Breeding shrub willow as a feedstock for bioenergy, biofuels and bioproducts

Photo courtesy Ben Ballard

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Willow Biomass Team

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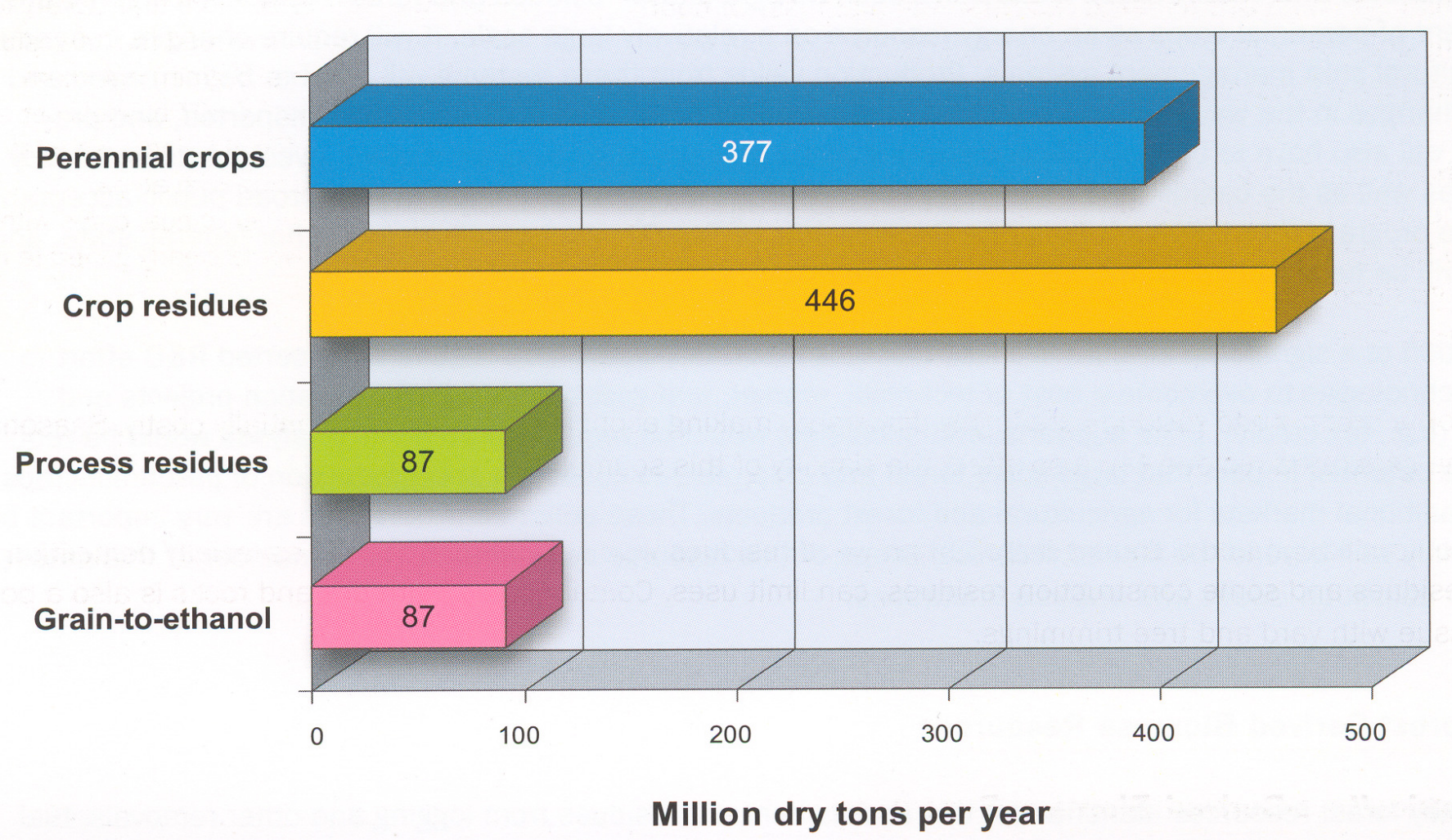
30% of fuel from biofuels by 2030



Perlack et al., 2005

Regional Perennial Energy Crops

Willow Shrubs

Hybrid Poplar

Mechanical planting of unrooted cuttings

Growing willow as an agricultural crop on marginal land

- Coppice after 1st year
- Growth – 3 to 4 m yr^{-1}
- Harvest every 3-4 years for maximum yield
- Plants stay vigorous through >7 harvests

'SV1' three years after coppice

Harvesting willow in the winter

Coppice Resources Ltd. cutter head
New Holland FX Forage Harvester

100 lbs. N per acre applied after harvest

Case New Holland

Forest Biotechnology

Commercial application of willow

Lyonsdale Biomass Facility owned by Catalyst Renewables LLC

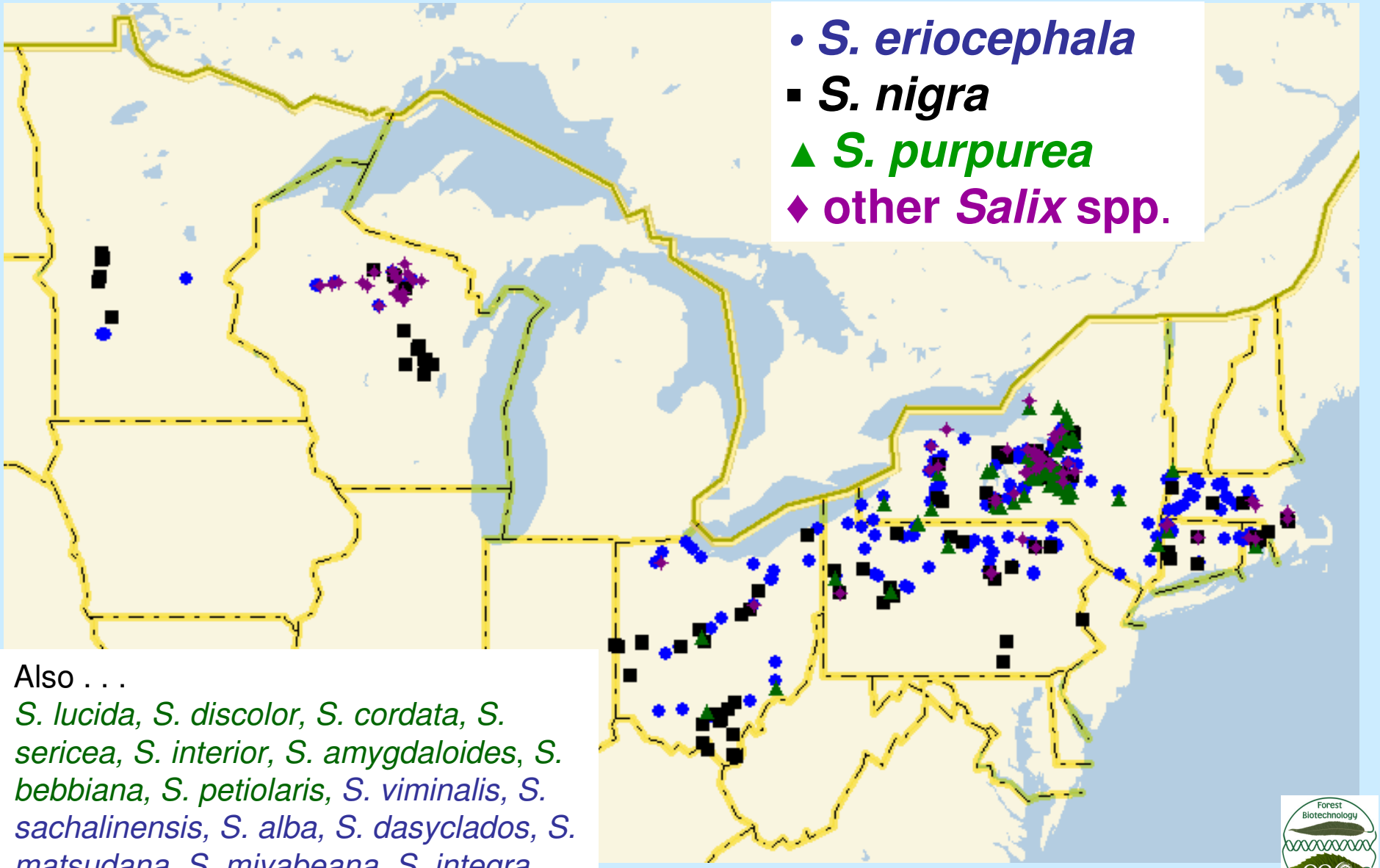
19 MW wood-fired CHP & pilot ethanol plant

Wood-fired boiler at Lyonsdale Biomass, Lyons Falls, NY

Breeding willow at SUNY-ESF

- High genetic diversity
- Little domestication
- Short generation time
- Clonal propagation
- Many species can hybridize

More than 600 Accessions Collected: 1995 - 2006



Also . . .
S. lucida, S. discolor, S. cordata, S. sericea, S. interior, S. amygdaloides, S. bebbiana, S. petiolaris, S. viminalis, S. sachalinensis, S. alba, S. dasyclados, S. matsudana, S. miyabeana, S. integra . . .

Breeding within the subgenus Vetrix

Subgenus Vetrix

- Shrubs
- Diploids and polyploids
- Temperate distribution

Subgenus Salix

- Trees
- Diploids
- Subtropical distribution

Adapted from Dorn, 1976.

Successful crosses within the subgenus Vetrix

Section ↓	Section→ Species of Female Parent	Species of Pollen Parent							
		Cordatae	Cinerella		Viminella		Helix		
		eriocephala	*discolor*	*cinerea*	*viminalis*	*sachalinensis*	*purpurea*	*miyabeana*	*integra*
Cordatae	*eriocephala*	79/98	0/1	0/1			0/15	0/10	
Cinerella	*discolor*	1/1		1/1	0/1	0/1	0/2	0/1	
	cinerea	0/1						0/1	
Viminella	*viminalis*	1/4					0/1	5/5	
	sachalinensis				0/1	0/1		2/4	
Helix	*purpurea*	2/14*	0/1		1/4	1/4	26/53	13/25	2/2
	miyabeana				0/3	0/3		1/3	0/1
Griseae	*sericea*	2/2			1/1*	1/1*	1/2	0/2	
Hastatae	*cordata*	3/5	0/1		0/1	0/1	0/2		
Hybrid	*dasyclados*	5/8					0/4	1/3	

*Less than 10 viable offspring produced

- Intra-specific crosses are more successful than inter-specific
- Crosses between subgenera are rarely successful

Breeding for increased biomass

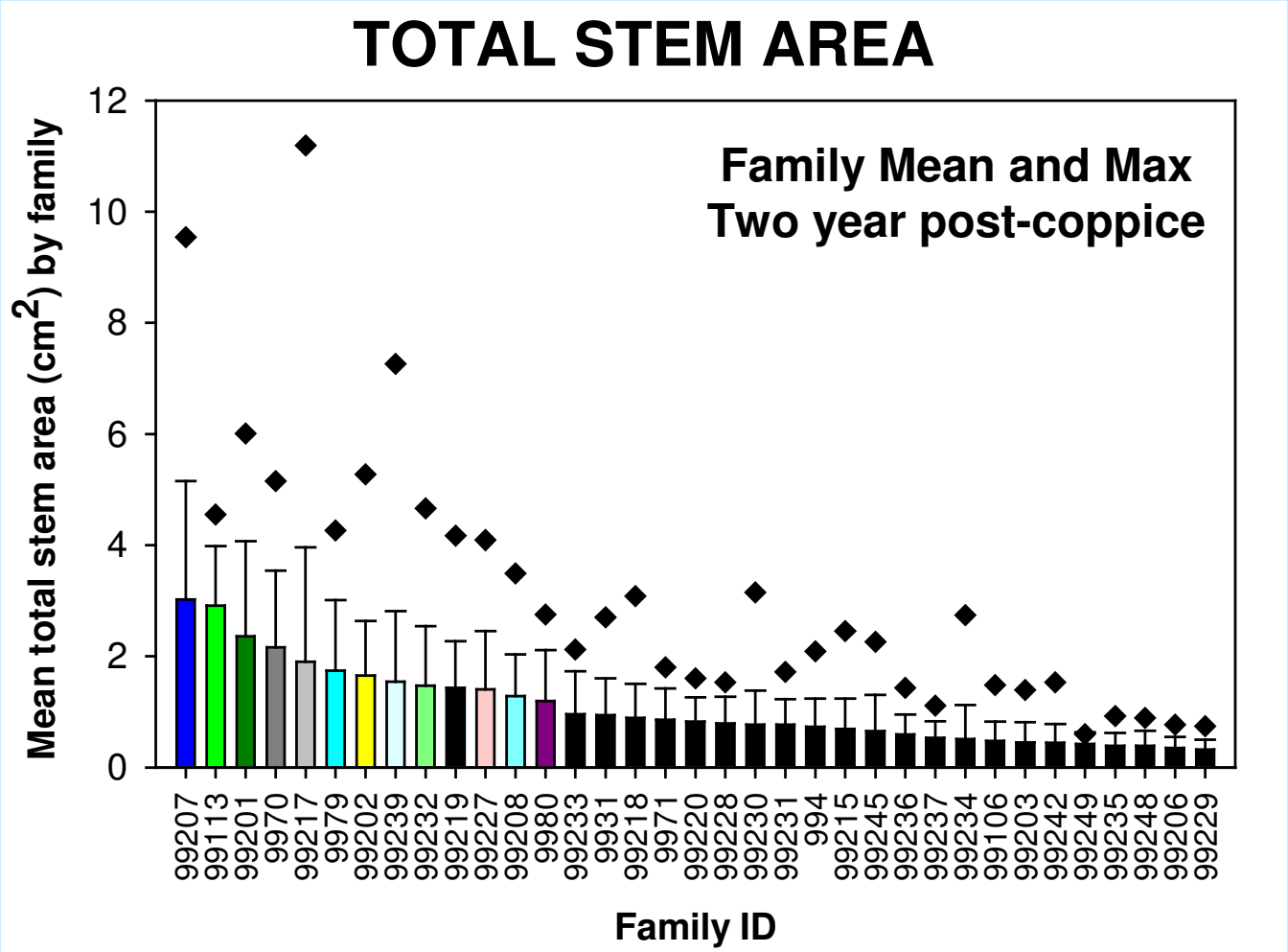
Since 1998, more than 575 crosses attempted

26 families of
Salix purpurea

82 families of
Salix eriocephala

91 other families, mainly *Salix sachalinensis, Salix miyabeana* and hybrids

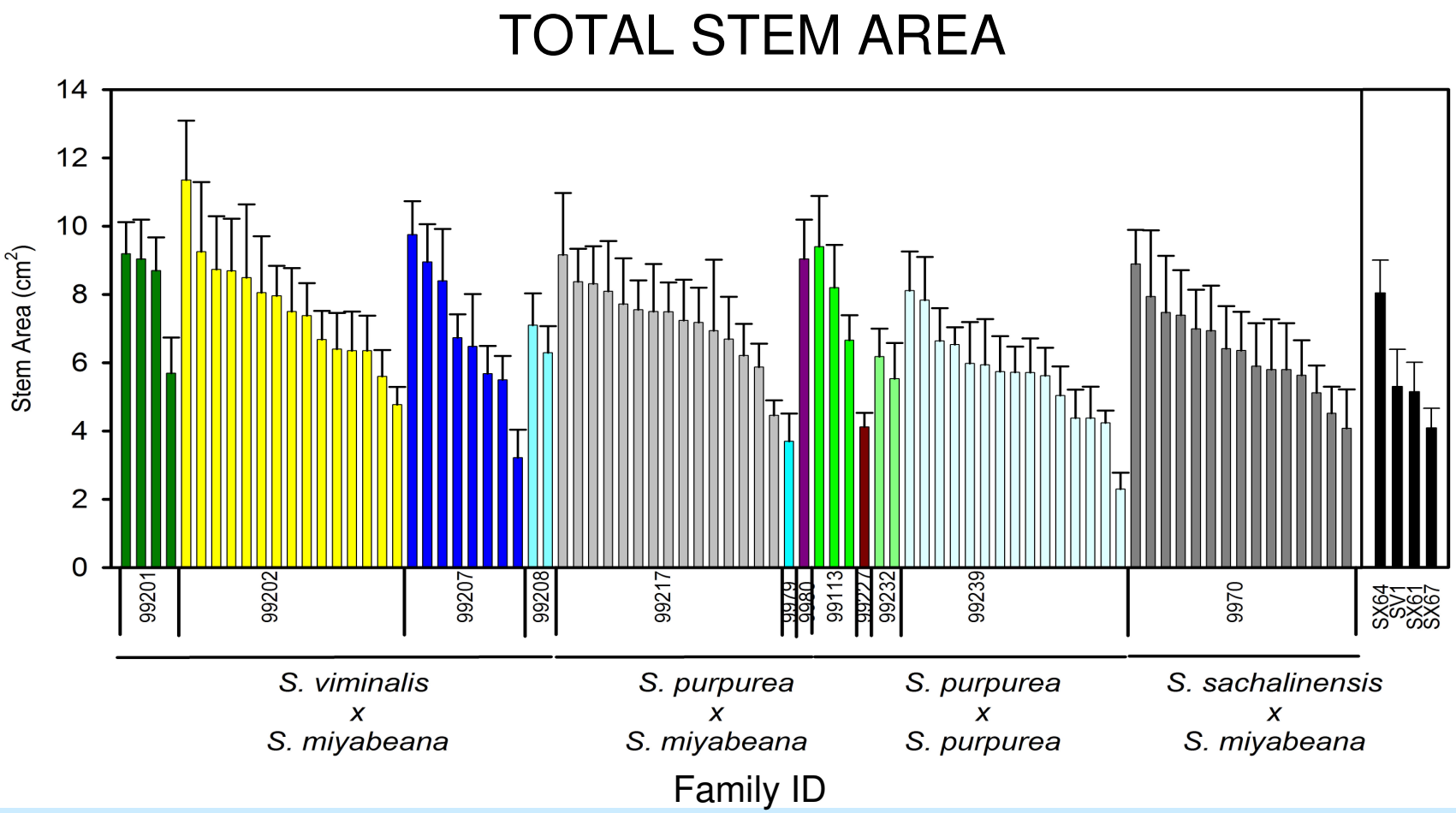
1999 Family Screening Trial
Syracuse, NY



2002 Genetic Selection Trial

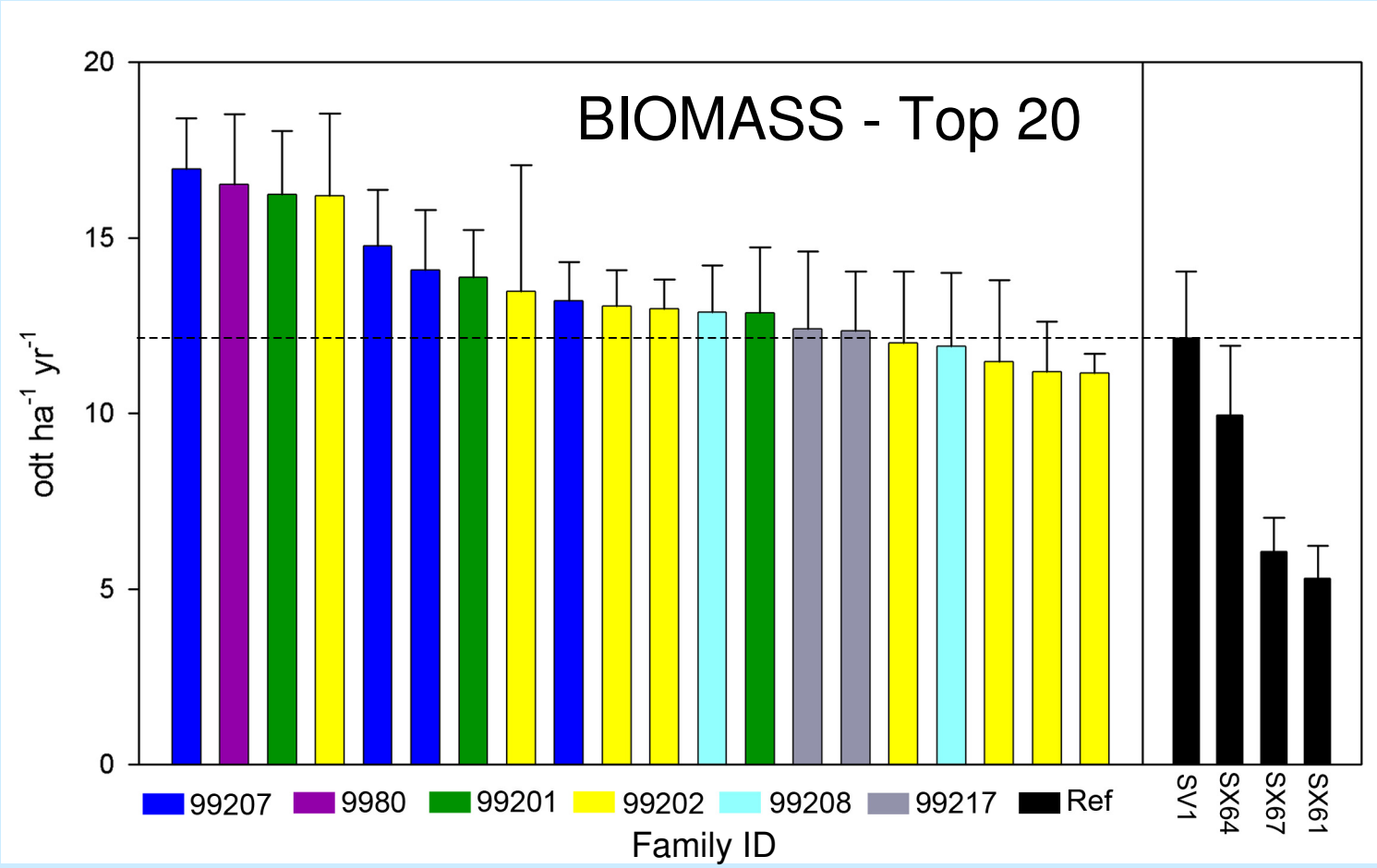
First year post-coppice measurements

Four-plant plots; eight reps; Tully, NY



2002 Genetic Selection Trial

Biomass harvest - Two years post-coppice



- *15 varieties with greater yield than 'SV1'*
- *top variety had 40% greater yield than 'SV1'*

Yield Trials Established in 2005, 2006, 2007

2006: 1 year post-coppice, Belleville, NY

<u>Also in 2006:</u>
Waseca, MN
Edmonton, Alberta

<u>Also in 2007:</u>
Escanaba, MI
Middlebury, VT
Saskatoon, Saskatchewan
Montréal, Québec
Loughgall, N. Ireland

Commercial varieties are now available

Clone ID #	Variety epithet PPpatent pending
99207-018	‘Owasco’ PP
9980-005	‘Oneida’ PP
99201-007	‘Otisco’ PP
99113-012	‘Onondaga’
99202-011	‘Tully Champion’ PP
9970-036	‘Canastota’ PP
9871-031	‘Sherburne’
9882-034	‘Fish Creek’ PP
99239-015	‘Allegany’
99217-015	‘Millbrook’ PP
SX61	
SX64	
SX67	
S25	
S365	
SV1	

- **Double A Vineyards (Fredonia, NY) will produce and sell whips for commercial scale-up (www.DoubleAWillow.com)**
- **Nursery beds >100,000 plants in 2006**

Acknowledgements and Funding

Dr. Tim Volk
Dr. Larry Abrahamson
Dr. Ed White
Dennis Rak

Dr. Rich Kopp
Ingrid Phillips
Michelle Serapiglia
Jason Purdy

Ken Burns
Mark Appleby
Kathleen Pitcher
Tom Burchhardt

USDA Rural Development

CSREES EDUCATION RESEARCH EXTENSION USDA

NYSERDA New York State Energy Research and Development Authority

OAK RIDGE NATIONAL LABORATORY
Managed by UT Battelle for the Department of Energy

Forest Biotechnology