

# **Invasives and Biofuels**

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# Biofuel derived substitutes for petroleum

- Two categories of liquid biofuels
  - First generation
    - Ethanol (from plant starch, sugar)
    - Biodiesel (from plant & animal oils)
    - Methanol (wood)
  - Second generation
    - Cellulosic ethanol production
    - Woody plants and grasses

# First Generation Biofuels

- **Examples: Corn, Soybeans, sunflower, sugar cane**
- **Costly: Requires high input of resources**
  - Fertilizer, pesticides, tillage
  - Utilization prime agricultural land
- **Degrades natural resources**
  - Dead zone in the Gulf of Mexico
- **Human food chain**
- **Generally, will not persist without human intervention**
  - Rarely invasive



# Second Generation Biofuels

- Uses grasses, herbs, and trees
- Grown on marginal, lower productivity land
- Neutral to negative carbon budget
- Low resource demand (fertilizer, pesticides)
- Not in human food chains
- Perennial Crops
  - Once planted they will persist
  - Can be invasive

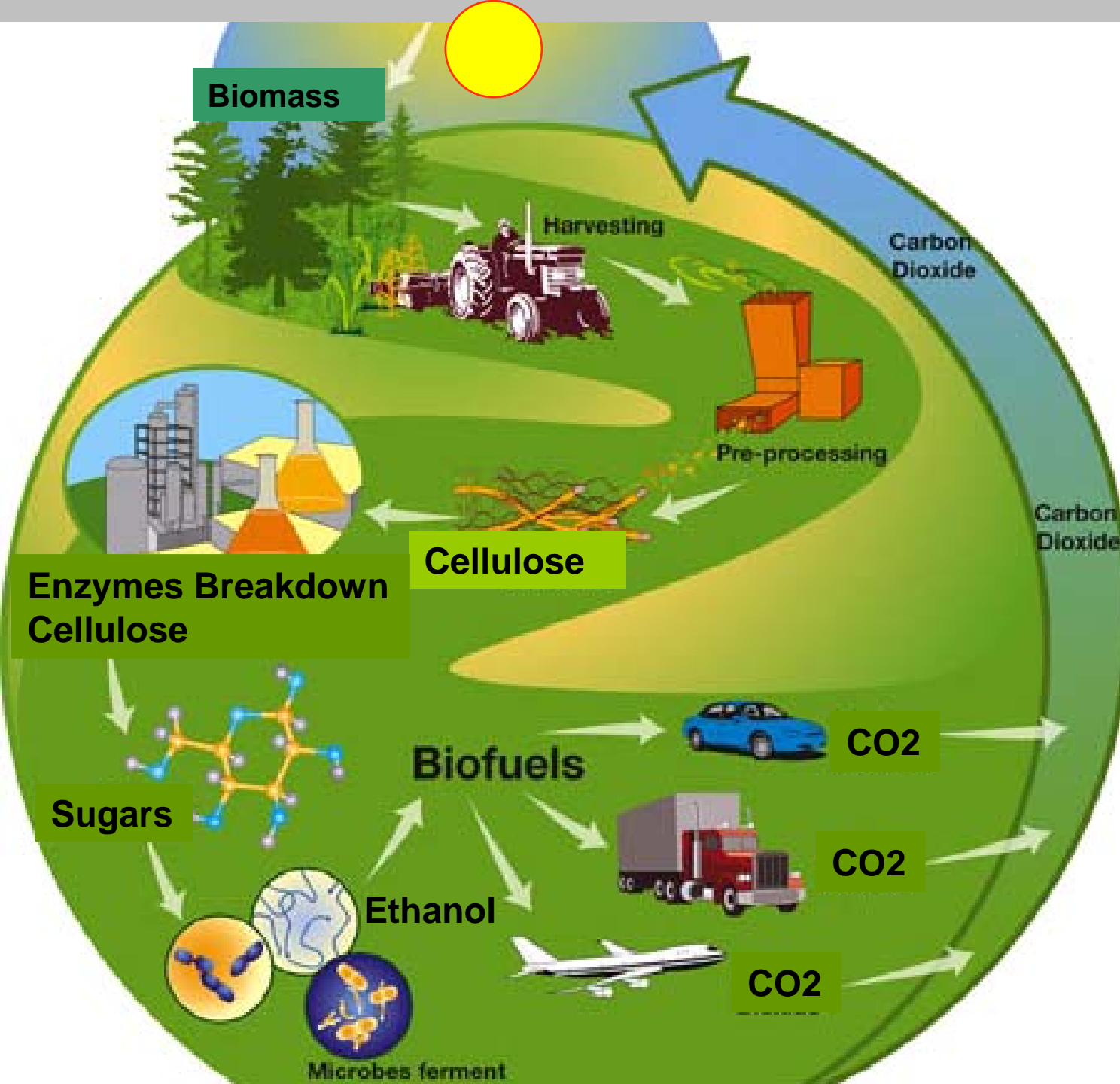


*Miscanthus giganteus*



Switchgrass

# Second Generation Biofuels



# Fossil Energy Requirements of Different Fuels



# Desirable Characteristics of Biofuel Plants

- C 4 photosynthesis
- Long canopy duration
- Perennial
- No known pests or diseases
- Rapid growth in spring -(to outcompete weeds)
- Sterility
- High water-use efficiency
- Partition nutrients belowground in the fall

# Two Potential Conflicts in the Nation's Biofuel Program



**Call for energy independence**

**Invasive Species Executive Order**

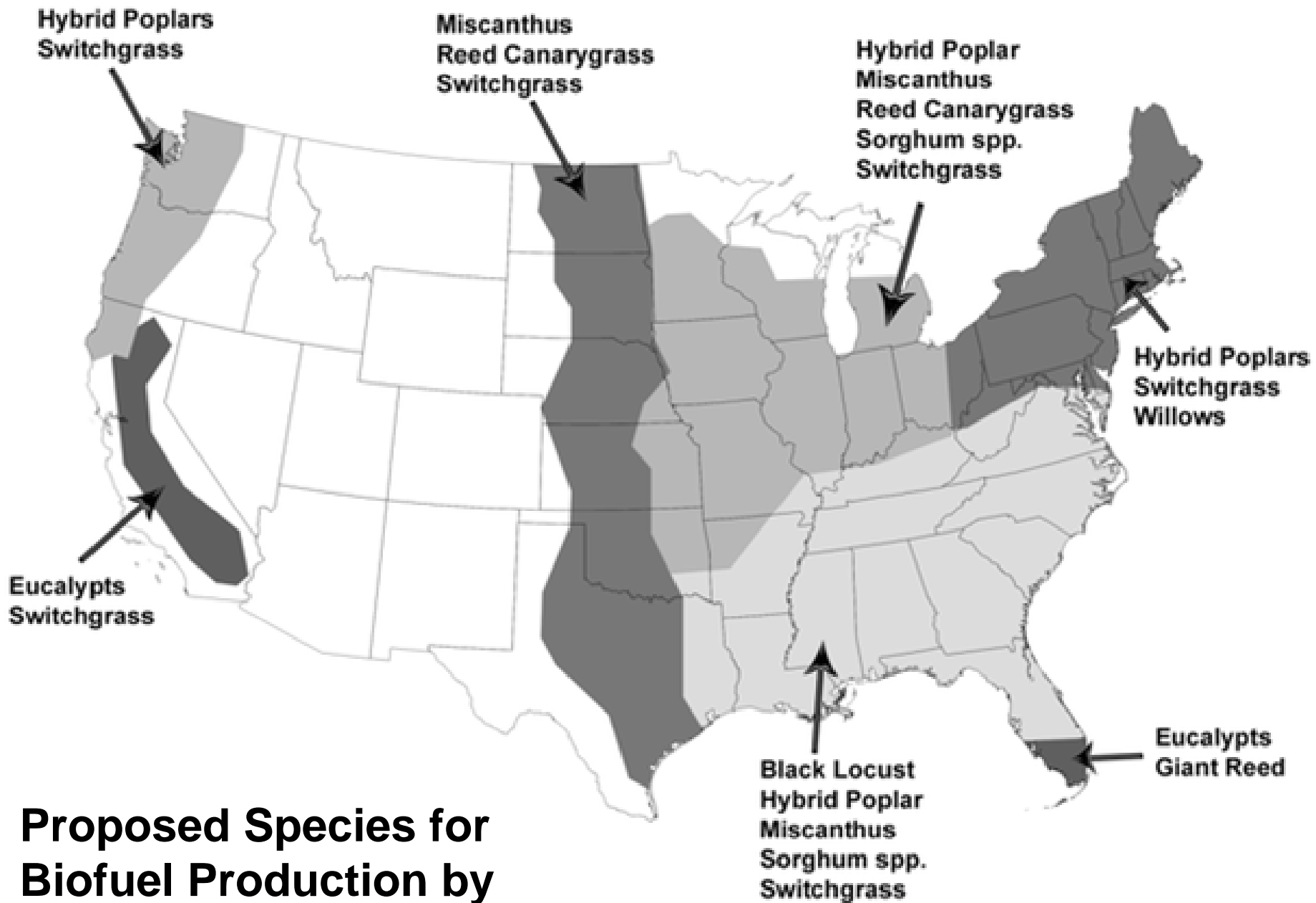
# Call for Energy Independence

- “We must continue investing in new methods of producing ethanol, using everything from wood chips, to grasses, to agricultural wastes...Let us build on the work we’ve done and reduce gasoline usage in the United States by 20 percent in the next 10 years...”
- *-2007 State of the Union Address*

# Reducing Effect of Invasive Species

Executive order 13112

(3) Federal agencies shall “not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of **invasive species** in the United States or elsewhere unless, pursuant to guidelines that it has prescribed, **the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species**; and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions.”



**Proposed Species for  
Biofuel Production by  
Region**

**U.S. Dept. of Energy 2007**

# Genetically Modified Biofuel Plants

- **Eucalypts**
  - Cold tolerance
  - ArboGen: reduced lignin and insecticidal properties?
  - Invasive eucalypts
    - Australia, South Africa
    - ***Eucalyptus globulus*** (blue gum)  
California
- **Hybrid poplars**
  - Male sterility
  - Reduced lignin
- No history for these genotypes

Blue Gum



# The ones we know: Proposed Biofuel Plants Considered to be invasive or noxious

- **Black locust** –  
California, New England,  
Connecticut,  
Massachusetts
- **Reed canary grass** –  
Northeastern USA,  
Nebraska and the Great  
Plains, Wisconsin,  
Minnesota, Ohio,  
Southern and Western  
USA, Alaska, and others

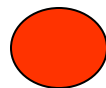
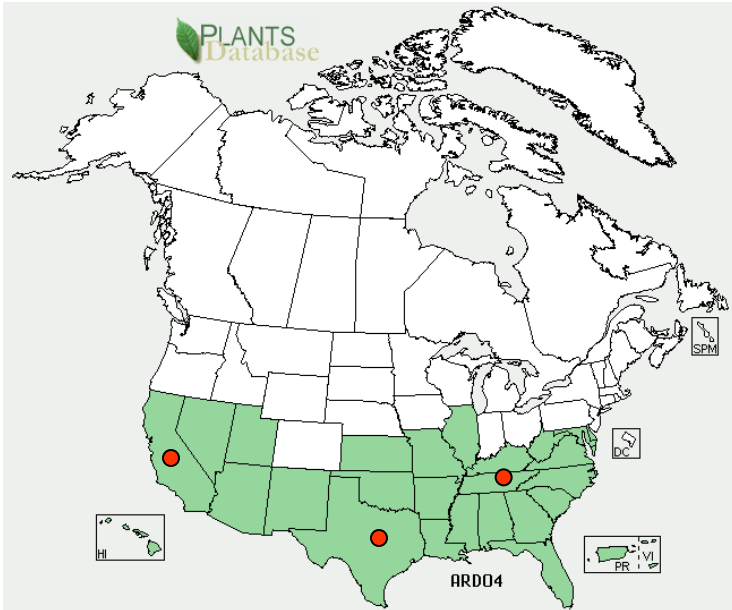
## Black Locust



## Reed Canary Grass



# *Arundo donax* (Giant Reed)



**Invasive Status**

# *Arundo donax*

- Native to freshwaters of eastern Asia
- Widely cultivated
  - Asia, southern Europe, north Africa, and the Middle East for thousands years
- North and South America and Australasia in the 1800's
  - California 1820 – thatch roofs and fodder
  - Reeds for musical instruments
  - Horticultural plantings

# Vegetative Growth and Reproduction

- 8 meter tall
- 20 tons / ha above-ground dry mass
- Reproduction
  - Apparently No viable seed N. America
  - Flood-fragmentation & dispersal of vegetative propagules
  - Rhizome growth extends colony



# Giant Reed Ecology

- Invasive pest throughout the warmer coastal freshwaters of the United States, from Maryland to northern California (Bell 1997).
- Occupies riparian habitats
  - Alters hydrological Regimes
  - Transpires large amounts of water
  - Outcompetes native vegetation
    - Shading
    - Water competition

Giant Reed

*Arundo donax*



# Giant Reed

- **Interferes with levee management**
- **Can increase bank erosion**
- **Increases risk of high intensity fires**
- **No wildlife value**
  - **Federally endangered bird**

**Least Bell's vireo**  
*(Vireo bellii pusillus)*



**Brian E. Small**

**Federally Endangered**

**Reed Grass Displaces Native Riparian  
Shrubs and removes nesting cover**

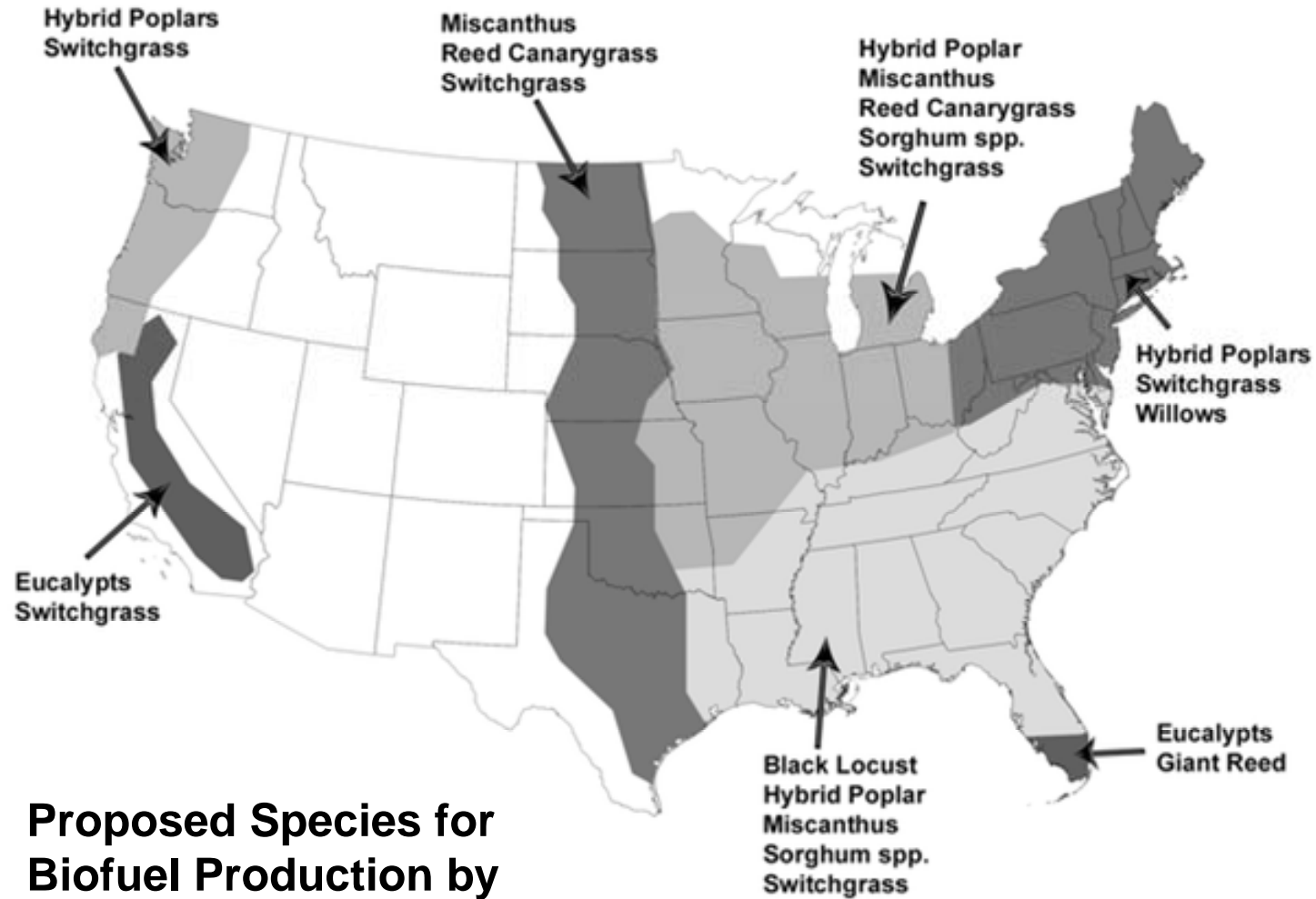
**Willow flycatcher**  
*(Empidonax traillii eximus)*



**Steve Zack**

**Federally Threatened**

# Where will Reed Grass be used as a biofuel?

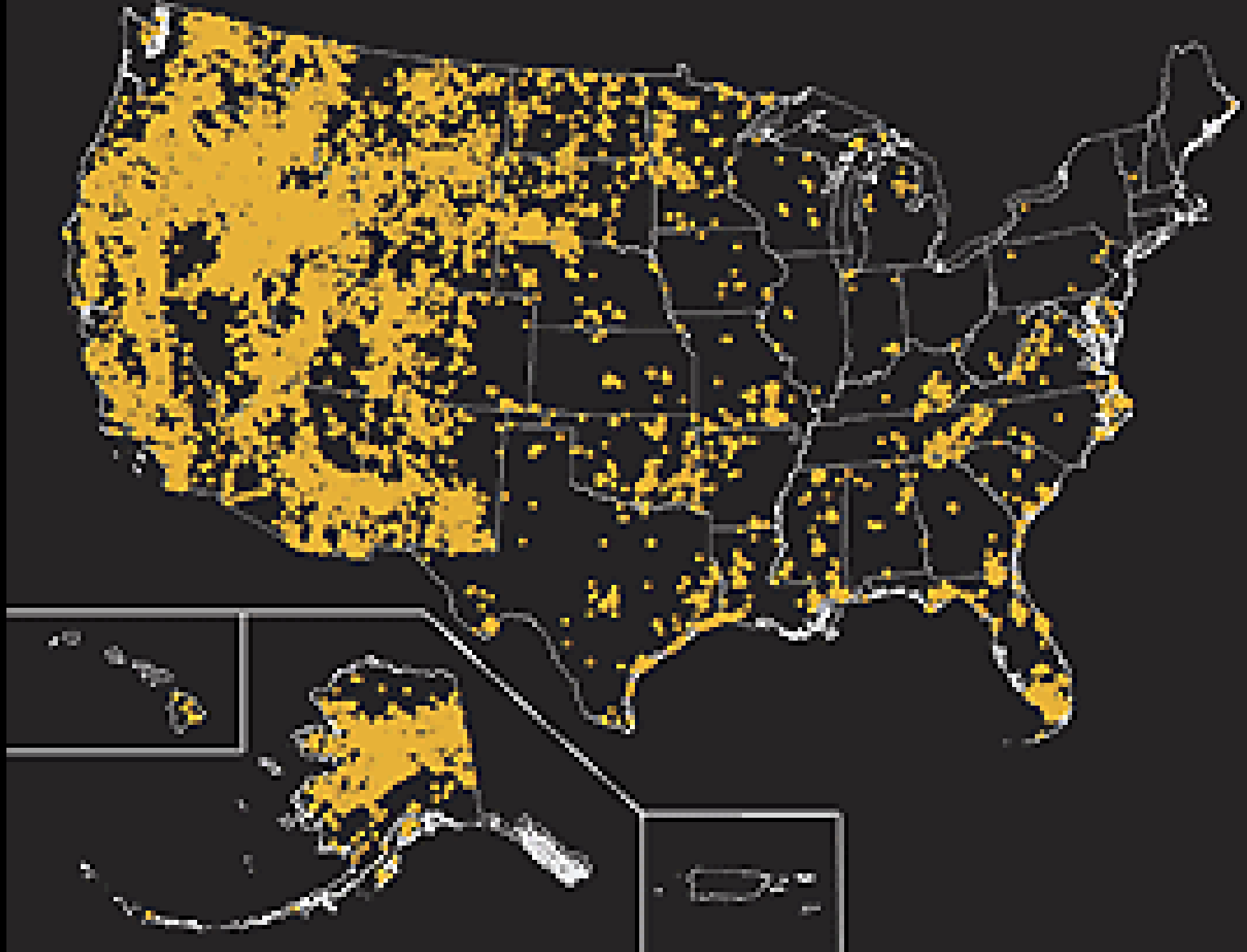


**Proposed Species for Biofuel Production by Region**

# S. Central FL Lots of Waterways and drainage – Close to Everglades

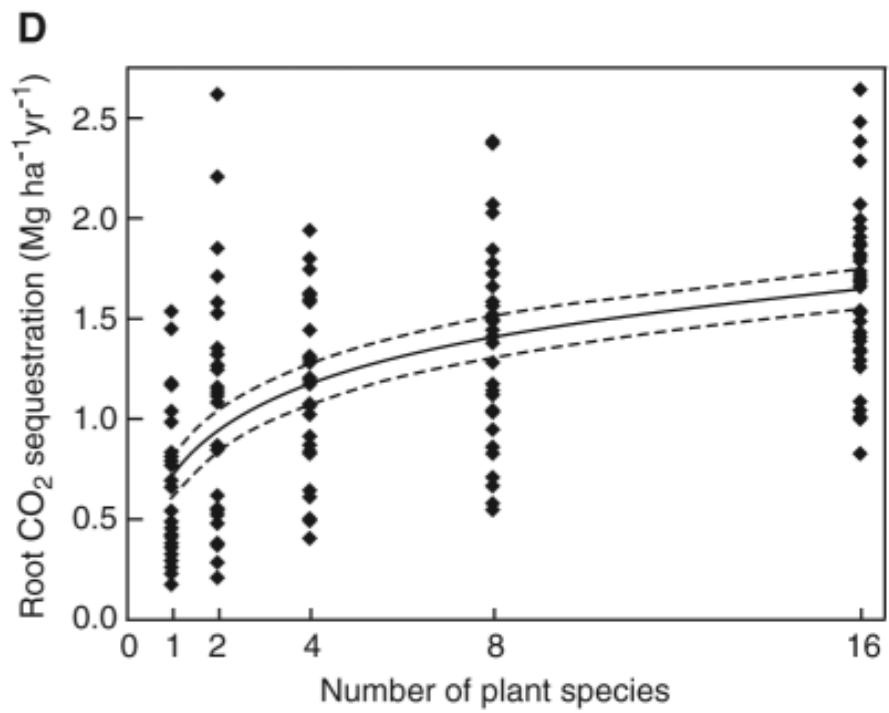
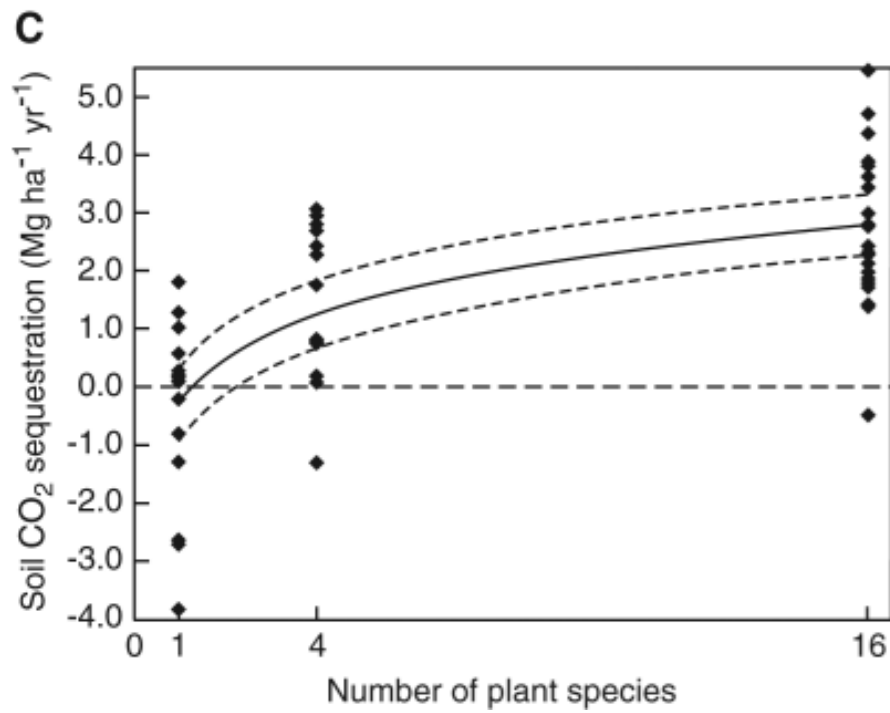
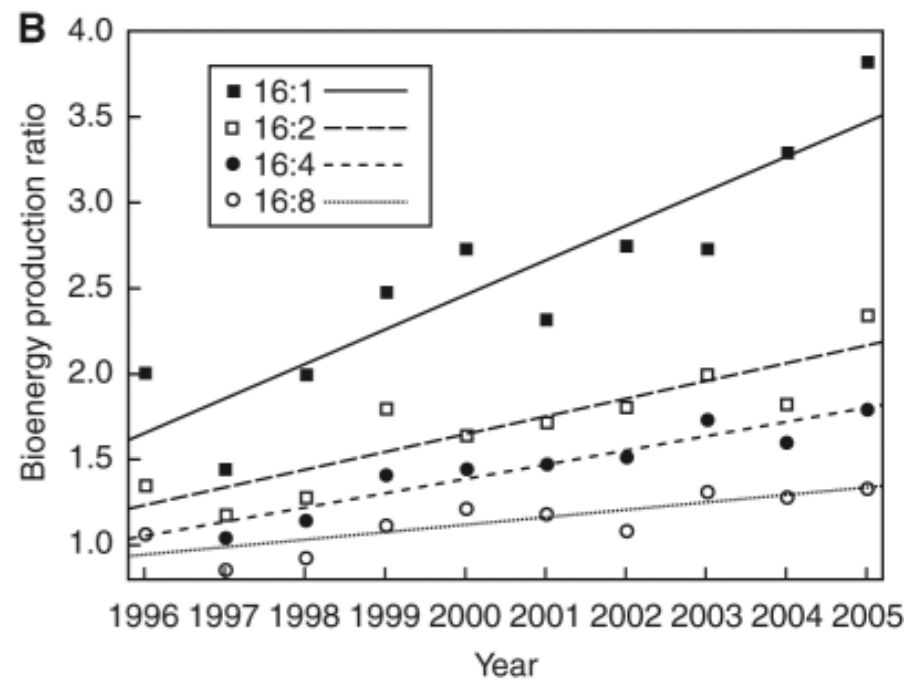
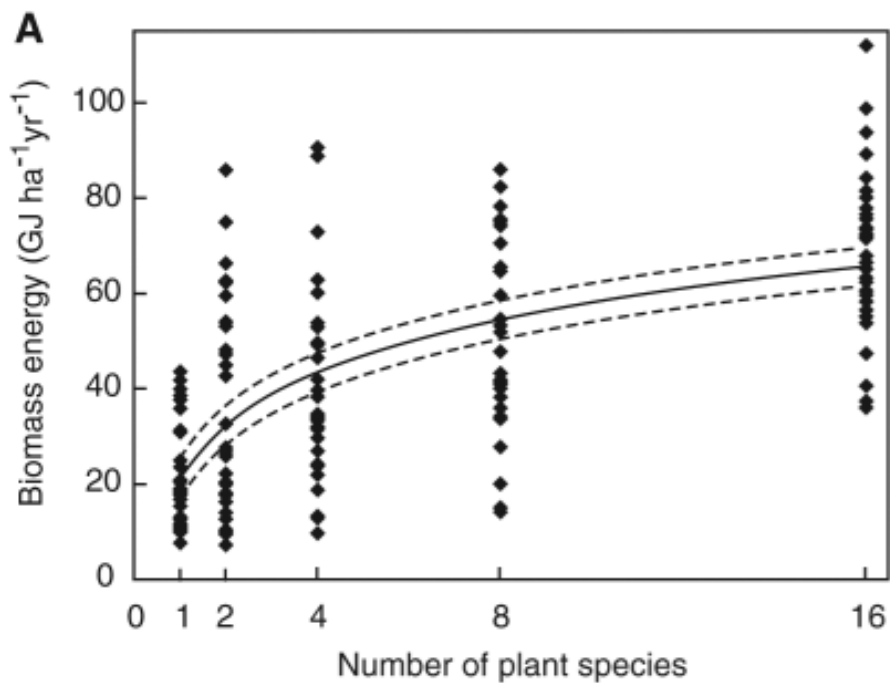


# Fires on Natural USA Land 1980-2003



# Monocultures of Native Grasses

- **Selected variety of native prairie grasses**
- **Grow well in cultivated plots and produce more biomass than local strains**
- **Diverse mixtures of prairie plantings forbs and grasses may do better in Low input systems**
- **Tilman et al. 2006 Science 314: Carbon-Negative Biofuels from Low-Input High-Diversity Grassland Biomass**



“Native Cultivars” may be invasive outside and within their historic geographic range

- Experimental studies indicate that Switchgrass has great potential to be invasive in California (Barney and DiTomaso 2008, ESA Meetings)
- Cultivars of switchgrass can dominate restorations and potentially could disrupt native prairie remnants

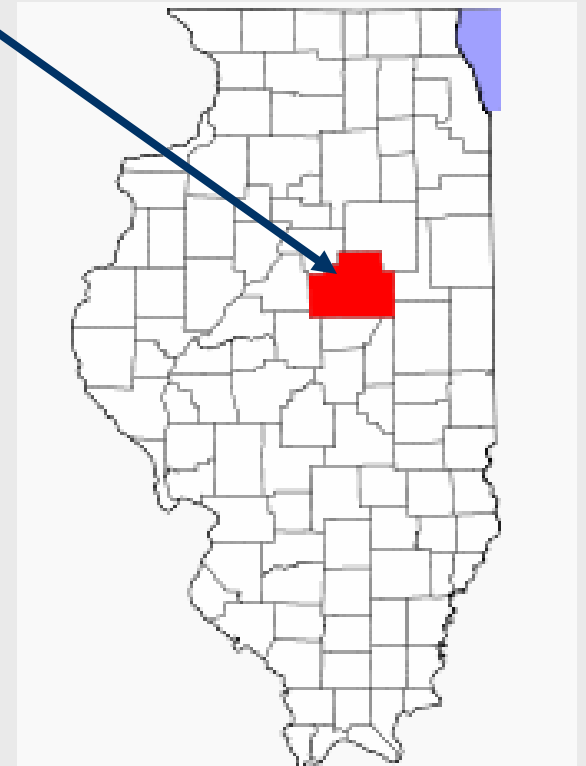
*Panicum virgatum*  
“Not your father’s Switchgrass”

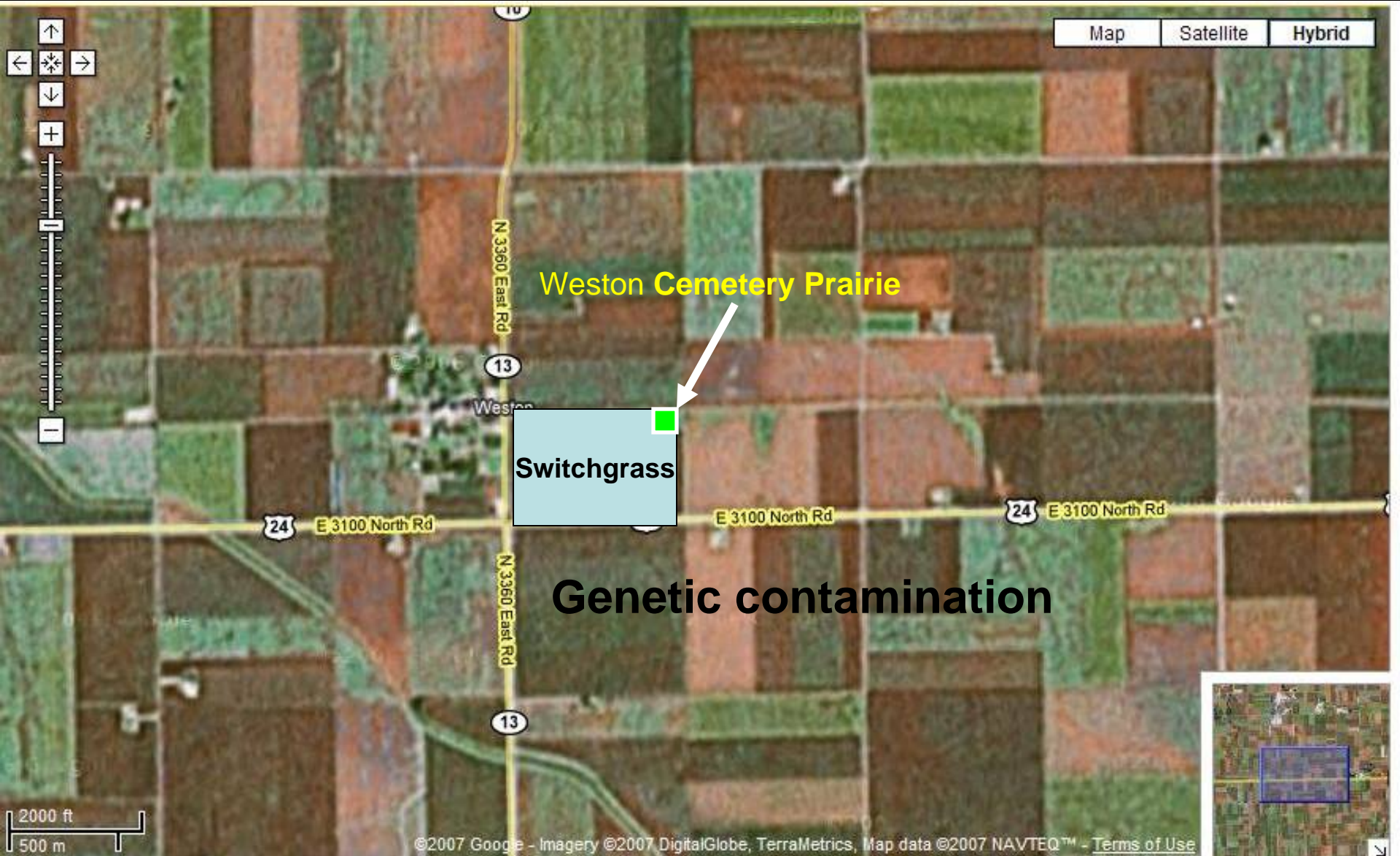




McLean County

- **McLean County**
- **Total: 759,040 Acres**
- **Original Prairie: 683,136 Acres**
- **Remaining High Quality 4 acres**





Map Satellite Hybrid

Weston Cemetery Prairie

Switchgrass

Genetic contamination

# Weston Cemetery Prairie





# Evaluating Invasive Potential

- **Weed Assessment Model (Pheloung *et al.* 1999. J. of Environ. Mangmt.)**
- **Developed in Australia for screening plant introductions (now adapted for HI, FL, CA)**
  - **49 questions (yes or No)**
  - **Scores**
    - **< 1 = acceptable – low risk**
    - **1-6 = require evaluation**
    - **>6 Should be rejected**
- **Quarantined Field evaluation**

# WRA scores for biofuel crop candidates

<u>Score</u>	<u>Outcome</u>
<1	Accept
1-6	Evaluate
>6	Reject

- *Miscanthus x giganteus*: 4

- Switchgrass: 14
- *Arundo donax*: 24

Dr. Adam Davis

USDA-ARS, Invasive Weed Management Unit

UIUC Crop Sciences Department

## Biology/Ecology

A	<b>4</b> <i>Undesirable traits</i>	4.01	Produces spines, thorns or burrs
C		4.02	Allelopathic
C		4.03	Parasitic
A		4.04	Unpalatable to grazing animals
C		4.05	Toxic to animals
C		4.06	Host for recognised pests and pathogens
C		4.07	Causes allergies or is otherwise toxic to humans
E		4.08	Creates a fire hazard in natural ecosystems
E		4.09	Is a shade tolerant plant at some stage of its life cycle
E		4.10	Grows on infertile soils
E		4.11	Climbing or smothering growth habit
E		4.12	Forms dense thickets

# Weed Assessment Model

## 49 Questions

- Domestication/cultivation (3)
- Climate and Distribution (5)
- Weed elsewhere (5)
- Undesirable traits (12)
- Plant type (4)
- Reproduction (7)
- Dispersal Mechanism (8)
- Persistence attributes (5)
- Phelough et al. 1999. J. of Environ. Mangmt.

# Weed Risk Assessment system

(Pheloung et al. 1999)

- Developed in Australia for screening plant introductions (now adapted for HI, FL, CA)
- Composed of 49 T/F questions about species traits:
- Model trained using data set of 370 species
- Test sensitivity: 90% correct classification

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<http://www.daffa.gov.au/ba/reviews/weeds/system>