Strategies for Improving Yield & Quality in Warm Season Grasses

Roger Samson and Stephanie Bailey Stamler
Resource Efficient Agricultural Production (REAP)-Canada
Ste Anne de Bellevue, Quebec
rsamson@reap-canada.com

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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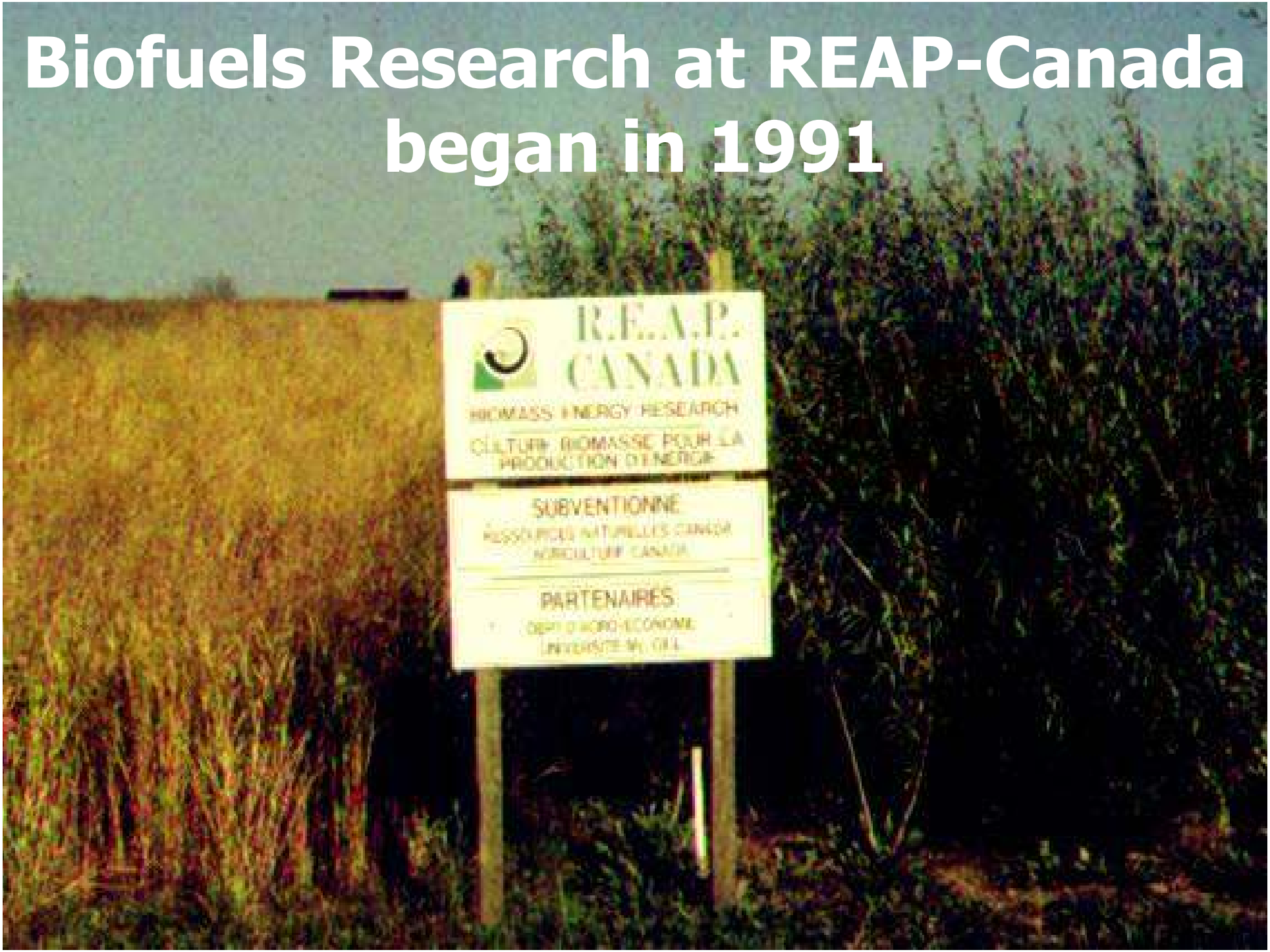
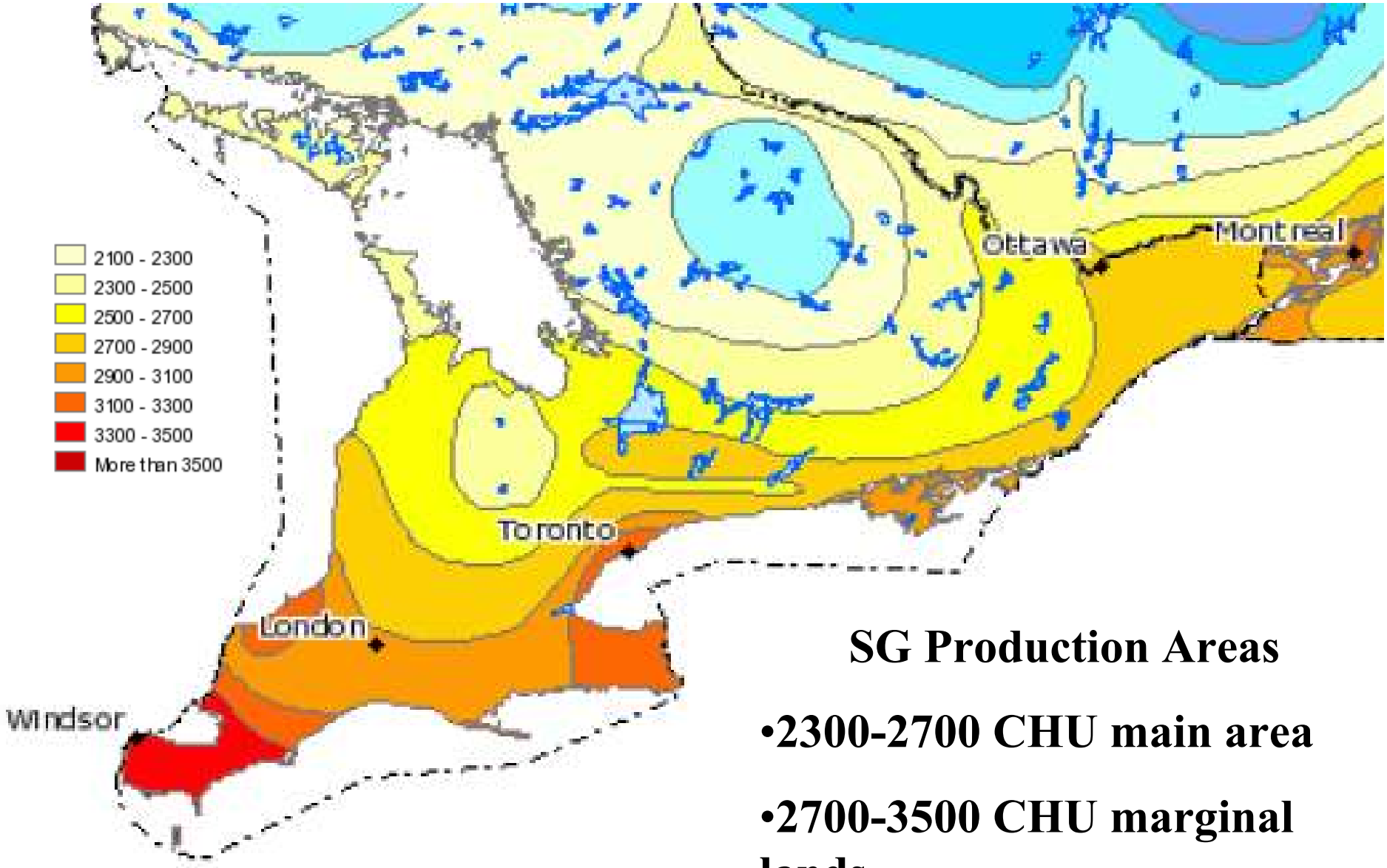
Biofuels Research at REAP-Canada began in 1991



Identifying a Land Base



SG Production Areas

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

1. Yield Improvement Strategies

- Site selection (especially in cooler zones)
- Choose a cultivar that matches the corn heat unit heat unit zone
- Potential for mixtures
- Best management mowing practices
- Breeding to increase yield

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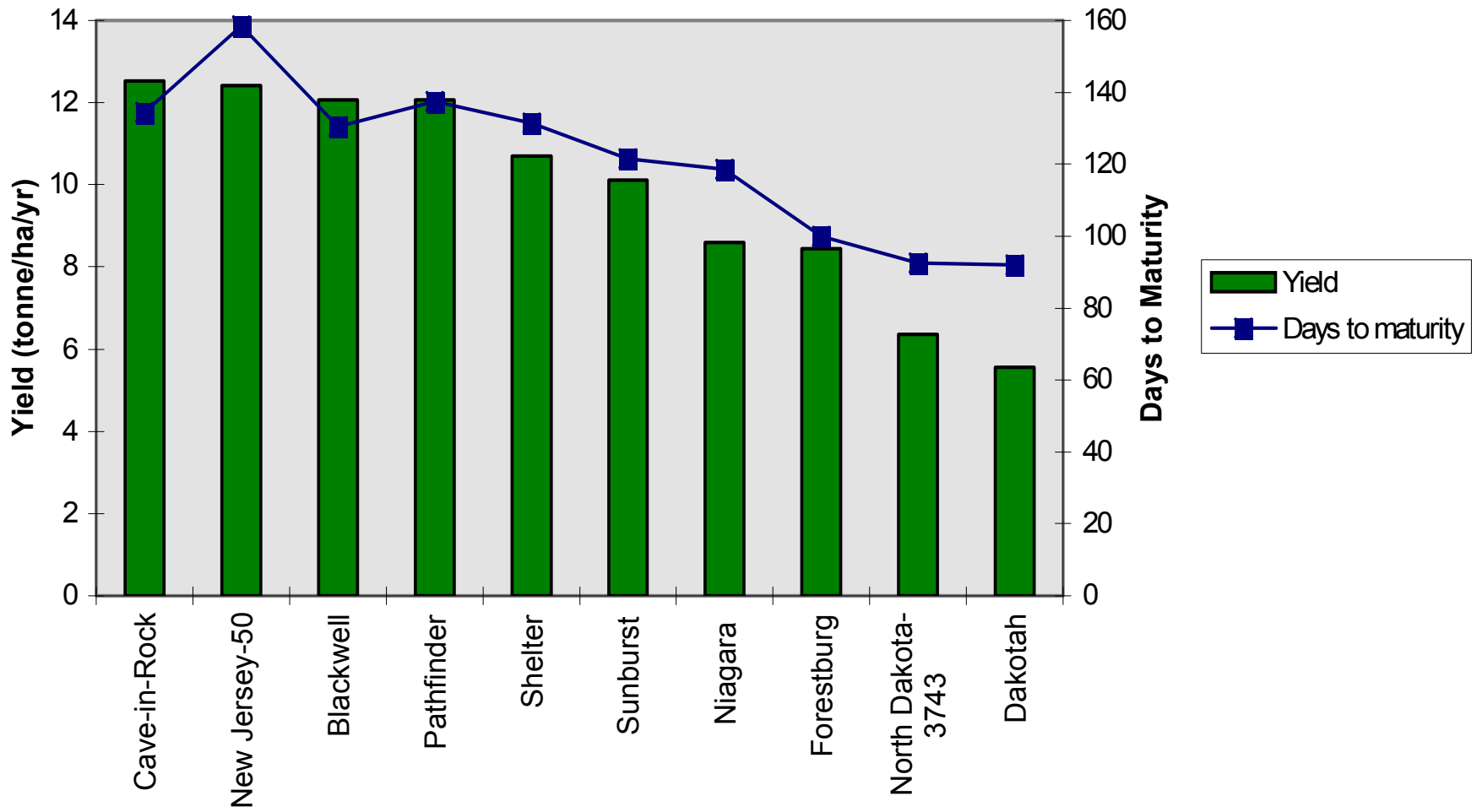
Fall Yield of Switchgrass Cultivars at Ste. Anne de Bellevue, Quebec (1993-1996)



2008 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, Shawnee	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

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Cultivar and Species Mixtures

- Diseases will become more serious as acreage expands (Switchgrass can have ergot and rust, especially with western materials)
- Big bluestem and switchgrass mixtures showing some potential in US studies
- Switchgrass mixtures out yielding monocultures in some US studies (lowland and upland ecotype mixtures)

Best Management Mowing Practices

1. For winter hardiness mowing at 10 cm has been important in Quebec and Eastern Ontario

2. Fall mowing and spring harvesting has improved biomass quality and yield

Fall Switchgrass Harvest

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FALL
WINTER
SPRING

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%**

Machine Harvested Recovered Yields in Arnprior, Ont. 2007

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

*21% higher yield
significantly different ($p<0.05$)

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TECUMSEH SWITCHGRASS (115-120 days)

	Days to Maturity	Yield (ODT/ha)				Yield Relative to Baseline (%)
		1998	*1999*	*2000*	*Average*	
Clay (Alfred, Ontario)						
Cave in Rock	135	4.5	13.7	11.9	10.0	n/a
Sunburst	120	4.3	11.1	9.2	8.2	100%
REAP 922	120	4.8	12.1	10.1	9.0	110%
REAP 921	120	3.2	10.7	8.7	7.5	92%
Sandy Soil (Alfred, Ontario)						
Cave in Rock	135	7.2	11.0	9.0	9.1	n/a
Sunburst	120	6.4	9.4	6.6	7.5	100%
REAP 922	120	6.5	9.9	8.2	8.2	109%
REAP 921	120	8.2	11.2	8.6	9.3	124%
Sandy Loam Soil (Ste. Anne de Bellevue, Quebec)						
Cave in Rock	135	-	-	9.2	9.2	n/a
Sunburst	120	-	-	7.9	7.9	100%
REAP 922	120	-	-	9.5	9.5	120%
REAP 921	120	-	-	11.8	11.8	149%
Overall Yield Increase Relative to Sunburst -Baseline (%; Average of 7 site years))						
REAP 922 (Blue jacket)						**111%**
REAP 921 (Tecumseh)						**113%**

Improving Grass Pellet Quality

Opportunity:

- Residential pellet demand exceeds wood pellet supply in a depressed energy market

Solution:

- Use grasses to fuel the market to expand residential pellet use
- *What can be done?*

2. Strategies to Improve Quality

- Spring harvest to leach out aerosol forming compounds (especially K and Cl)
- Choice of soil type
- Quality of grass components
- Choice of species (e.g. BB vs SG)
- Fractionation

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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Impact of Soils on Ash Content

Studies with reed canary grass 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

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

Big Bluestem: A Lower Ash Pellet Than Switchgrass?

Big Bluestem

Native ecovars 60% stem

Switchgrass

Native ecovars 45-50% stem

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Harvest Period and Biomass Composition Changes

Biological Component	Fall m.c. (%)	Composition	
		Fall 2006	Spring 2007
Head	4	12.5 %	5.2%
Leaf	15	25 %	13.2%
Sheath	13	14.8 %	17.9%
Stem	25	47.7 %	63.7%

Whole plant moisture content was reduced to ~7% at baling in the spring

Can Straw Disc Mill Fractionation Processes Be Used For SG and BB?

- What is the best process?
- How can it be optimized?
- What fuel quality and proportions can we expect going to residential and commercial/industrial pellet markets?
- Can we readily pellet >90% stem material?

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?

Summary and Conclusions

- Both yield and quality of warm season grasses improvement in warm season grasses can be improved through cultural management and genetic improvement
- Yes-we can develop grass pellets as a convenient affordable residential pellet fuel


Thank You!
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