Miscanthus: biofuels, invaders or both?

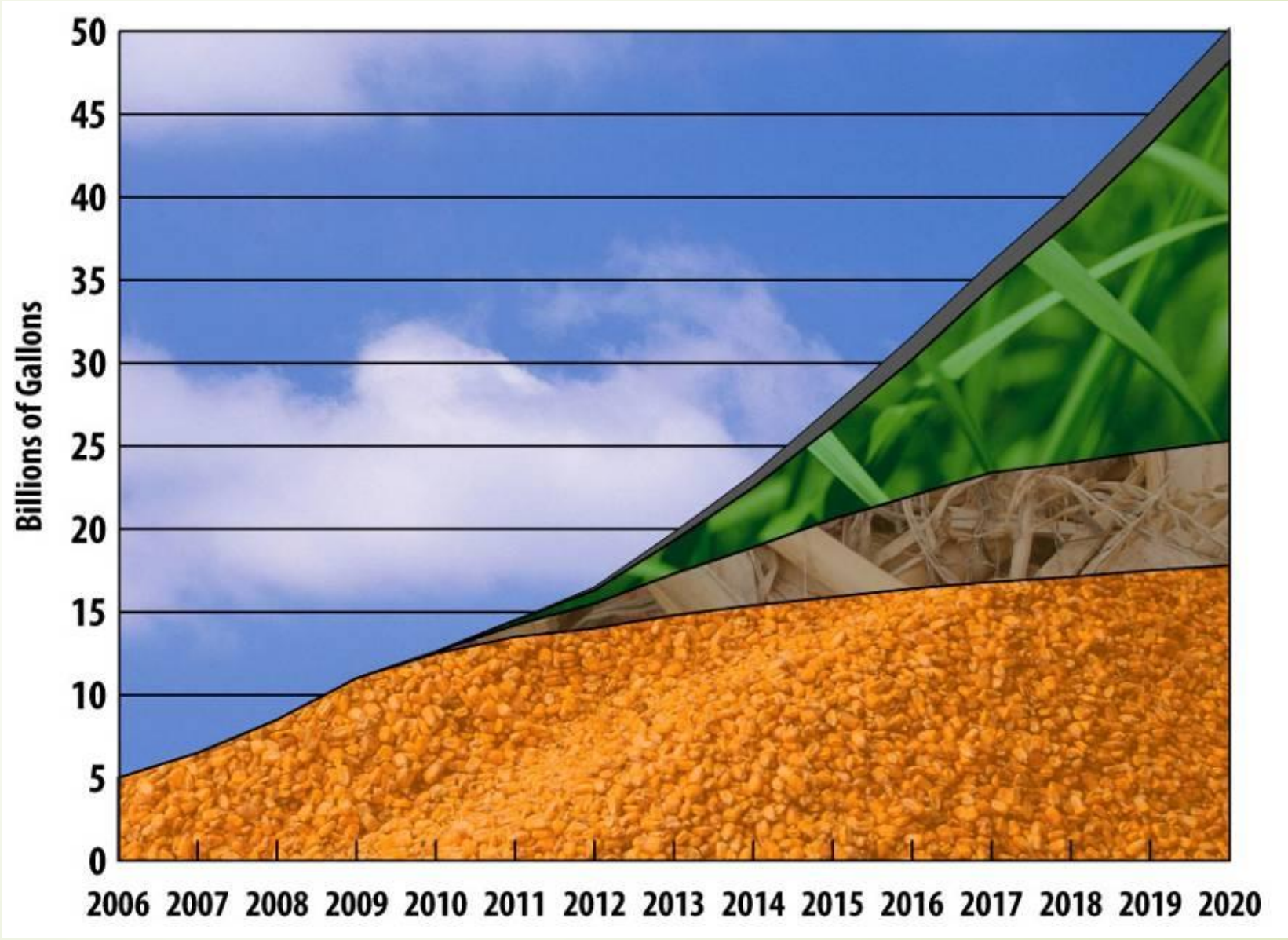
Emily Heaton[1], Allison Snow[2], Maria Mariti[2] and Catherine Bonin[1]

[1]Dept. Of Agronomy, Iowa State University

[2]Dept. of Evolution, Ecology, and Organismal Biology, The Ohio State University

36 Billion Gallons of Alternative Fuel…

2007 Energy Independence and Security Act



What makes a good biomass

- C4 photosynthesis
- Long canopy duration
- High water use effi
- Recycles
- can burning
- Sterile – non-invasive
- Winter standing
- Easily removed
- No known pests/diseases
- Easily managed

Raghu S, Anderson RC, Daehler CC, Davis S, Wiedenmann RN, Simberloff D, Mack RN (2006) Adding Biofuels to the Invasive Species Fire? Science, **313**.

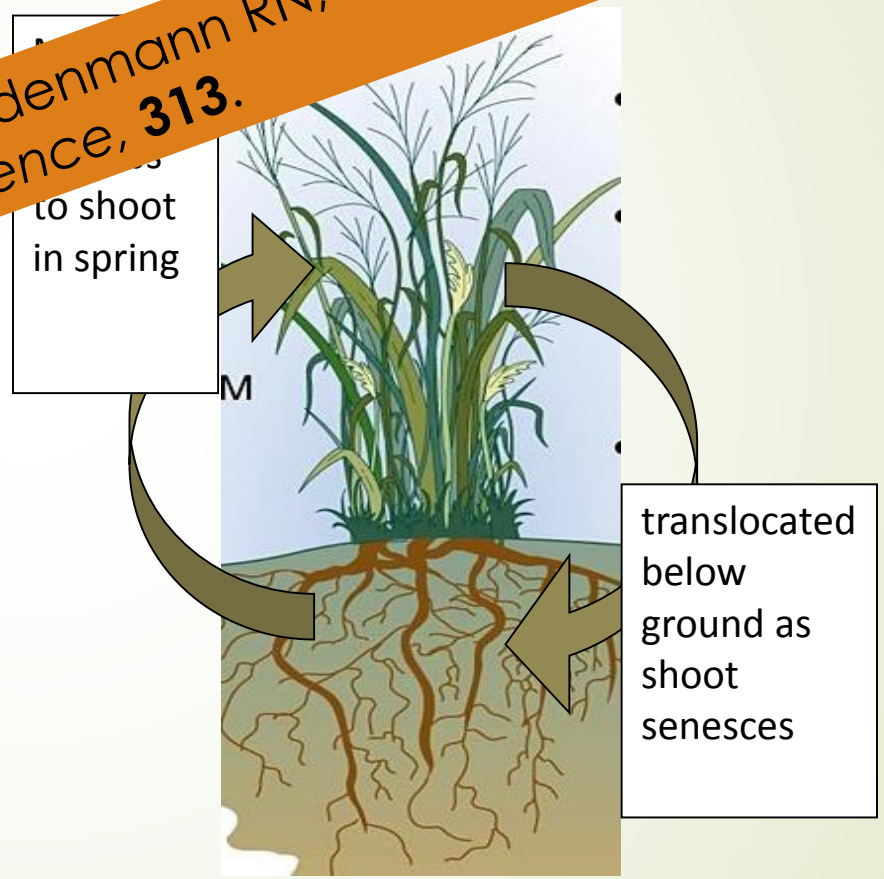
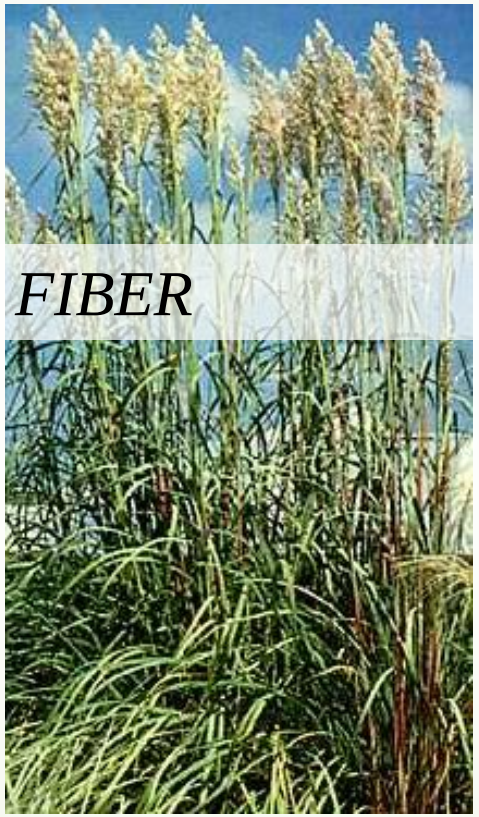


Fig 1: Translocation increases nutrient use efficiency in perennial grasses

What Are "The Canes"?
- multiple interbreeding genera and species
Examples include:

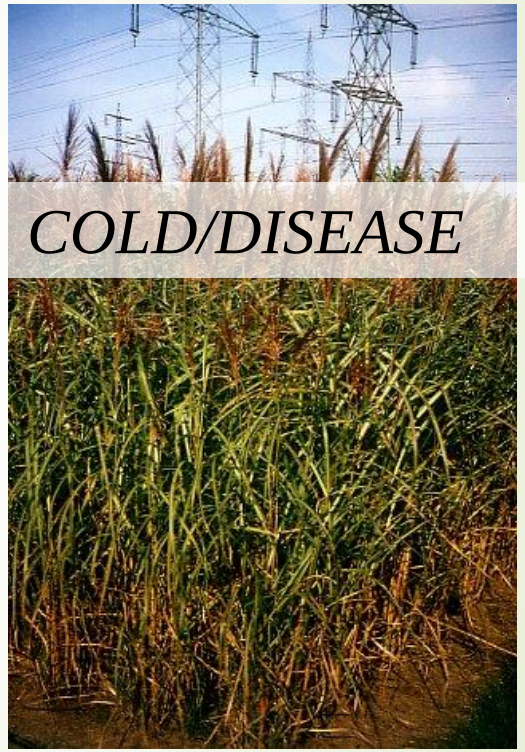
SUGAR

Saccharum spp.



FIBER

Erianthus spp.



COLD/DISEASE

Miscanthus spp.

M. × *giganteus*: Naturally Occurring Hybrid

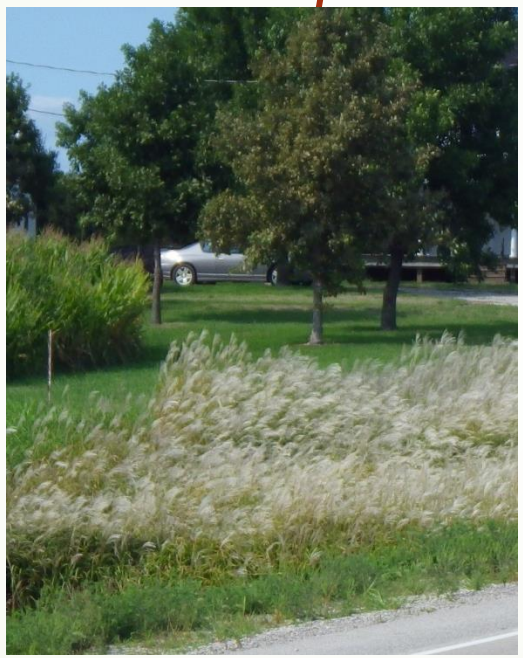
Miscanthus sinensis

Diploid

2n=2x=38

+

Miscanthus sacchariflorus



Tetraploid

2n=4x=76

=

Miscanthus x *giganteus*

Triploid

2n=3x=57

Distribution of three Asian *Miscanthus* species

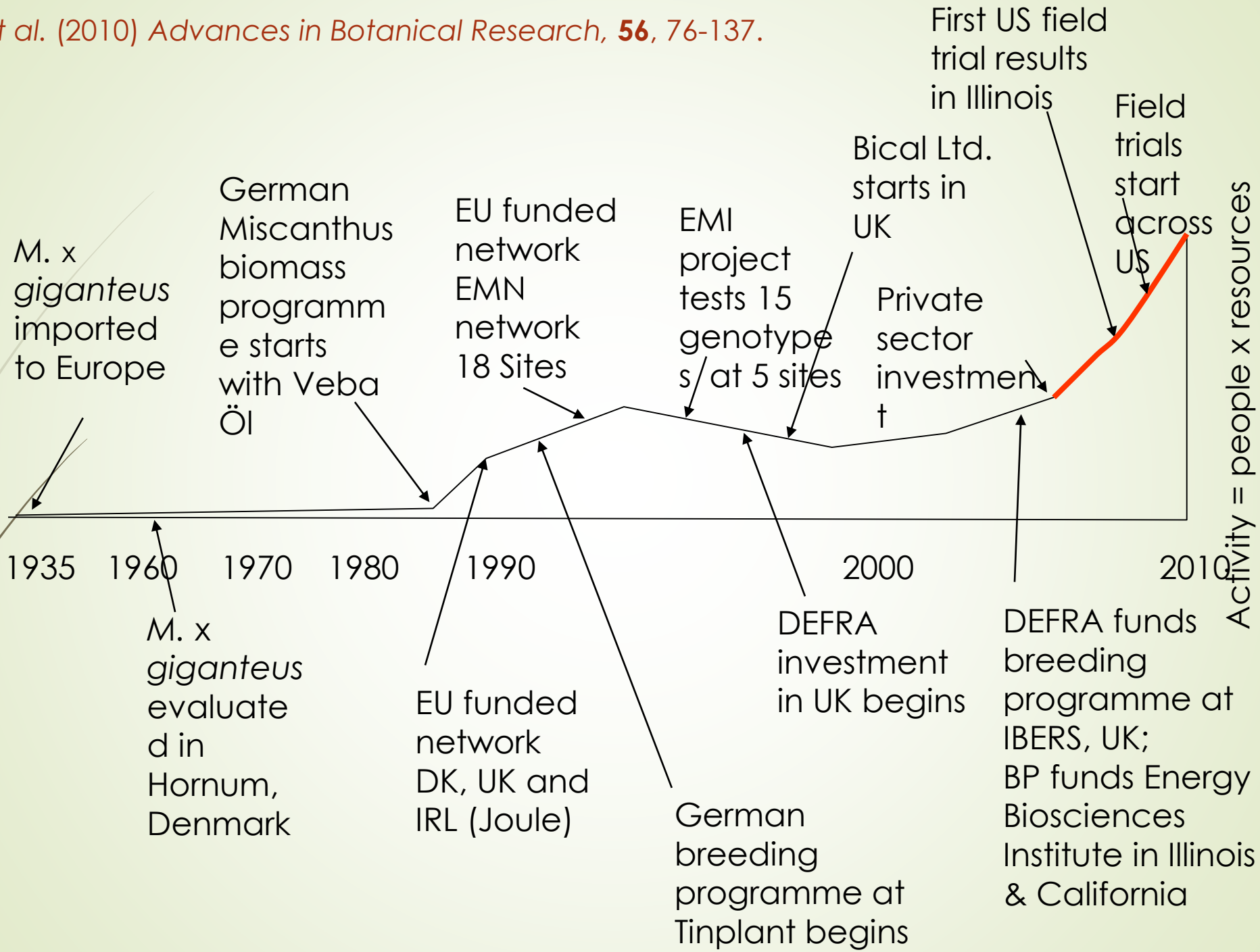
Original *M. x giganteus* hybrid collected in 1935 in Yokohama, Japan, cultivated in Denmark, then distributed throughout Europe and U.S. as an ornamental plant. Slide courtesy of Tom Voigt, UIUC.

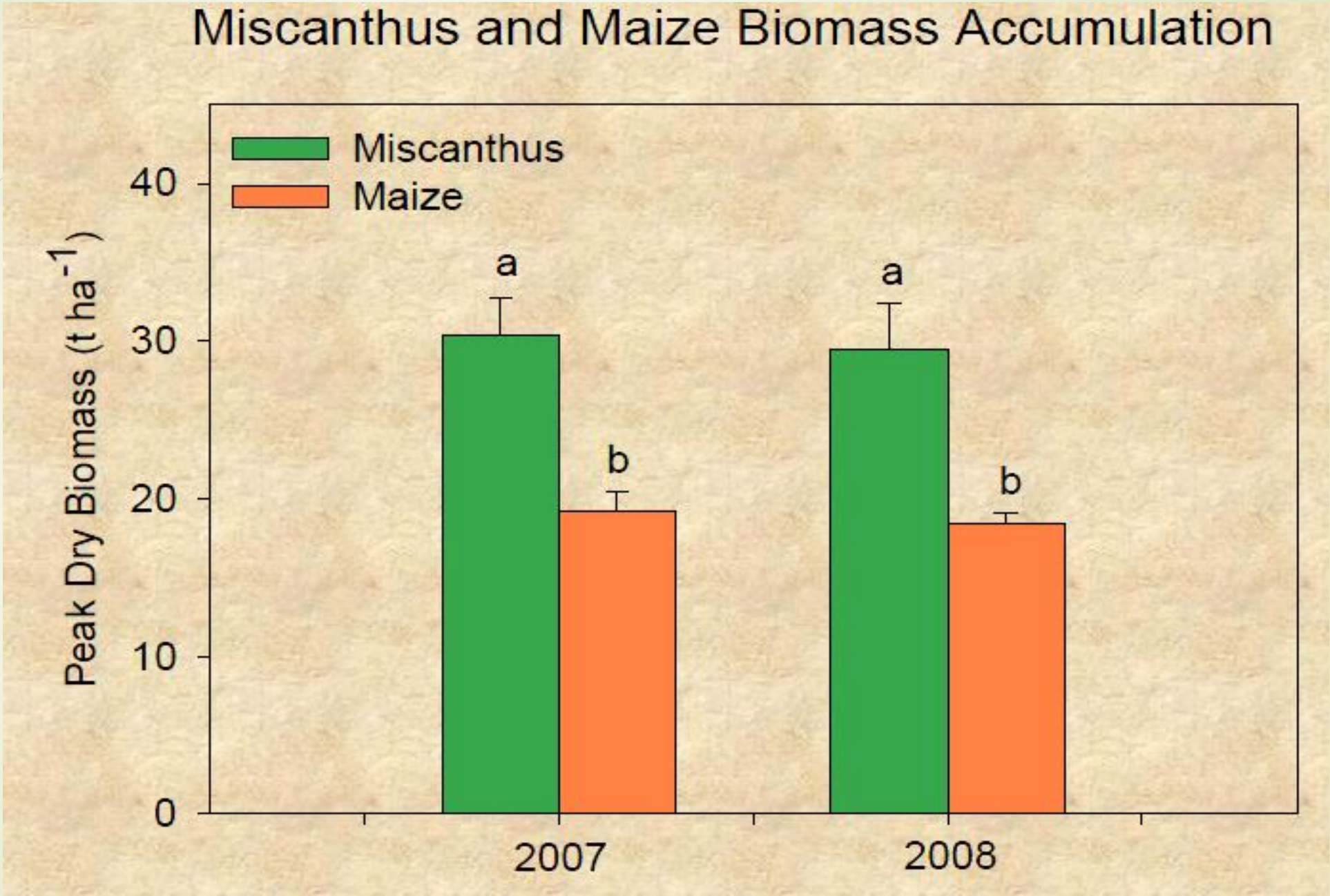
Giant Miscanthus (*Miscanthus × giganteus*)

A higher yielding alternative to switchgrass in some areas, especially the Midwest

- High Yielding (6-15 t/acre)
- Sterile clone
- Must be planted from rhizomes
- New to US: 10's to 100's of acres
- Widely planted in Europe: thousands of acres
- Used for heat and power with coal

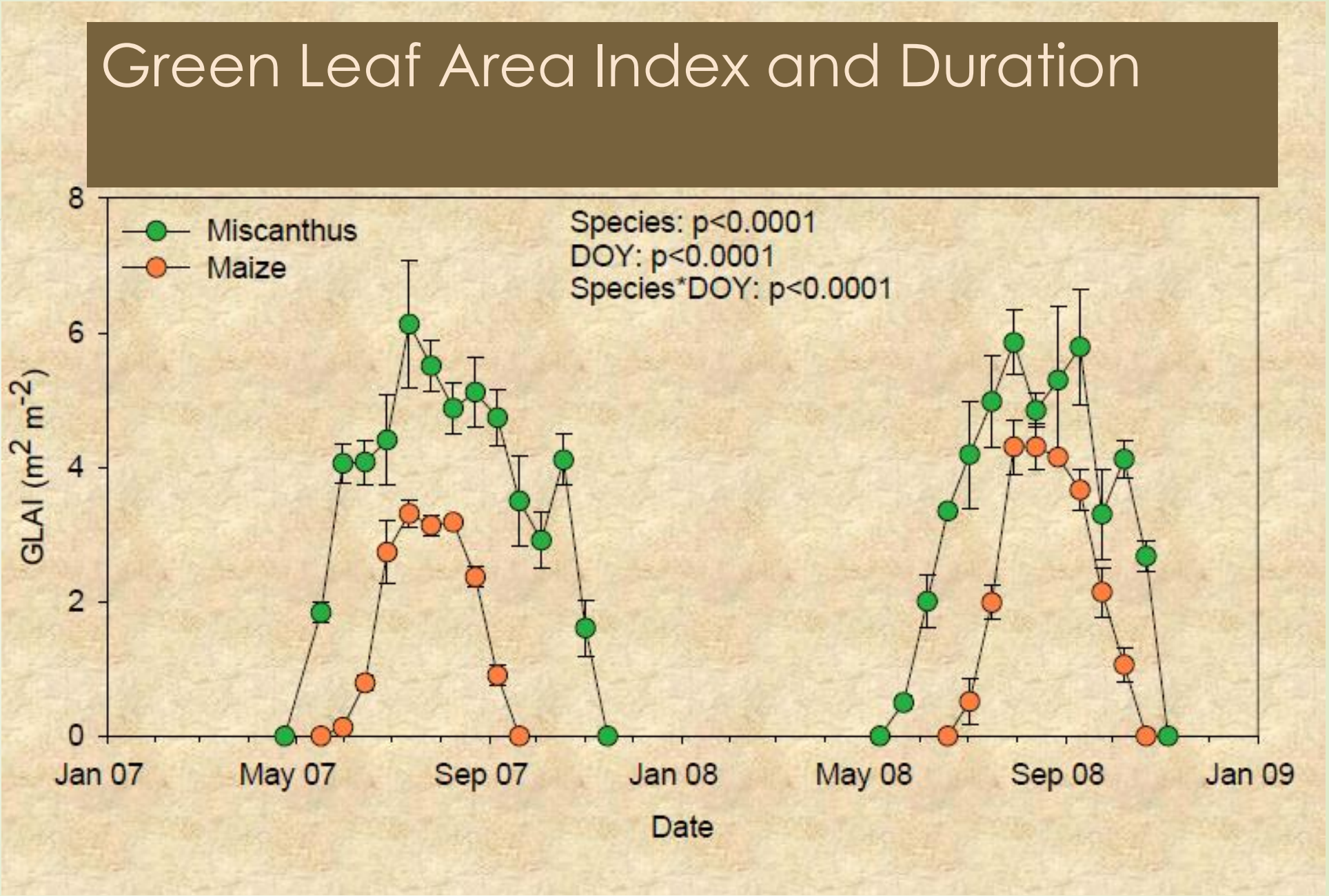
From Heaton *et al.* (2010) *Advances in Botanical Research*, **56**, 76-137.





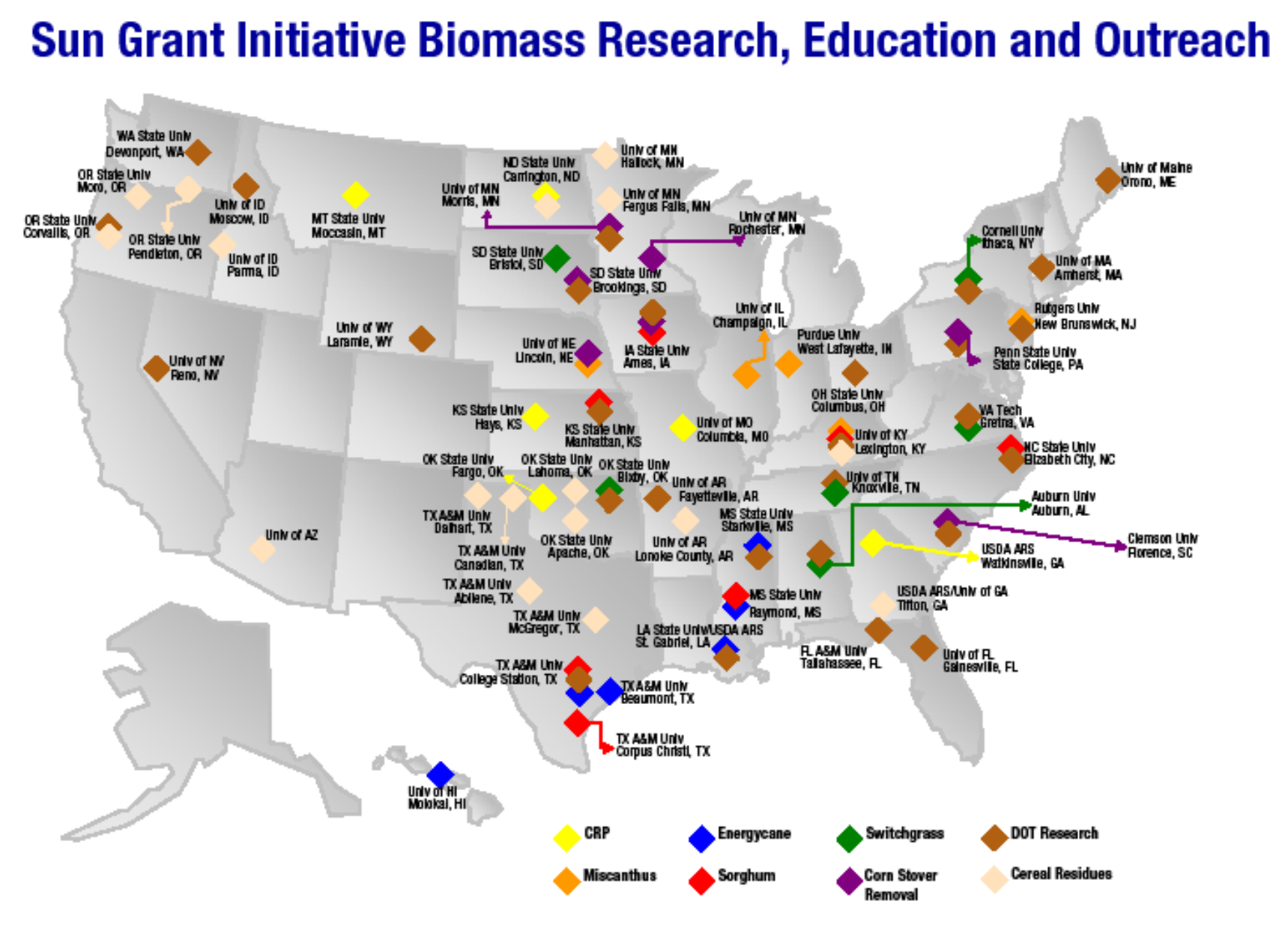
Dohleman, *et al.,* (2009) Plant Physiology

Green Leaf Area Index and Duration



Dohleman, *et al.,* (2009) Plant Physiology

Regional Feedstock Partnership

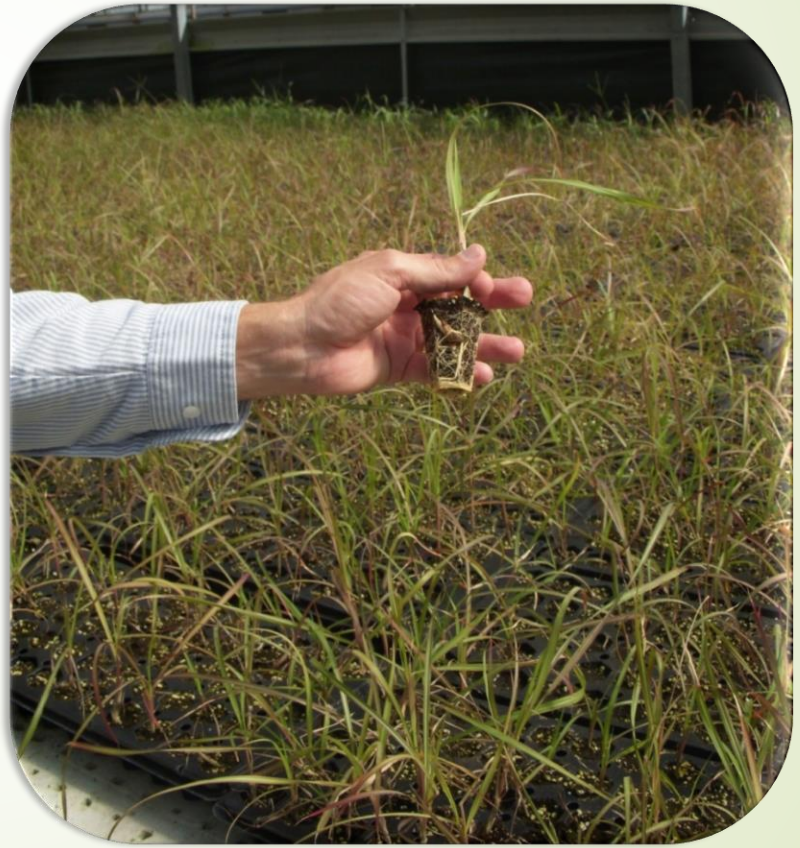


http://www.sungrant.org/Feedstock+Partnerships/Research+Plots/

Approach

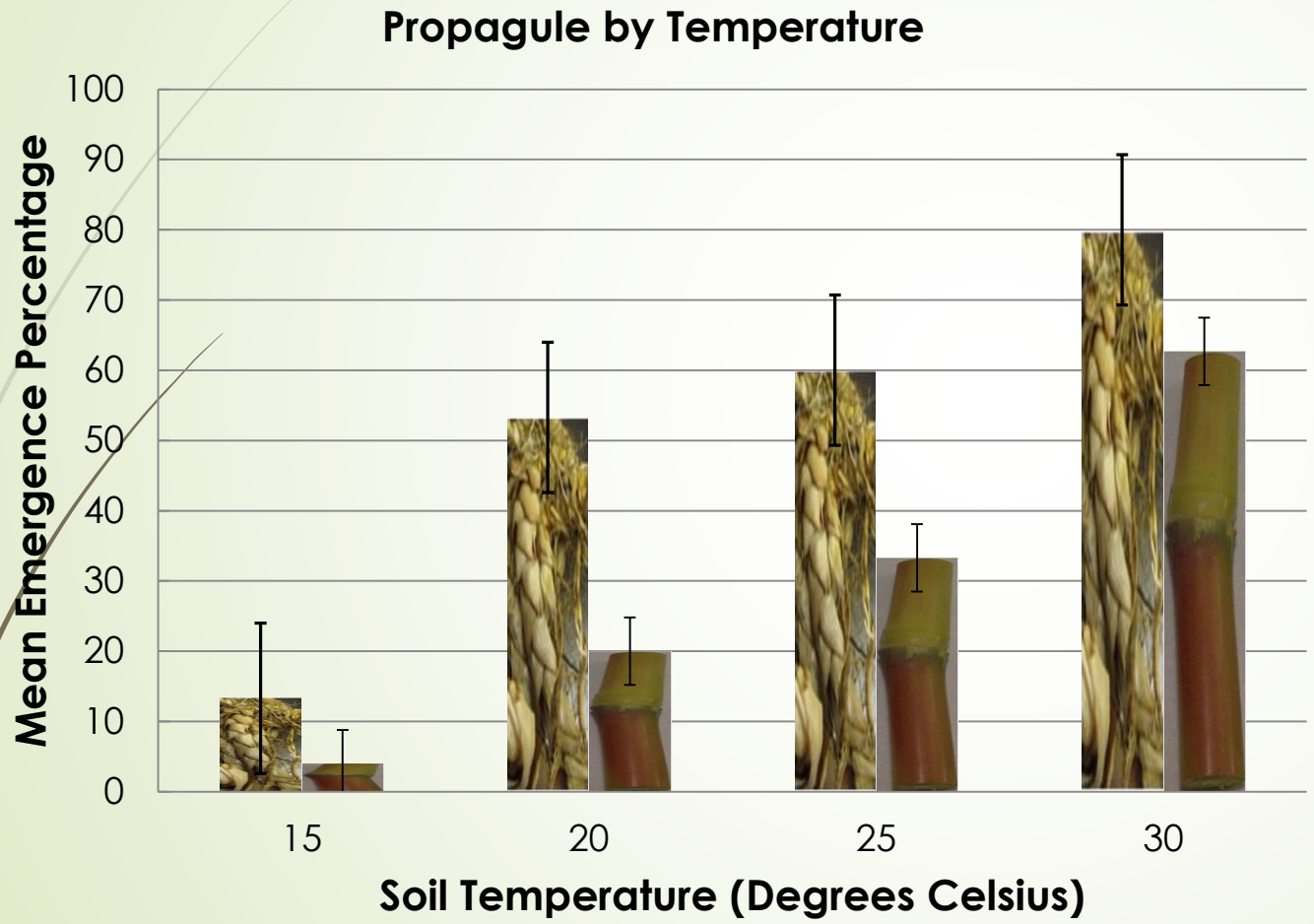
Rhizomes

Plugs




09/24/2009

M. × *giganteus* stems?



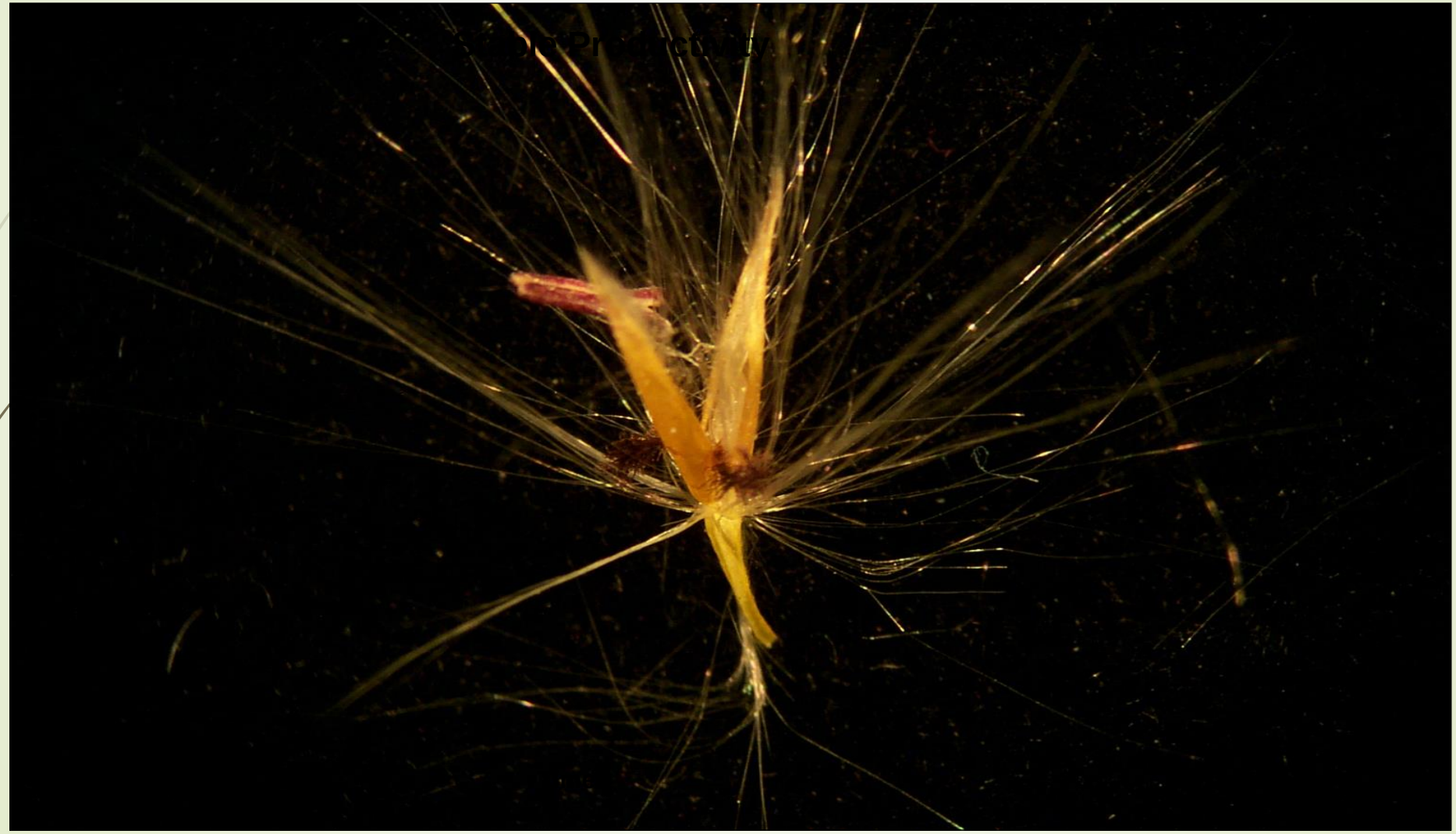
Nic Boersma

John Caveny

Boersma & Heaton (2012) *GCB Bioenergy*, **4**, 680-687.

Miscanthus, a closer look

M. × giganteus floret



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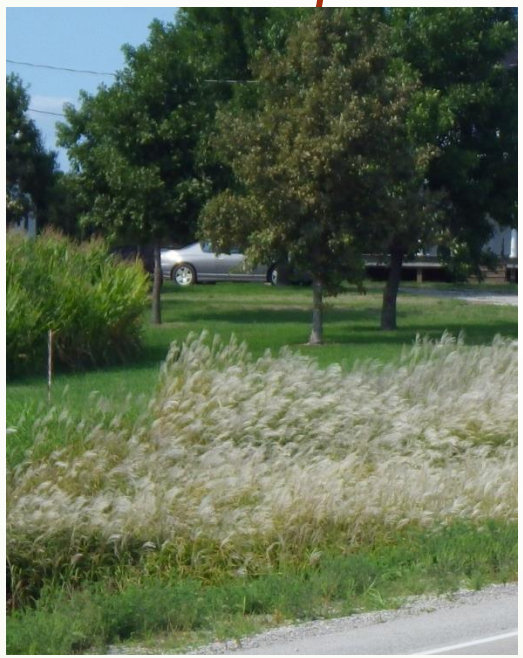

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M. sinensis vs. M. sacchariflorus

M. sinensis

- bunch grass
- hairs = spikelet
- awns on florets
- firmer flowers in many colors
- many foliage colors
- August-October flowering

M. sacchariflorus

- aggressive rhizomes
- hairs = 2x spikelet
- no awns
- white soft flowers
- only green foliage
- August-early September flowering

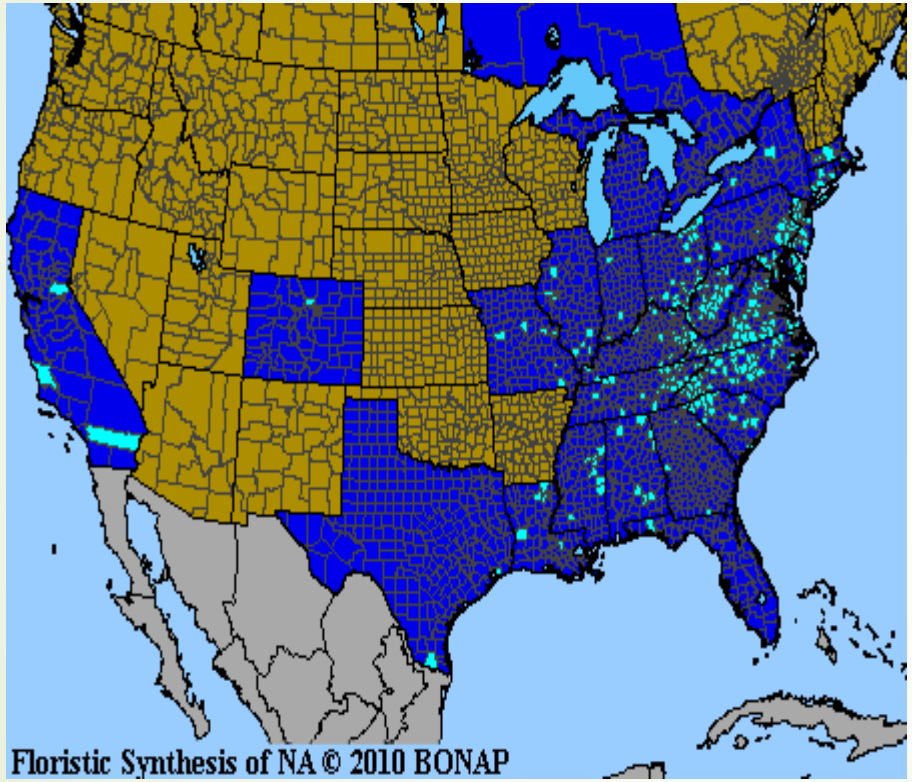
http://miscanthus.cfans.umn.edu/identification.html

M. *Sinensis* - Japan

Stewart RJ, Toma Y, Fernandez FG, Nishiwaki A, Yamada T, Bollero GA (2009) The ecology and agronomy of *Miscanthus sinensis*, a species important to bioenergy crop development, in its native range in Japan: a review. *GCB Bioenergy,* **1**, 126-153.

http://www.ask.com/wiki/Miscanthus_sinensis

M. *Sinensis* – Chinese Silvergrass



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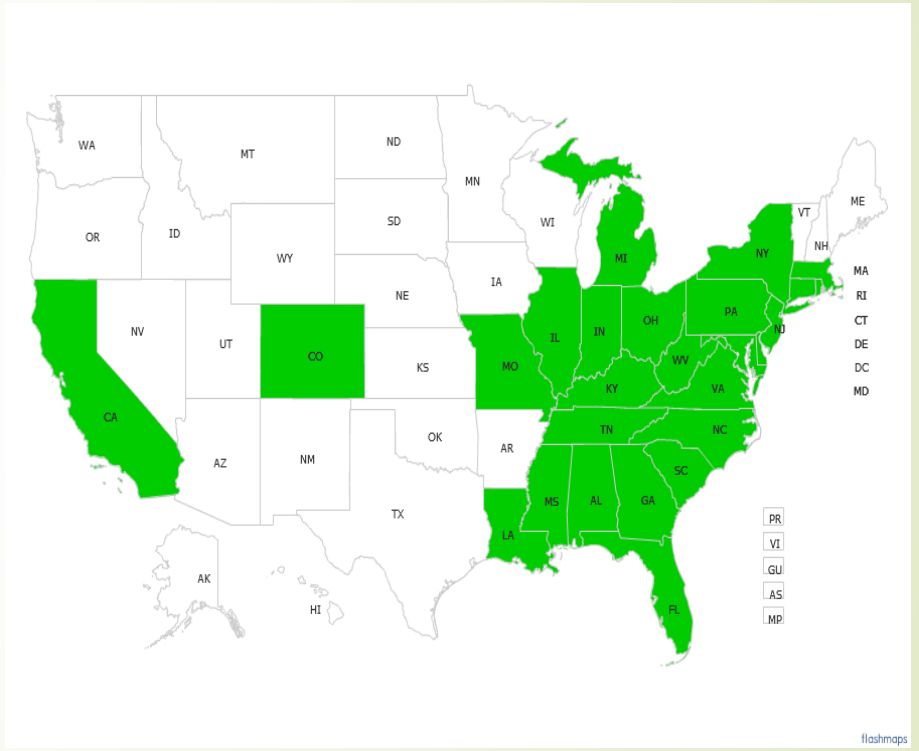

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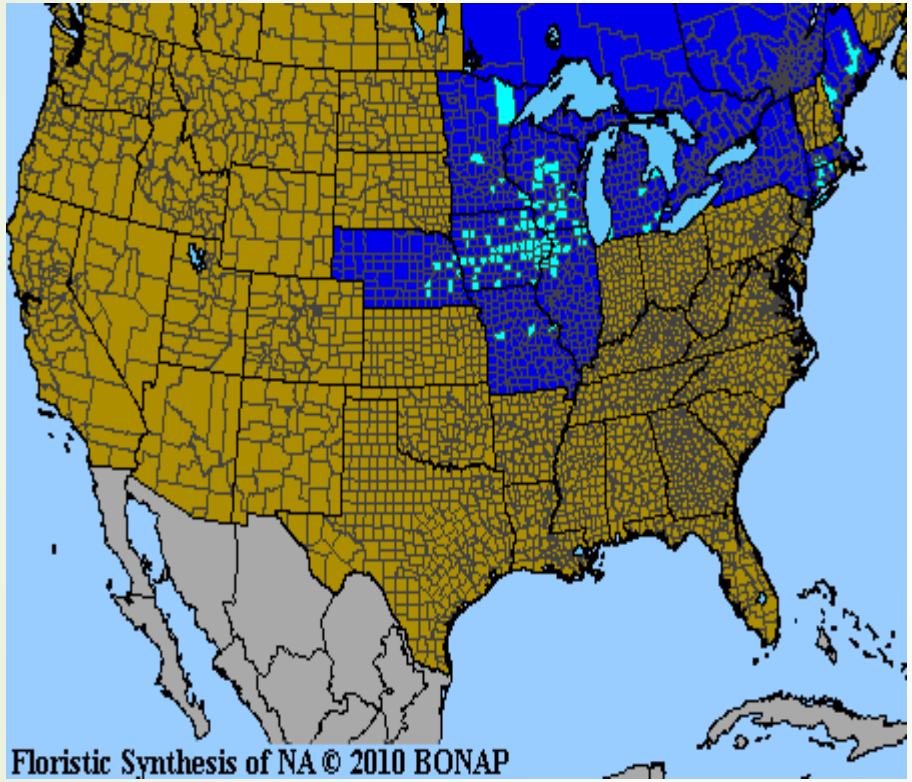
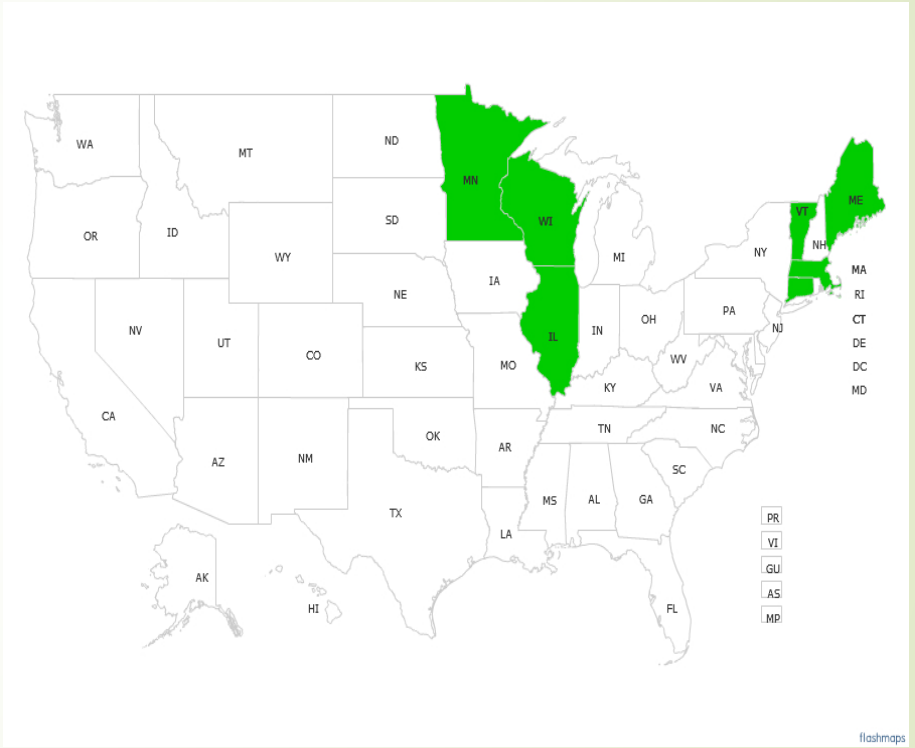
Original *M. x giganteus* hybrid collected in 1935 in Yokohama, Japan, cultivated in Denmark, then distributed throughout Europe and U.S. as an ornamental plant. Slide courtesy of Tom Voigt, UIUC.

M. sacchariflorus – Amur silvergrass



http://www.bonap.org/BONAPmaps2010/Miscanthus.html

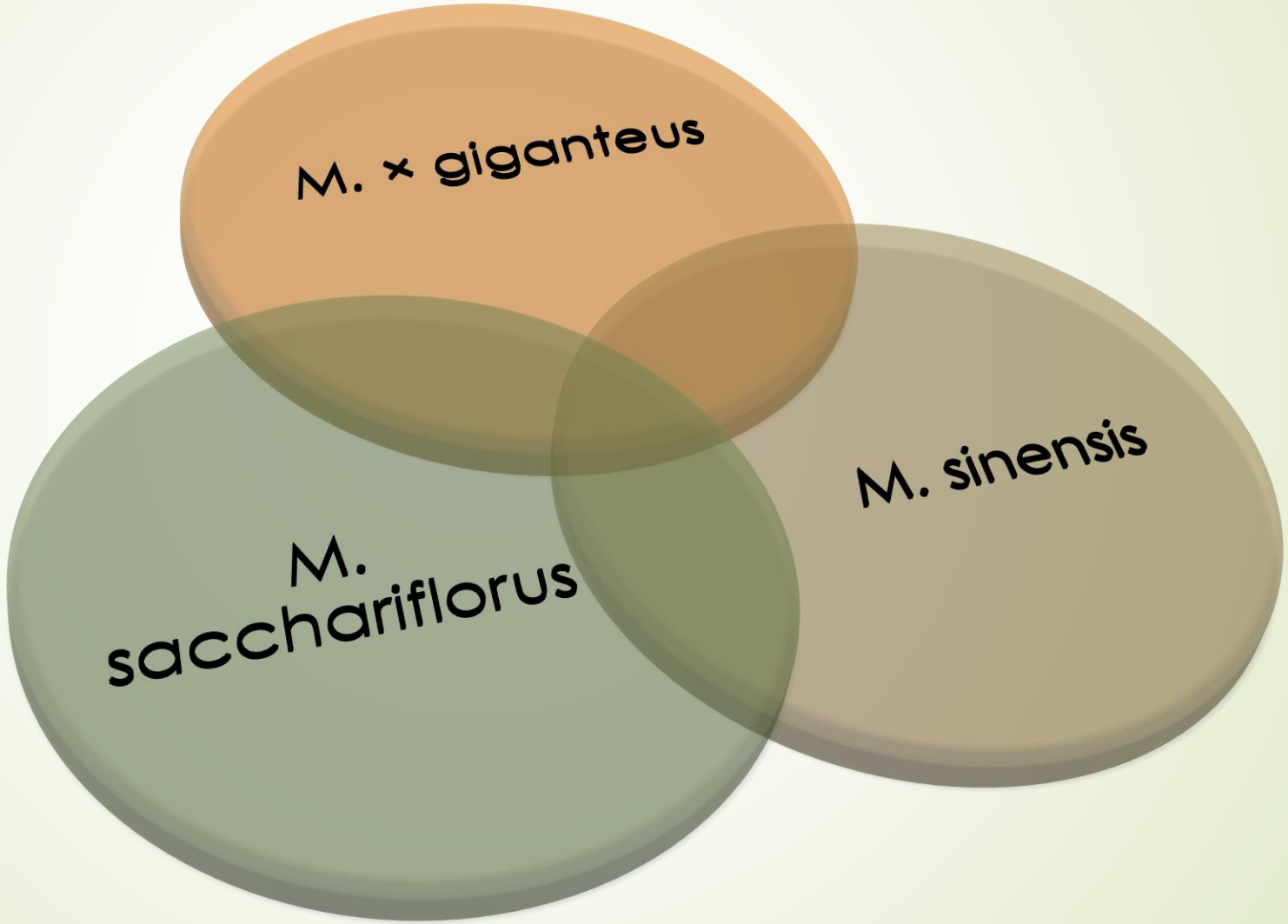


EDDMapS. 2012. Early Detection & Distribution Mapping System. The University of Georgia - Center for Invasive Species and Ecosystem Health. Available online at http://www.eddmaps.org/; last accessed December 12, 2012.

M. sacchariflorus

Eastern Iowa, 2012. Photo credit: Virgil Schmitt

Right place, right time?



Current work: assessing Miscanthus (and switchgrass) invasive potential

Goal: understand how likely new varieties are to flower, reproduce, establish and compete compared to existing varieties and native ecotypes

Model pollen flow and population dynamics

- 2 locations: Iowa, Ohio
- Range of germplasm: locally collected ecotypes, publically available cultivars, advanced breeding lines
- 3 experiments along ontogenic gradient: seed survival, seedling competition, mature plant fitness

Seed Survival

How long do switchgrass seeds last in the seed bank?

- Place clean, live, counted seed (tetrazolium test) in mesh bags
- Bury, dig up annually (3 years)
- Count seedlings that germinate

Seed Addition

How do seeds germinate and compete with competition?

- Sow at different densities
- 2 levels of competition provided by natural weed populations
- Seed production, biomass of switchgrass measured annually

Clonal Competition

Once established, how competitive are individual clones?

- Clonal seedlings planted with ‘high’ or ‘low’ competitor plants (high = *bromus tectorum*; low = *Schizachyrium scoparium)*
- Flowering time, seed set, morphology, biomass monitored
- Combined with other experiments’ results for systems modeling

Quinn LD, Allen DJ, Stewart JR (2010) Invasiveness potential of Miscanthus sinensis: implications for bioenergy production in the United States. *GCB Bioenergy*, **2**, 310-320.

Breeding & management approaches	Non-invasiveness goal	Commercial implications	Invasion risk
Triploid sterility Non-flowering	Preventing seed production	Higher clonal establishment costs or inter-species F1 seed production costs	Lower
Self-incompatibility		Regulatory requirements defining distance from compatible pollen source	
Functional non-flowering due to daylength No functional seed production due to daylength		Regulatory requirements to define planting regions	
Non-shattering seeds "Flightless" seeds	Preventing seed dispersal	Lower seed establishment costs	
Non-germination No survival to maturity	Preventing seed establishment	Higher regulatory risk	
Non-dormancy Inviable vegetative propagules	Ease of eradication	Higher regulatory risk	Higher

Additional references

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Speed Breeding in Action?