kw boilers


Pelco Boiler
35 kw?
TOP Pelco TOP

75 KW Boiler
Grovewood Heat

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Can we make a wood pellet substitute from grass?

- Need to keep stems somewhat thin (3.5- 5 mm thick and stem wall (0.7mm thick)
  (thick stems like miscanthus problematic for aerosol pollution)
- Cultivate on sandy soils (have lower silicic acid content than clay soils which makes lower ash fuels)
- Increase stem fraction through breeding and species choice
- Separate stems from leaves through air fractionation

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Ash and Energy Content of Overwintered Switchgrass

Plant Component	Ash Content	Energy Content (GJ/ODT)
Stems	1.03%	19.6
Seed Heads	2.38%	19.5
Leaf Sheaths	3.07%	18.7
Leaves	6.98%	18.4

***Overall weighted SG average ash content of 2.75% and 3.25% on sandy and clay sites respectively**

Impact of Soils on Ash Content

Studies with reed canarygrass in Sweden (Pahkala et al 1996) found ash contents of:

- Sandy soils 1.3%
- Organic soils 1.9%
- Clay soils 4.9%

In eastern Canada spring harvested whole plant switchgrass 2.75% & 3.21% ash on sandy loam and clay soils respectively (Samson et al 1999)

Clay soils have higher monosilicic acid content than sandy soils which result in more silica uptake into plants creating higher ash fuels

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Big Bluestem: a lower ash pellet than switchgrass?

Big Bluestem	Switchgrass
Native ecovars 60% stem	Native ecovars 45-50% stem

How close are grass stems to wood residues as pellet feedstocks?

Quality parameter	Wood residues	Switchgrass Stems	Difference
Energy	20.3 GJ/t	19.55 GJ/t	-3.7%
Ash	0.6%	1.03%	+72%

Will homeowners be content with a 1% ash pellet that doesn't clinker?

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

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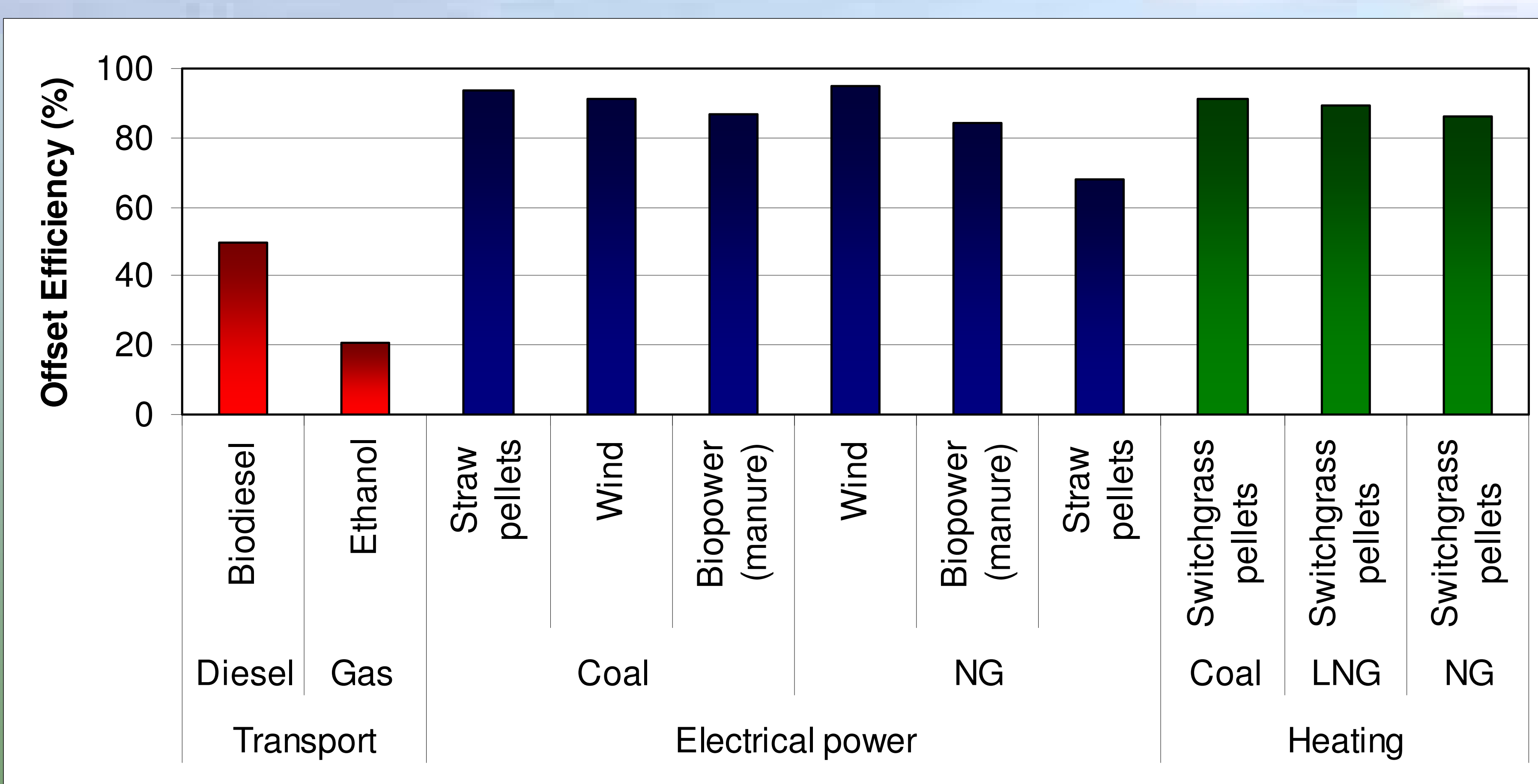
Samson and Bailey Stamler, 2009

Offset Efficiency of Biofuel Options (Samson et al 2008)



NG-natural gas; LNG-liquefied natural gas

Samson et al. 2008

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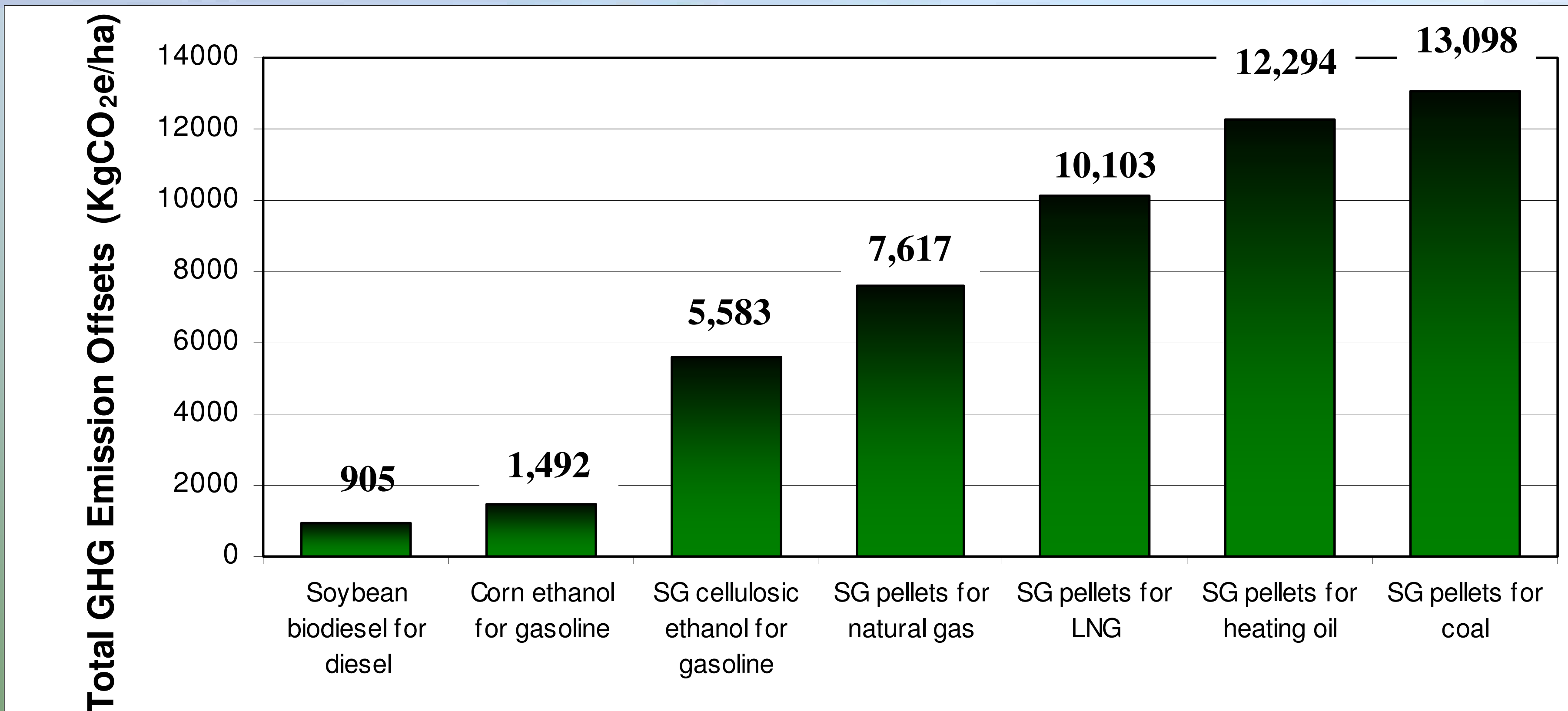
GHG Offsets From Ontario Farmland Using Biofuels



SG= switchgrass; LNG= liquified natural gas

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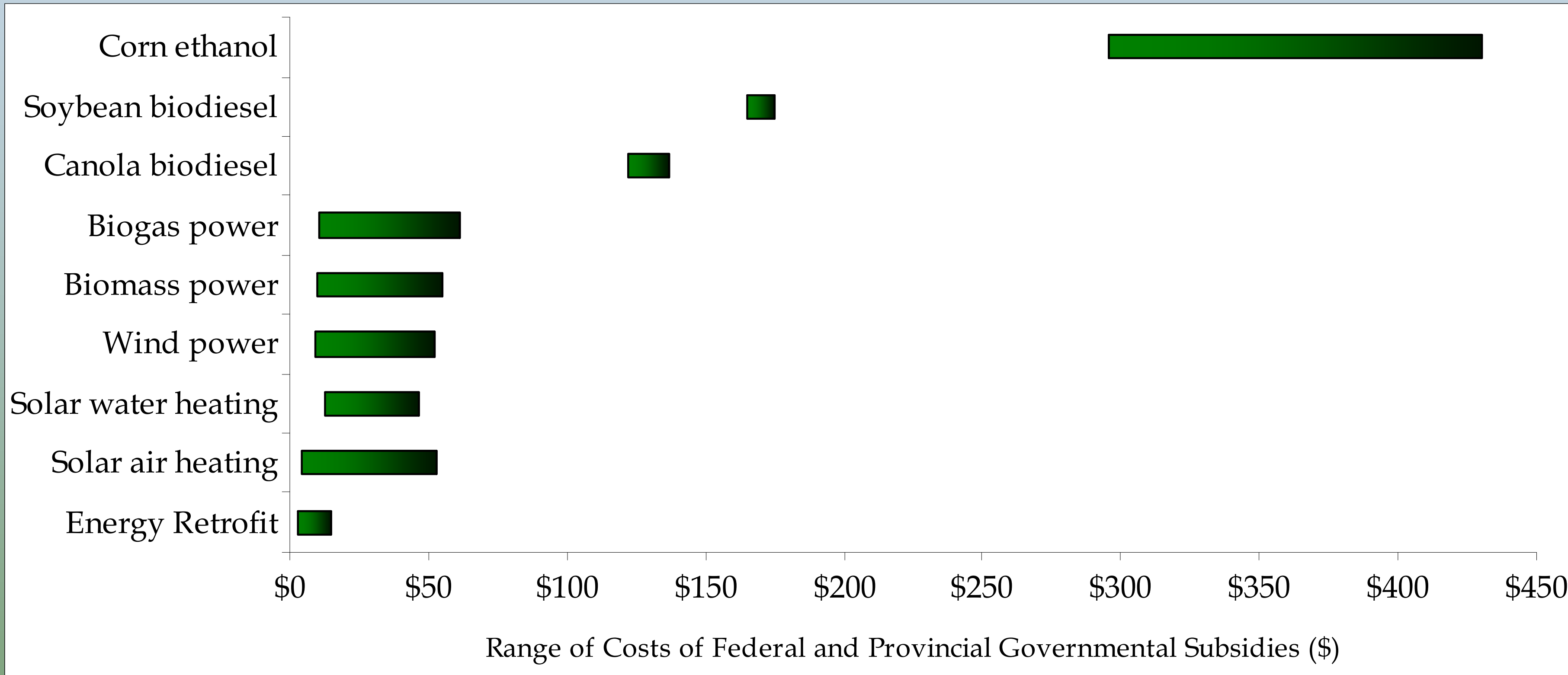
Costs required to offset 1 tonne CO_2e with Provincial & Federal Incentives in Canada



Note: No subsidies exist for pellets, a $2/GJ subsidy would cost about $25-$40/tonne CO_2 avoided

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Samson and Bailey Stamler, 2009

Summary and Conclusions

- Warm season grasses represent the most resource efficient way to capture solar energy through crop production
- WSG biomass quality for combustion is superior to other agri-fibre fuels
- There are no significant technical barriers to develop the grass pellet industry in Canada

Summary (Continued)

- Without subsidy the most likely market to emerge is in small boilers and stoves as a wood pellet replacement (or supplement)

- With political leadership to create subsidy reforms grass pellets will become a major success story for renewable energy and rural development

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Thank You!

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