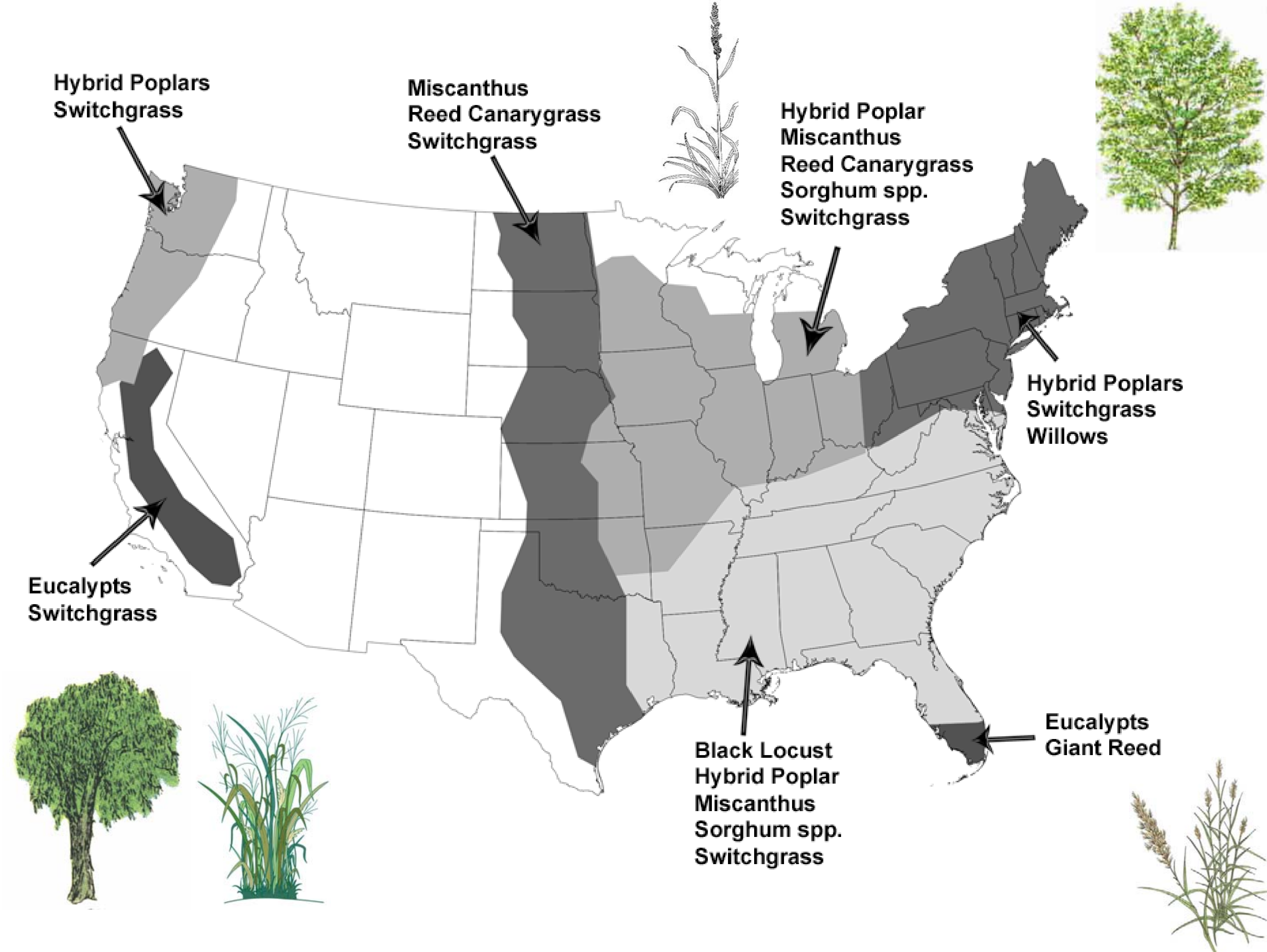
Risky Energy: Biofuels and Invasive Species

Jacob Barney, Joseph DiTomaso
University of California
Davis, CA

UCDAVIS
UNIVERSITY OF CALIFORNIA

Policy Initiatives Related to Bioenergy

- **Federal:**
  - “20 in 10”
    - Reduce gasoline usage by 20% in 10 years
    - 35 billion gallons renewable/alternative fuels in 2017
  - “30 by ‘30” = “Billion Ton Report”
    - Replace 30% of petroleum with biofuels by 2030
- **California:**
  - AB 32 “*Global Warming Solutions Act*”
    - Reduce GHG emissions to 1990 levels by 2020
  - Executive Order S-06-06
    - 20% of electricity be biomass-derived by 2020
    - In-state biofuel production: 20% - 2010, 40% - 2020, 75% - 2050
  - Executive Order S-01-07
    - Low Carbon Fuel Standard - transportation fuels
    - “2020 Target” - reduce carbon intensity by 10%



Hybrid Poplars
Switchgrass
Miscanthus
Reed Canarygrass
Switchgrass
Hybrid Poplar
Miscanthus
Reed Canarygrass
Sorghum spp.
Switchgrass
Hybrid Poplars
Switchgrass
Willows
Eucalypts
Switchgrass
Black Locust
Hybrid Poplar
Miscanthus
Sorghum spp.
Switchgrass
Eucalypts
Giant Reed

Panicum virgatum

Miscanthus × giganteus

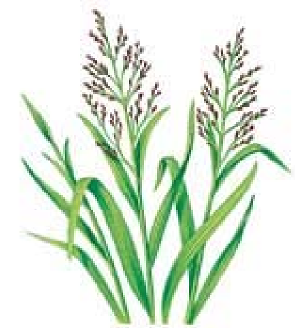
Arundo donax

Crops grown for energy:

- **Life history**
  - Perennial
  - High aboveground biomass production
  - Flowers late / little allocation to seed production
- **Physiology**
  - Tolerates
    - Drought
    - Low fertility
    - Saline soils
  - C_4 photosynthetic pathway
  - High water/nutrient use efficiency
- **Other**
  - Few residents pests
  - Allelopathic
  - Re-allocates nutrients to roots in fall

Crops grown for energy:

- **Life history**
  - Perennial
  - High aboveground biomass production
  - Flowers late / little allocation to seed production
- **Physiology**
  - Tolerates
    - Drought
    - Low fertility
    - Saline soils
  - C_4 photosynthetic pathway
  - High water/nutrient use efficiency
- **Other**
  - Few residents pests
  - Allelopathic
  - Re-allocates nutrients to roots in fall



	Agronomic crops		Potential biofuel feedstocks		Invasive species with agronomic origin
	Corn	Soybean	Switchgrass	Giant Reed	Johnsongrass
Perennial	-	-	X	X	X
C_4 photosynthesis	X	-	X	-	X
Rapid establishment rate	X	X	X	X	X
Long canopy duration	X	-	X	X	X
Grows at high densities	-	-	X	X	X
Tolerates water stress	-	-	X	-	-
Tolerates low fertility soils	-	-	X	X	X
Tolerates saline soils	-	-	*	*	-
Re-allocates nutrients to perennating structures in fall	-	-	X	X	X
No major pests/diseases	-	-	X	X	X

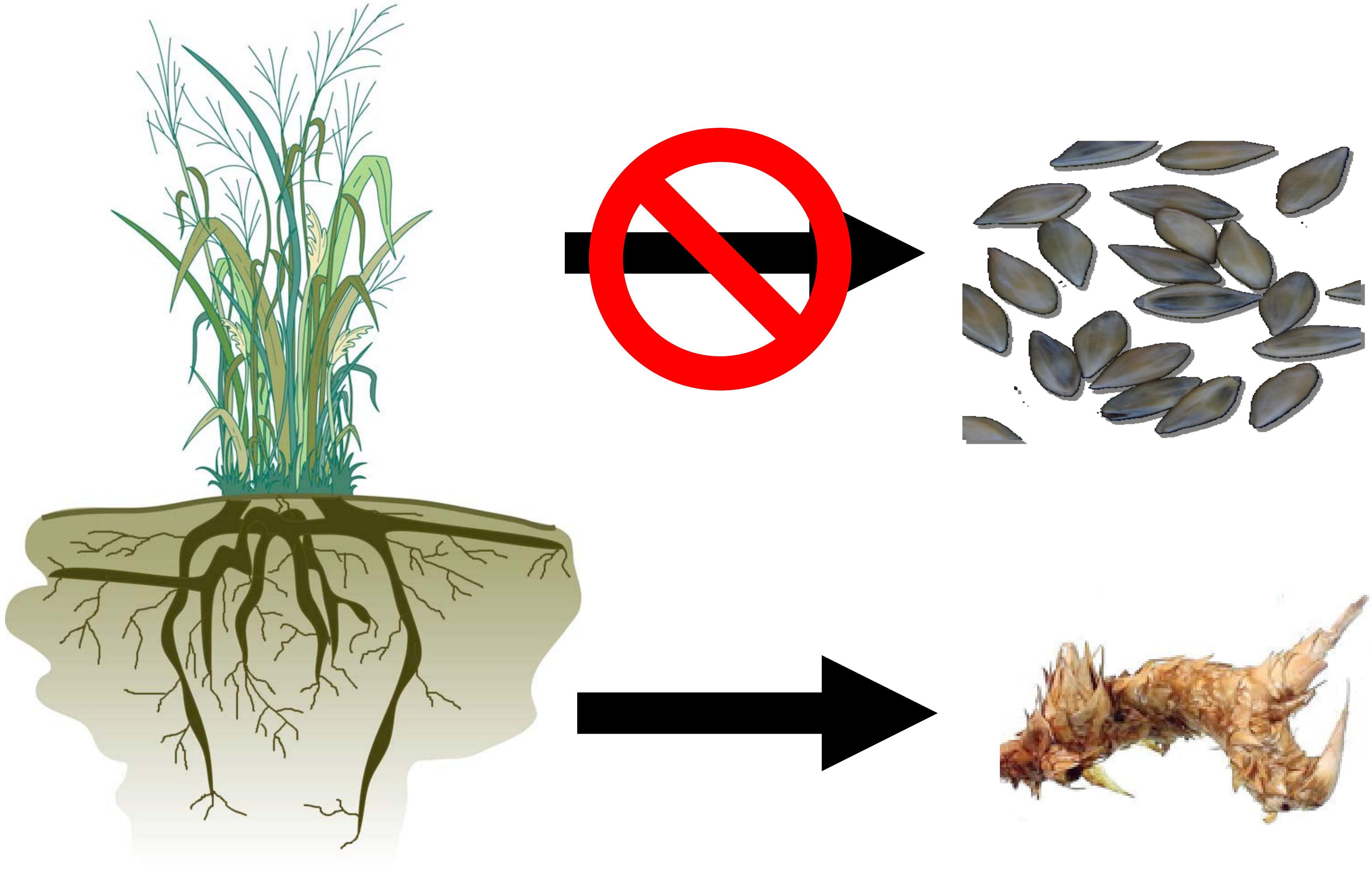
How Will Genetic Modification Affect Potential Invasiveness?

- **Yield Improvement**
- **Crop adaptation to marginal lands**
- **Increase amenability to bio-processing**
- **Multi-product development**

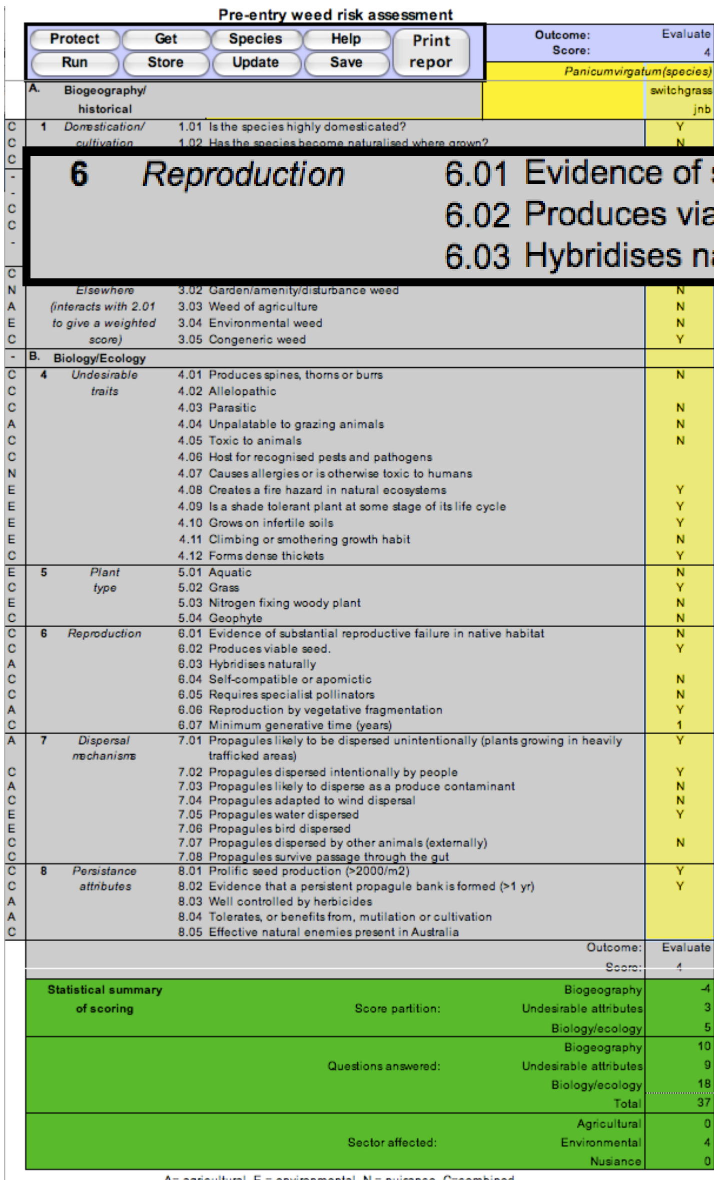
- **Drought tolerance**
- **Salt tolerance**
- **Herbicide resistance**
- **Increased cellulose content**
- **Increased yield**
- **Water-use-efficiency**
- **Nutrient-use-efficiency**

Drought tolerance

Minimizing risk: sterilization



Weed Risk Assessment



Pre-entry weed risk assessment

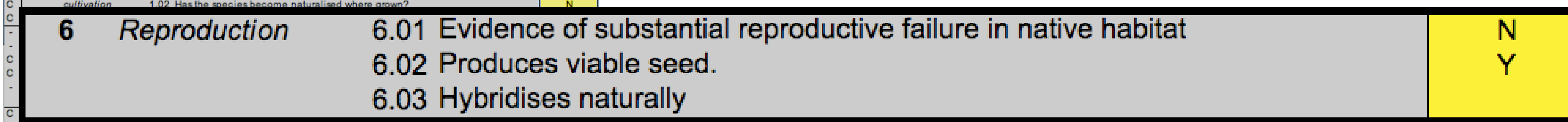
Protect | Get | Species | Help | Print repor
Run | Store | Update | Save

Outcome: Evaluate
Score: 4
Panicumvirgatum(species) switchgrass jnb

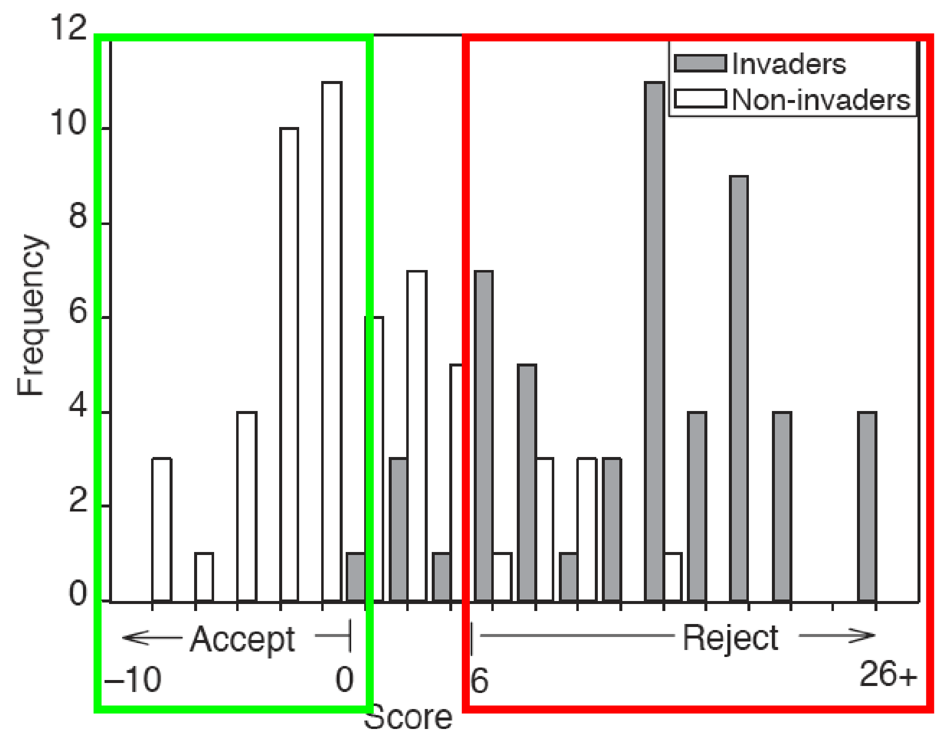
	A.	Biogeography/ historical		
C	1	Domestication/ cultivation	1.01 Is the species highly domesticated?	Y
C			1.02 Has the species become naturalised where grown?	N
C		Elsewhere	3.02 Garden/amenity/disturbance weed	N
N		(interacts with 2.01	3.03 Weed of agriculture	N
A		to give a weighted	3.04 Environmental weed	N
E		score)	3.05 Congeneric weed	Y
-	B.	Biology/Ecology		
C	4	Undesirable traits	4.01 Produces spines, thorns or burrs	N
C			4.02 Allelopathic	
C			4.03 Parasitic	N
A			4.04 Unpalatable to grazing animals	N
C			4.05 Toxic to animals	N
C			4.06 Host for recognised pests and pathogens	
N			4.07 Causes allergies or is otherwise toxic to humans	
E			4.08 Creates a fire hazard in natural ecosystems	Y
E			4.09 Is a shade tolerant plant at some stage of its life cycle	Y
E			4.10 Grows on infertile soils	Y
E			4.11 Climbing or smothering growth habit	N
C			4.12 Forms dense thickets	Y
E	5	Plant type	5.01 Aquatic	N
C			5.02 Grass	Y
E			5.03 Nitrogen fixing woody plant	N
C			5.04 Geophyte	N
C	6	Reproduction	6.01 Evidence of substantial reproductive failure in native habitat	N
C			6.02 Produces viable seed.	Y
A			6.03 Hybridises naturally	
C			6.04 Self-compatible or apomictic	N
C			6.05 Requires specialist pollinators	N
A			6.06 Reproduction by vegetative fragmentation	Y
C			6.07 Minimum generative time (years)	1
A	7	Dispersal mechanisms	7.01 Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)	Y
C			7.02 Propagules dispersed intentionally by people	Y
A			7.03 Propagules likely to disperse as a produce contaminant	N
C			7.04 Propagules adapted to wind dispersal	N
E			7.05 Propagules water dispersed	Y
E			7.06 Propagules bird dispersed	
C			7.07 Propagules dispersed by other animals (externally)	N
C			7.08 Propagules survive passage through the gut	
C	8	Persistance attributes	8.01 Prolific seed production (>2000/m2)	Y
C			8.02 Evidence that a persistent propagule bank is formed (>1 yr)	Y
A			8.03 Well controlled by herbicides	
A			8.04 Tolerates, or benefits from, mutilation or cultivation	
C			8.05 Effective natural enemies present in Australia	

		Outcome:	Evaluate
		Score:	4
Statistical summary of scoring	Score partition:	Biogeography	-4
		Undesirable attributes	3
		Biology/ecology	5
	Questions answered:	Biogeography	10
		Undesirable attributes	9
		Biology/ecology	18
		Total	37
	Sector affected:	Agricultural	0
		Environmental	4
		Nusiance	0

A= agricultural, E = environmental, N = nuisance, C=combined



6	Reproduction	6.01 Evidence of substantial reproductive failure in native habitat	N
		6.02 Produces viable seed.	Y
		6.03 Hybridises naturally	



from Daehler et al. 2000

Policy Implications

- No restrictions unless state/federal noxious weed
- **Senate Bill 1242** - Jon Tester [D-MT]
  - Amend Federal Crop Insurance Act & Farm Security and Rural Investment Act of 2002
  - Crop insurance and loans
  - “*information [exists] to demonstrate that there are sufficient safeguards to prevent the spread of the crop as a noxious weed*”

Policy Implications

Horticulture - ***St. Louis Declaration 2001***

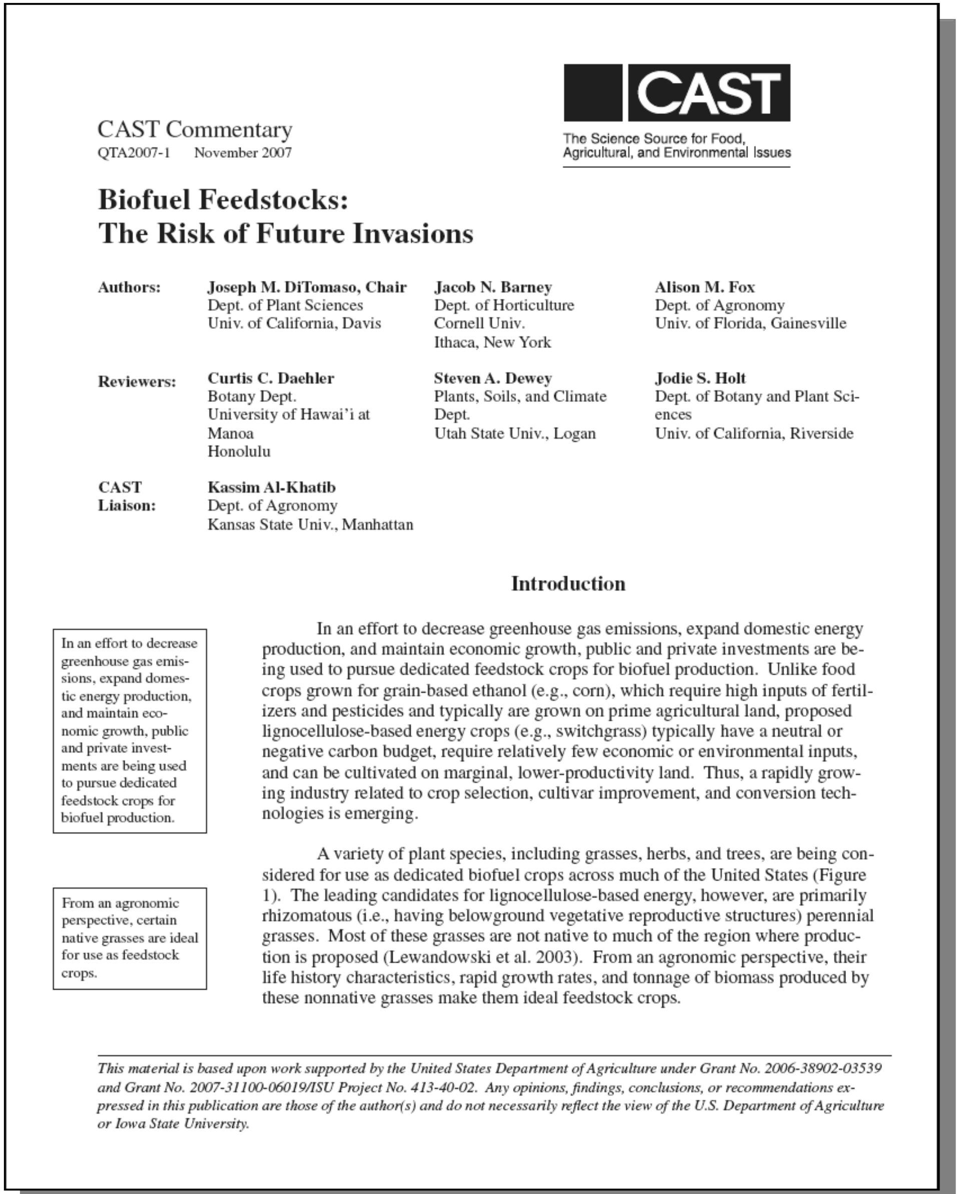
1. ***Findings and Principles***
2. ***Voluntary Codes of Conduct***
   - **Government**
   - **Nursery Professionals**
   - **The Gardening Public**
   - **Landscape Architects**
   - **Botanic Garden and Arboreta**

"self-governance, self-regulation"

Meeting of researchers, nursery professionals, landscape architects, government officials, garden writers

How do we prevent cultivating the next invader?

1. Risk assessment
2. Climate-matching analysis
3. Cross-hybridization potential
4. Escape potential
   - Seed / rhizome
5. Ecological analyses
   - Disturbance tolerance
   - Community invasibility
6. Create eradication plan



CAST

The Science Source for Food, Agricultural, and Environmental Issues

CAST Commentary

QTA2007-1 November 2007

Biofuel Feedstocks:
The Risk of Future Invasions

Authors:	**Joseph M. DiTomaso, Chair** Dept. of Plant Sciences Univ. of California, Davis	**Jacob N. Barney** Dept. of Horticulture Cornell Univ. Ithaca, New York	**Alison M. Fox** Dept. of Agronomy Univ. of Florida, Gainesville
Reviewers:	**Curtis C. Daehler** Botany Dept. University of Hawai'i at Manoa Honolulu	**Steven A. Dewey** Plants, Soils, and Climate Dept. Utah State Univ., Logan	**Jodie S. Holt** Dept. of Botany and Plant Sciences Univ. of California, Riverside
CAST Liaison:	**Kassim Al-Khatib** Dept. of Agronomy Kansas State Univ., Manhattan		

Introduction

In an effort to decrease greenhouse gas emissions, expand domestic energy production, and maintain economic growth, public and private investments are being used to pursue dedicated feedstock crops for biofuel production.

In an effort to decrease greenhouse gas emissions, expand domestic energy production, and maintain economic growth, public and private investments are being used to pursue dedicated feedstock crops for biofuel production. Unlike food crops grown for grain-based ethanol (e.g., corn), which require high inputs of fertilizers and pesticides and typically are grown on prime agricultural land, proposed lignocellulose-based energy crops (e.g., switchgrass) typically have a neutral or negative carbon budget, require relatively few economic or environmental inputs, and can be cultivated on marginal, lower-productivity land. Thus, a rapidly growing industry related to crop selection, cultivar improvement, and conversion technologies is emerging.

From an agronomic perspective, certain native grasses are ideal for use as feedstock crops.

A variety of plant species, including grasses, herbs, and trees, are being considered for use as dedicated biofuel crops across much of the United States (Figure 1). The leading candidates for lignocellulose-based energy, however, are primarily rhizomatous (i.e., having belowground vegetative reproductive structures) perennial grasses. Most of these grasses are not native to much of the region where production is proposed (Lewandowski et al. 2003). From an agronomic perspective, their life history characteristics, rapid growth rates, and tonnage of biomass produced by these nonnative grasses make them ideal feedstock crops.

This material is based upon work supported by the United States Department of Agriculture under Grant No. 2006-38902-03539 and Grant No. 2007-31100-06019/ISU Project No. 413-40-02. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture or Iowa State University.

"Non-native species and bioenergy: Are we cultivating the next invader?"

jbarney@ucdavis.edu