Biological Control of Cogongrass: Progress and Perspectives

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Outline

- Background on Cogongrass
- Potential for Biological Control
- Research on Natural Enemies
- Cogongrass IPM
- Questions and Comments

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Cogongrass

- *Imperata cylindrica* (L.) Raeuschel (Poaceae)
- Federal Listed Noxious Weed
- Introduced into Southeastern US as Forage Grass
- Invasive in Alabama, Mississippi, & Florida

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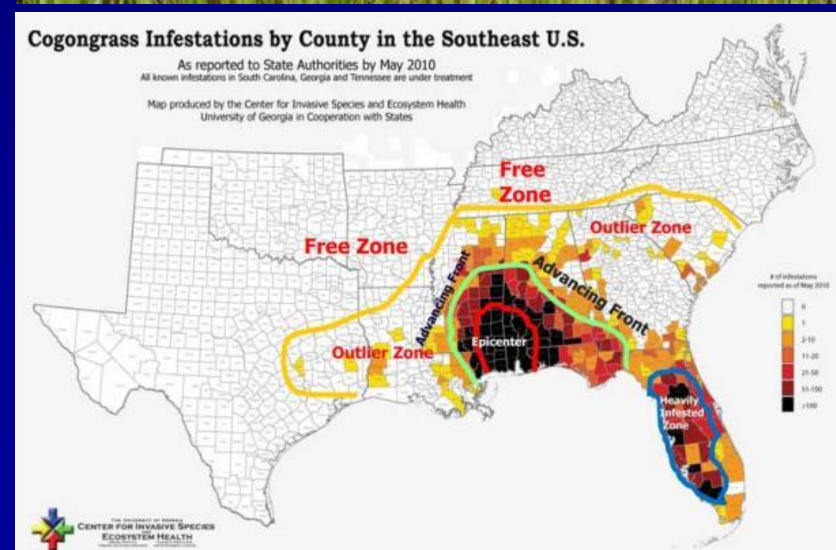
Cogongrass

- **Rhizomatous perennial grass (60% of biomass)**
- **Allelopathic properties**
- **Forms large monocultures**
- **C_4 photosynthesis**
- **Fire adapted – provides fuel for frequent, intense fires**
- **Displaces native, desirable vegetation**
- **Infests > 1.5 million acres in the southeastern USA**



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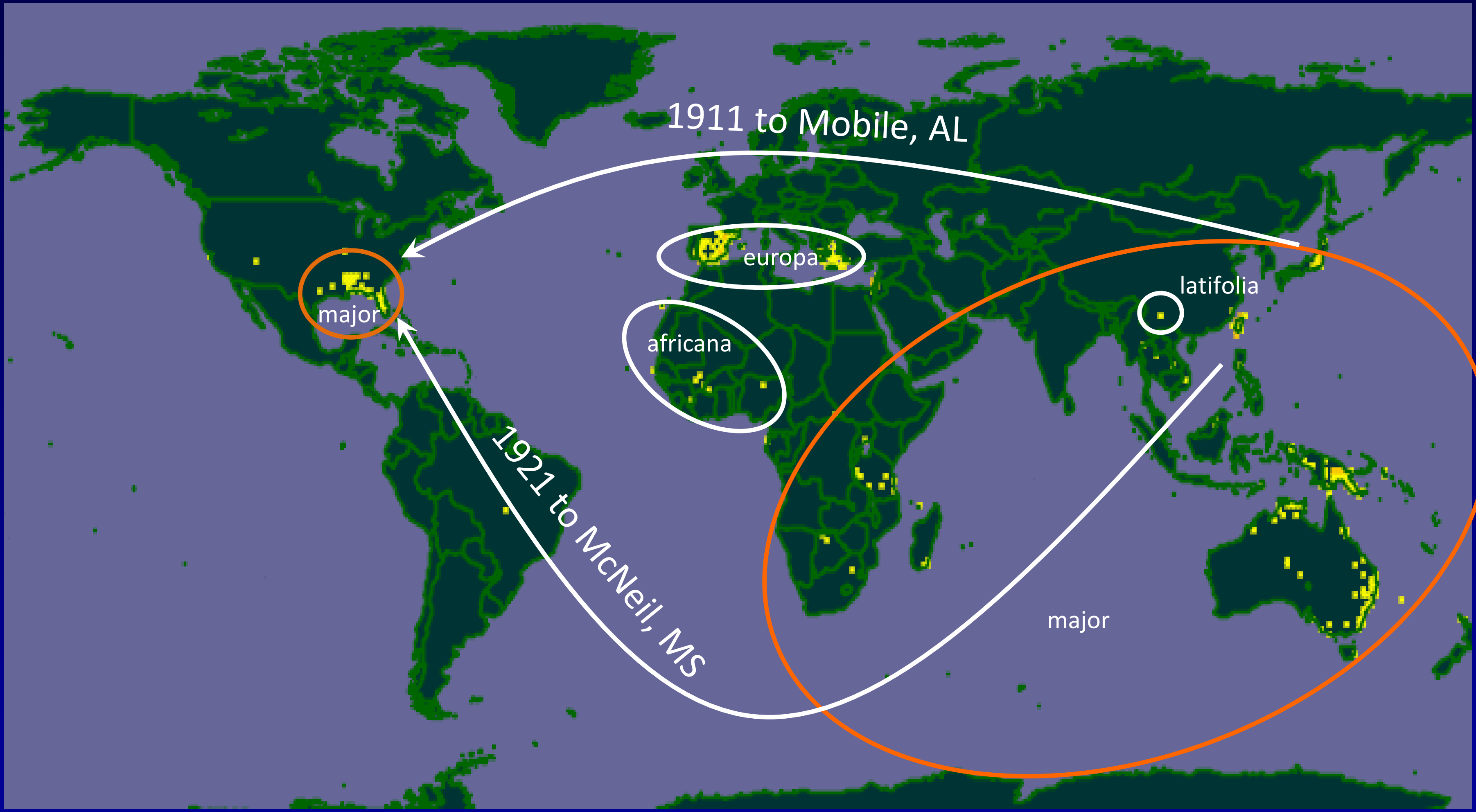
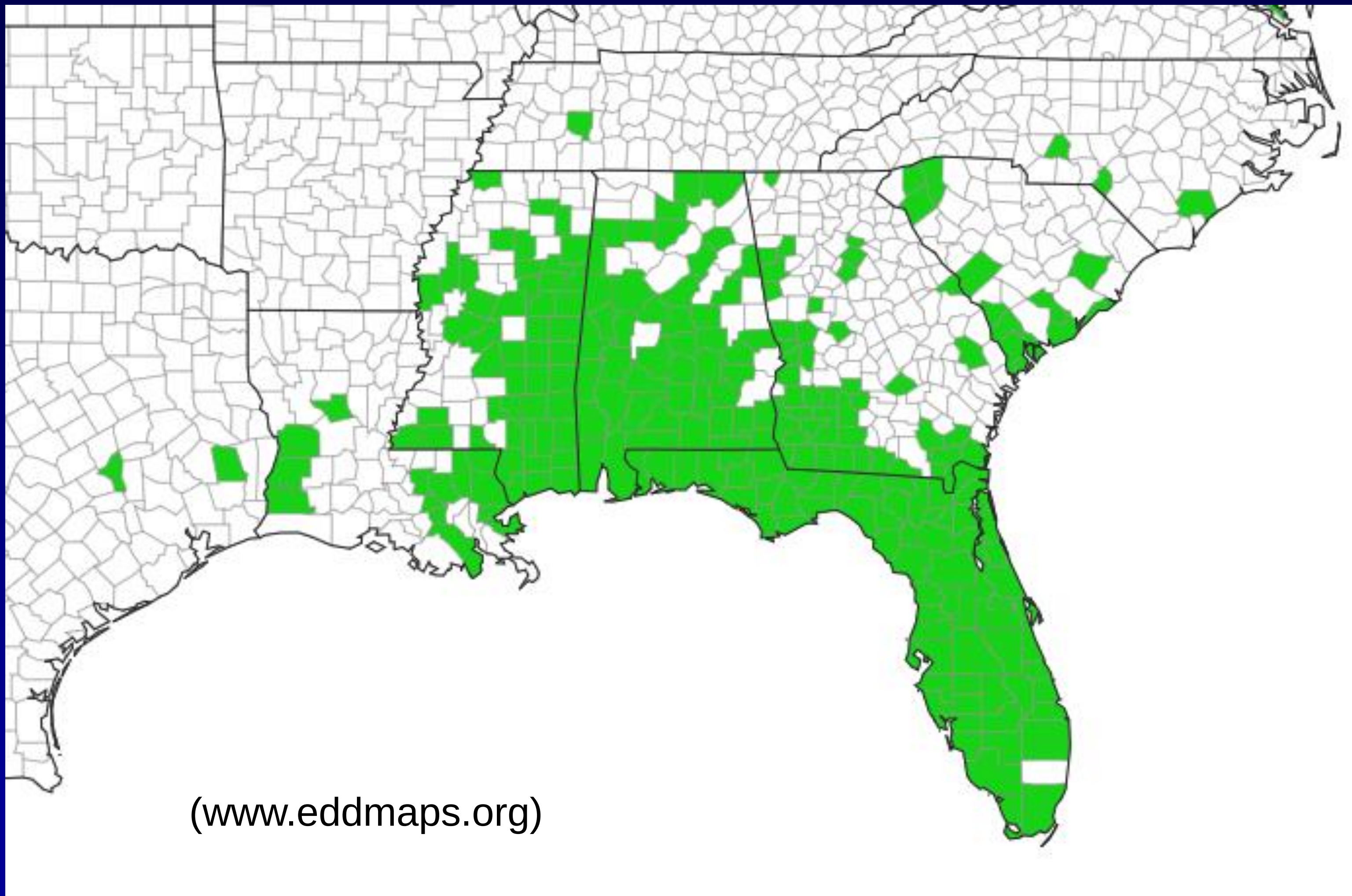
Distribution of *Imperata cylindrica*



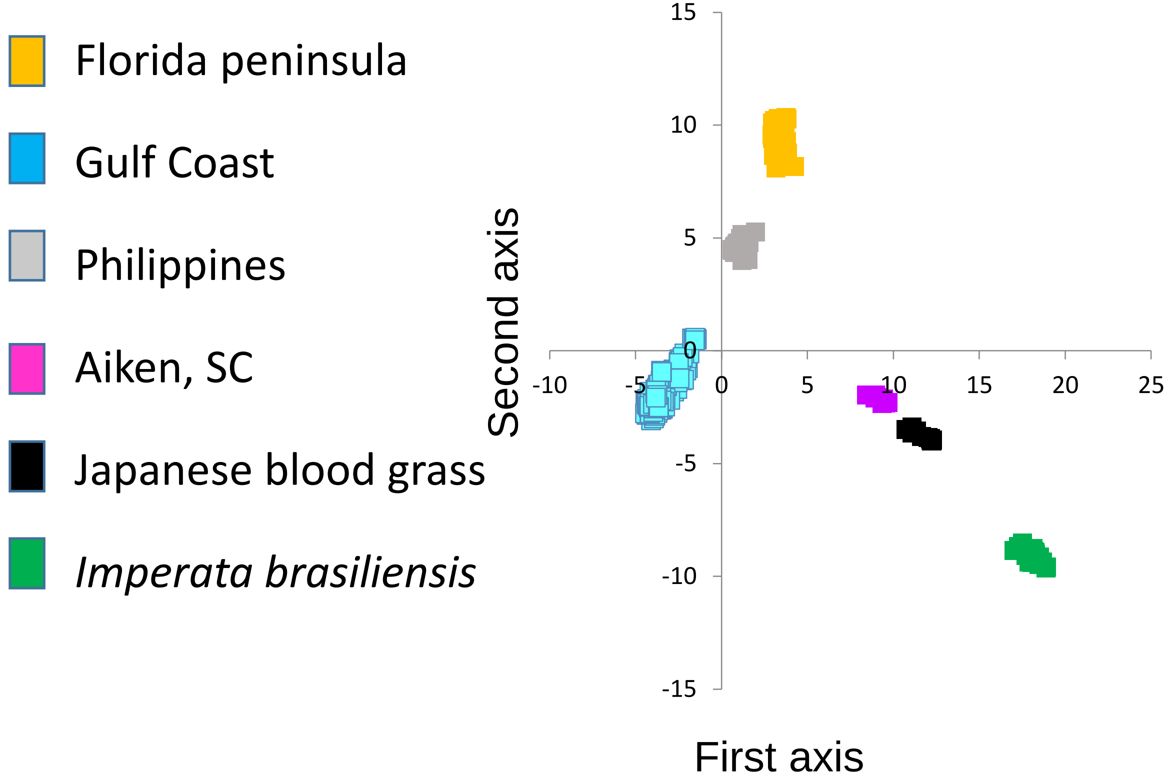
Source: Global Biodiversity Information Facility (gbif.org)

US Distribution



(www.eddmaps.org)

Genetic Diversity of US Cogongrass



Burrell, M., A. E. Pepper, G. Hodnett, J. A. Goolsby, W. A. Overholt, A. E. Racelis, R. Diaz and P. E. Klein. 2015. Exploring origins, invasion history and genetic diversity of *Imperata cylindrica* (L.) P. Beauv. (Cogongrass) in the United States using genotyping by sequencing. Molecular Ecology. DOI: 10.1111/mec.13167.

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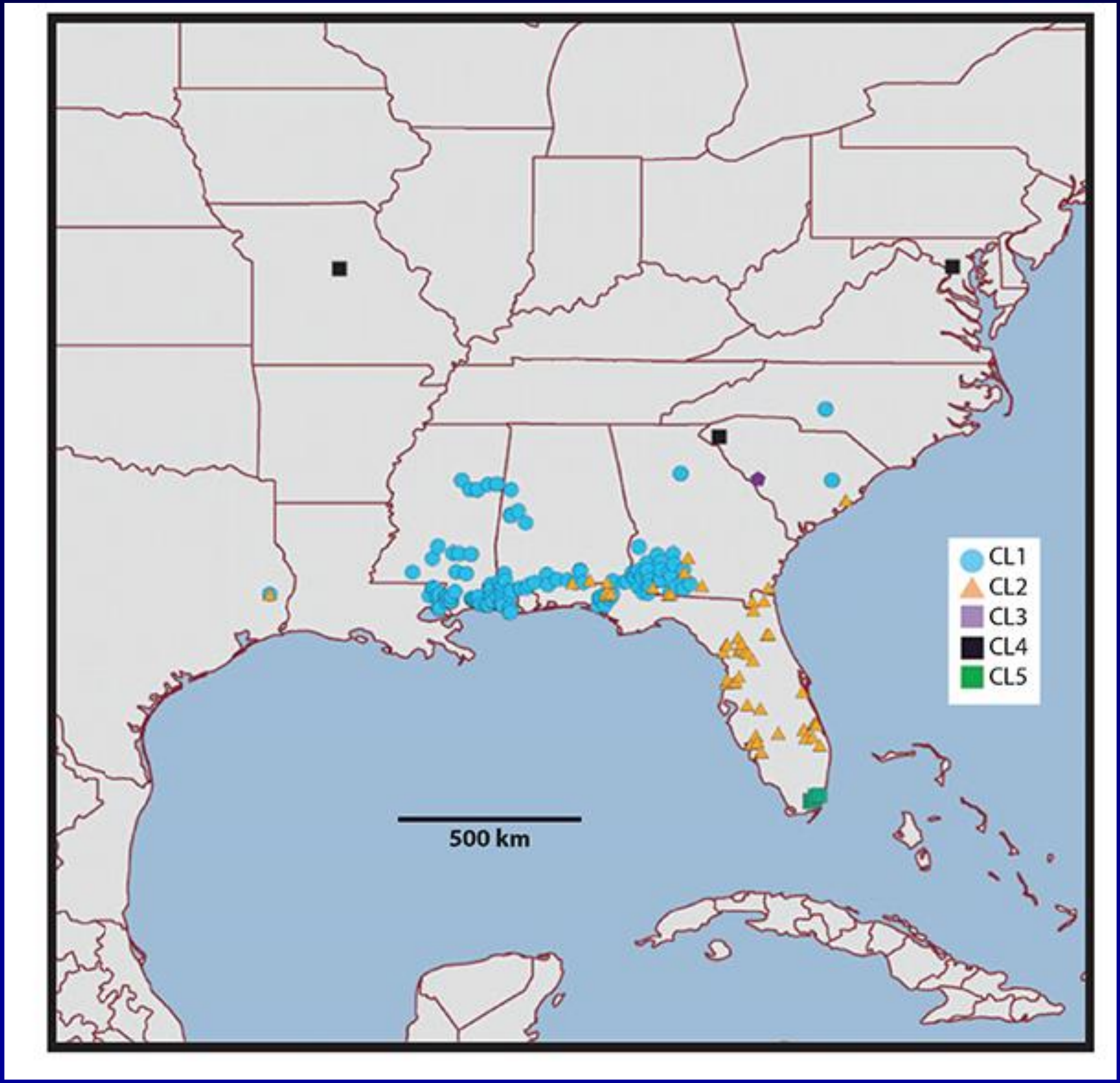
US Distribution by Genotype



Burrell et al. (2015)

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Biological Control

- Use of Living Organisms, Such as Insects, Nematodes, Bacteria, Viruses, or Fungi to Suppress Weed Populations
- Three Approaches:
  - Importation or Classical (Arthropods, Pathogens)
  - Augmentation (Arthropods, Pathogens, Grass Carp)
  - Fortuitous (Adventive Organisms)
- Importation or Classical Approach
  - Most Widely Used Method for Weeds
  - Highly Regulated

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Importation (Classical) BioControl

- **Introduction and Release of *Host Specific* Natural Enemies from the Weed's Native Range to Reduce Its Population Density in the Adventive[1] Range**

[1]Arrived into a specified geographical region from elsewhere by ANY means.

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Rationale for Importation BioControl

- Once Established, Non-Native Invasive Plants often develop High Populations
- Why?
  - Suitable Climate & Geography
  - 'Enemy Release' Hypothesis
    - Escape From Natural Enemies that Regulate Plants in Native Range (Williams 1954)

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Goal of Importation BioControl

- Reunite Natural Enemies with their Hosts (Broad Sense)
- Natural Enemies Introduced to Suppress & Maintain the Density of the Pest at “ACCEPTABLE” Levels
- Important Caveats
  – Biological Control is ***NOT*** Eradication
  – Creates Opportunity to Combine BioControl w/ Other Tactics

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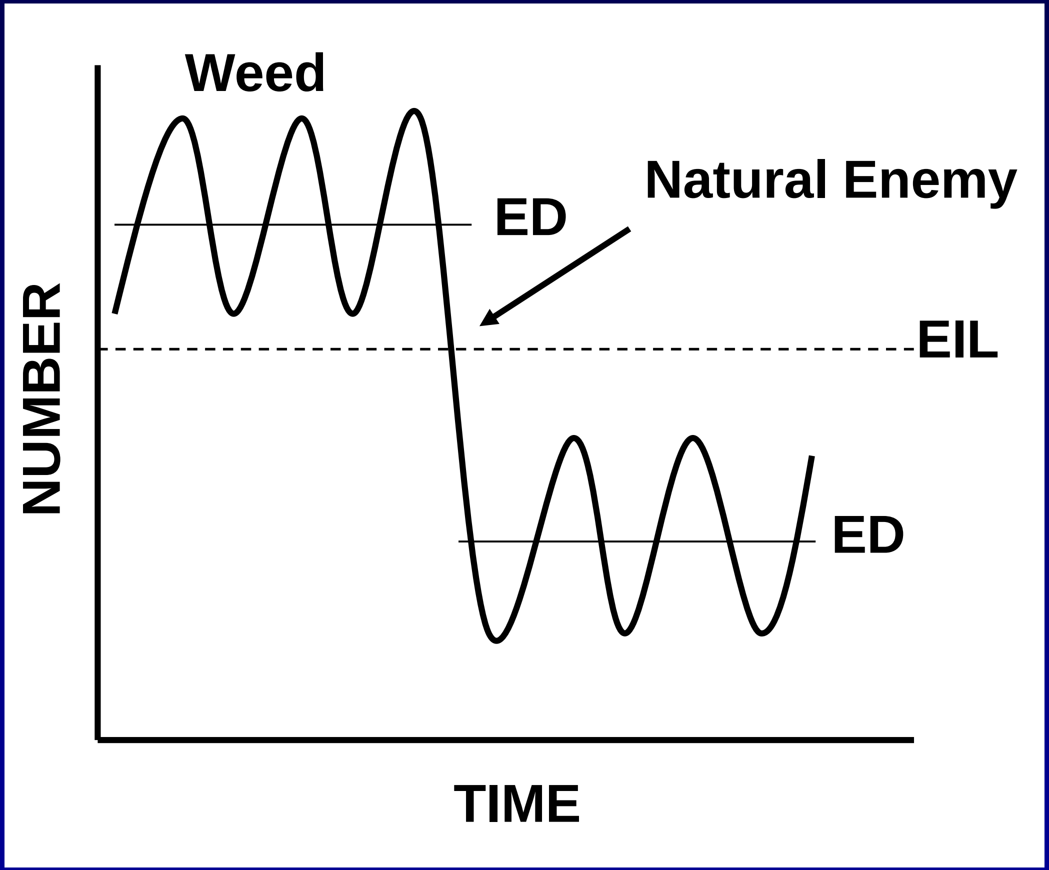
How Does BioControl Work ?

- Weed establishes equilibrium density (ED)* above economic / ecological injury level (EIL)**
- Natural enemy lowers ED & maintains it below EIL

*ED - Long term mean density

**EIL – Lowest density causing economic or ecological damage



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Why is Cogongrass Invasive?

- Anecdotal evidence for supporting 'Enemy Release' Hypothesis (Van Loan et al. 2002)
  - To date, biological control effort minimal
    - Limited surveys in East Africa- suspected center of origin for cogongrass (Evans 1991)
  - Conventional wisdom- grasses lack host specific natural enemies

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Grasses as BioControl Targets

- Often thought to have few specialized herbivores due to:
  - Simple architecture
  - Scarcity of secondary metabolites
  - Feeding deterrents (e.g. silica)
- Fear of non-target effects on crop grasses
  - 50% of human caloric intake from cereals
  - (e.g., wheat, rice, corn, millet, etc.)

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Natural Enemies of Grasses

GRASS	INSECT	REFERENCE
Arundo donax	*Tetramesa romana* (Eurytomidae)	Goolsby and Moran, 2009
" "	*Rhizaspidiotus donacis* (Diaspididae)	Goolsby et al. 2009
Spartina alterniflora	*Prokelisia marginata* (Delphacidae)	Grevstad et al. 2003
Phragmites australis	66 monophagous species outside of North America	Tewksbury et al. 2002
Hymenachne amplexicaulis	*Ischnodemus variegatus* (Blissidae)	Diaz et al. 2010
Imperata cylindrica	*Acrapex* spp. (Noctuidae)	Le Ru et al. 2014
" "	*Orseolia javanica* (Cecidomyiidae)	Mangoendihardjo (1980)

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Project Objectives

- Collect cogongrass natural enemies, establish colonies & quantify root crown/ rhizome impacts
- Demonstrate natural enemies are cogongrass specialists

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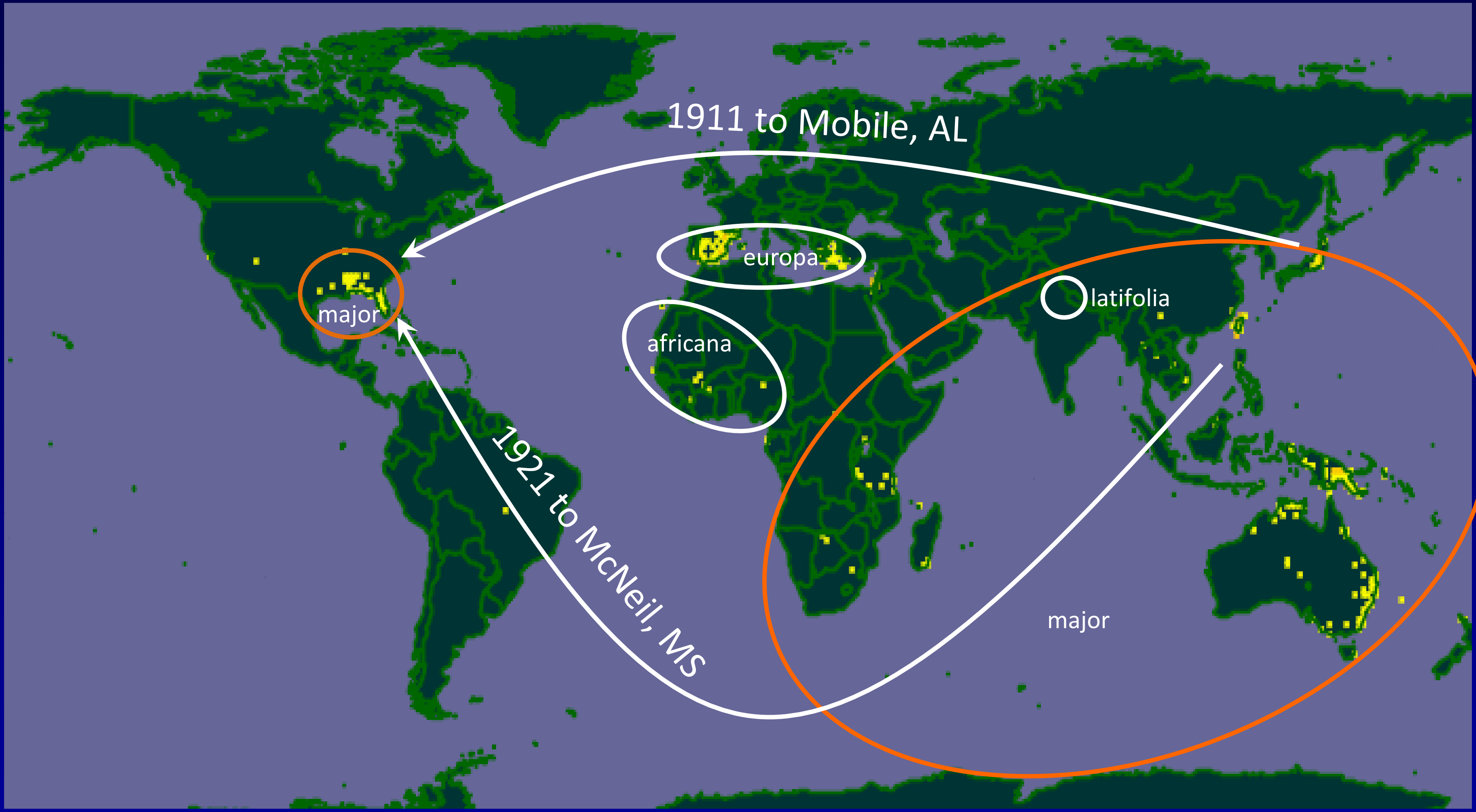
Distribution of *Imperata cylindrica*



Source: Global Biodiversity Information Facility (gbif.org)

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Survey Trip to Tanzania, Feb 2013

- **Meet Collaborators**
- **Collect *Acrapex* Borer From Cogongrass**
- **Establish Colonies at ICIPE in Nairobi, Kenya & UF/IFAS in Fort Pierce, FL**
- **Conduct Host Range Testing**

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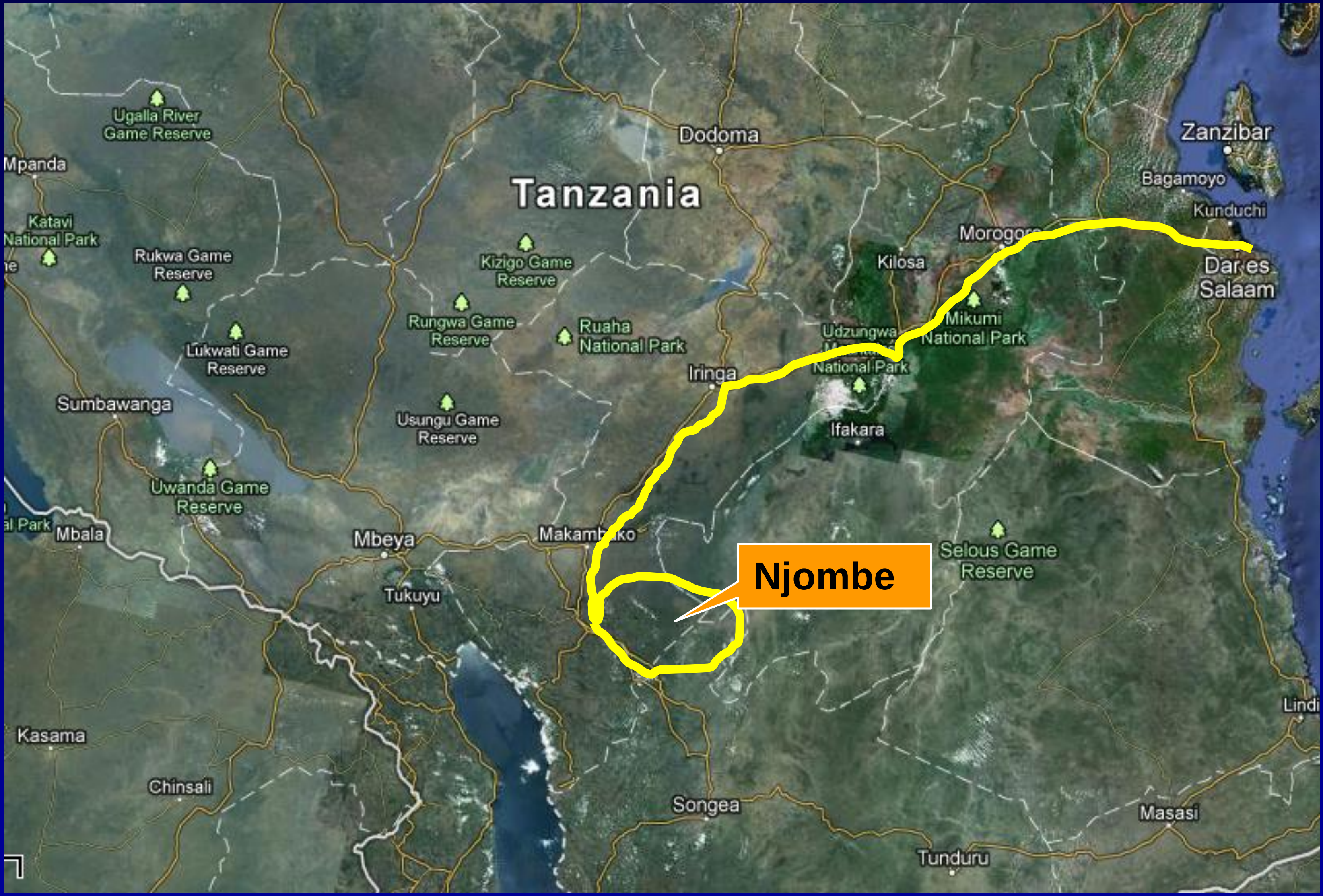
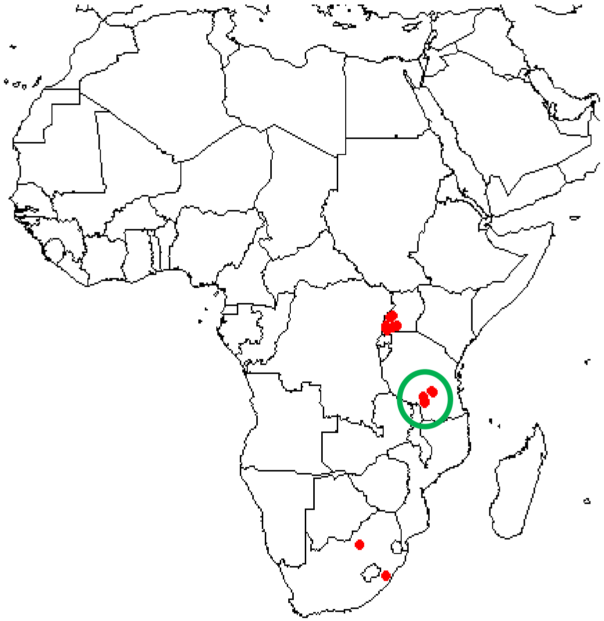
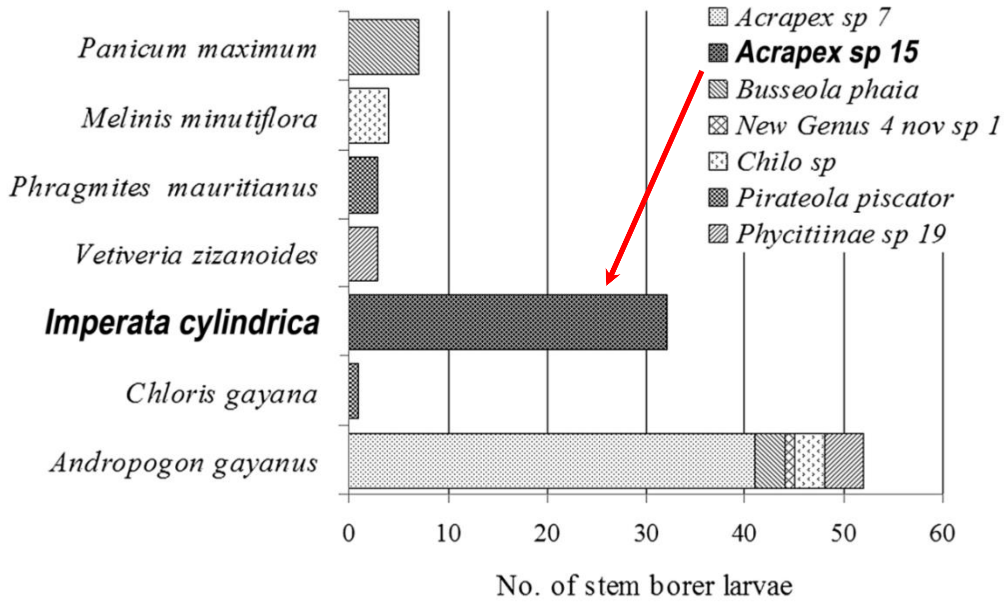
Tanzania Surveys, Feb 2013



Njombe, Tanzania





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Tanzania *Acrapex* Locality Projected onto the USA

Based on:

- annual precipitation
- minimum temperature in the coldest month

Tanzania Surveys, Feb 2013

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Tanzania Surveys, Feb 2013

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Tanzania Surveys, Feb 2013

Tanzania Surveys, Feb 2013

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Tanzania Surveys, Feb 2013

Biology of *Acrapex* Borer ??

- Eggs laid singly or in masses on cogongrass leaves
- Larvae enter near base of plants & bore downwards to rhizome
- Pupate in soil near rhizome

Overholt et al. (2016)

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Laboratory Rearing

Location of rearing	No. of larvae	No. parasitized larvae	No. of pupae (% of larvae)	No. of adults (% of pupae)	Eggs produced	F1 neonates (proportion of eggs)
UF-Fort Pierce	90	1	25 (27.7)	10 (45.5)	206	21 (10.2)
ICIPE-Nairobi	490	26	123 (25.1)	16 (13.0)	366	170 (46.4)

Diet	Number of larvae	Number of pupae	% pupated
Sugarcane diet with cogongrass	19	11	57.9%
Sugarcane diet without cogongrass	17	4	23.5%
ICIPE noctuid diet	27	7	25.9%

Overholt et al. (2016)

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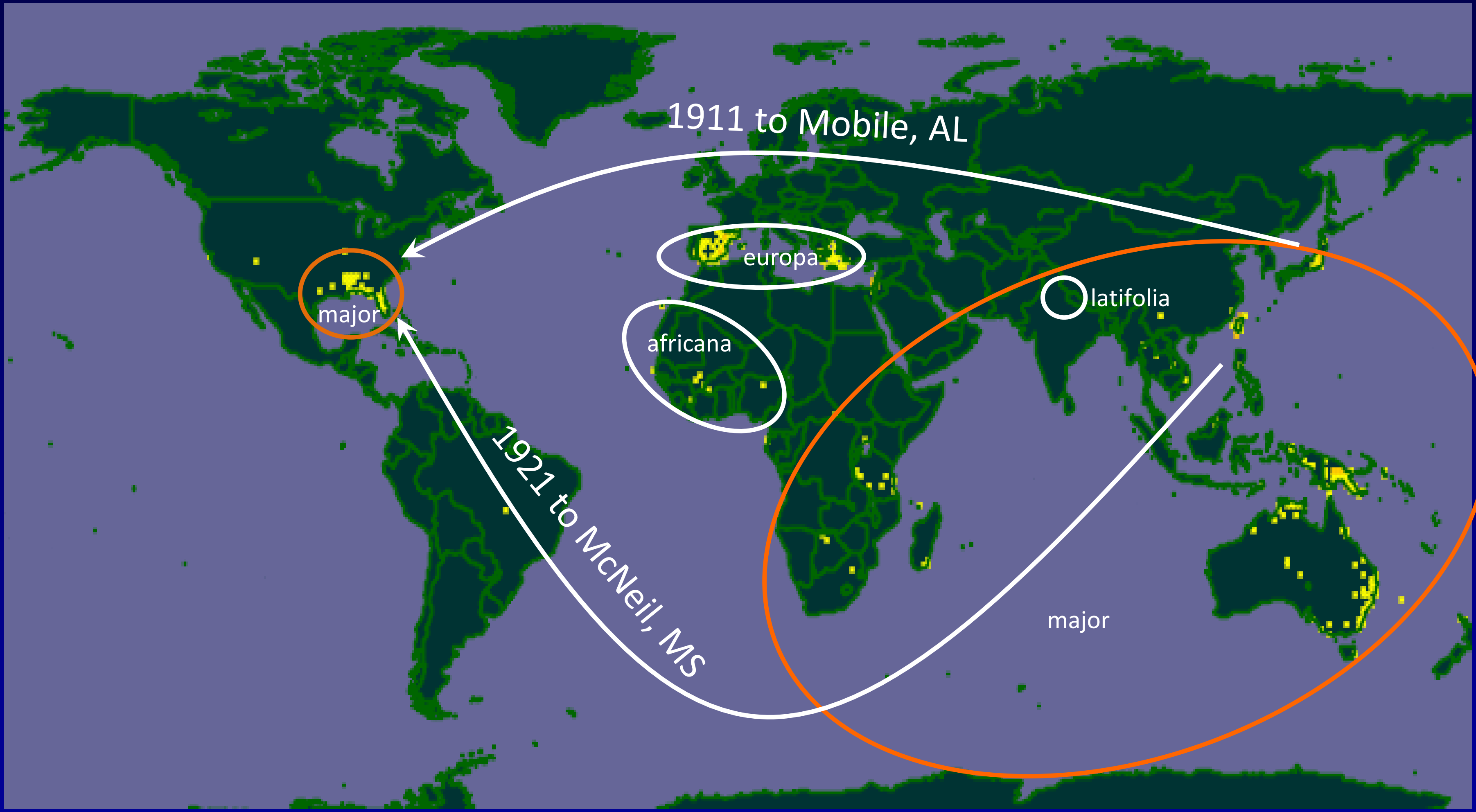

Source: Global Biodiversity Information Facility (gbif.org)

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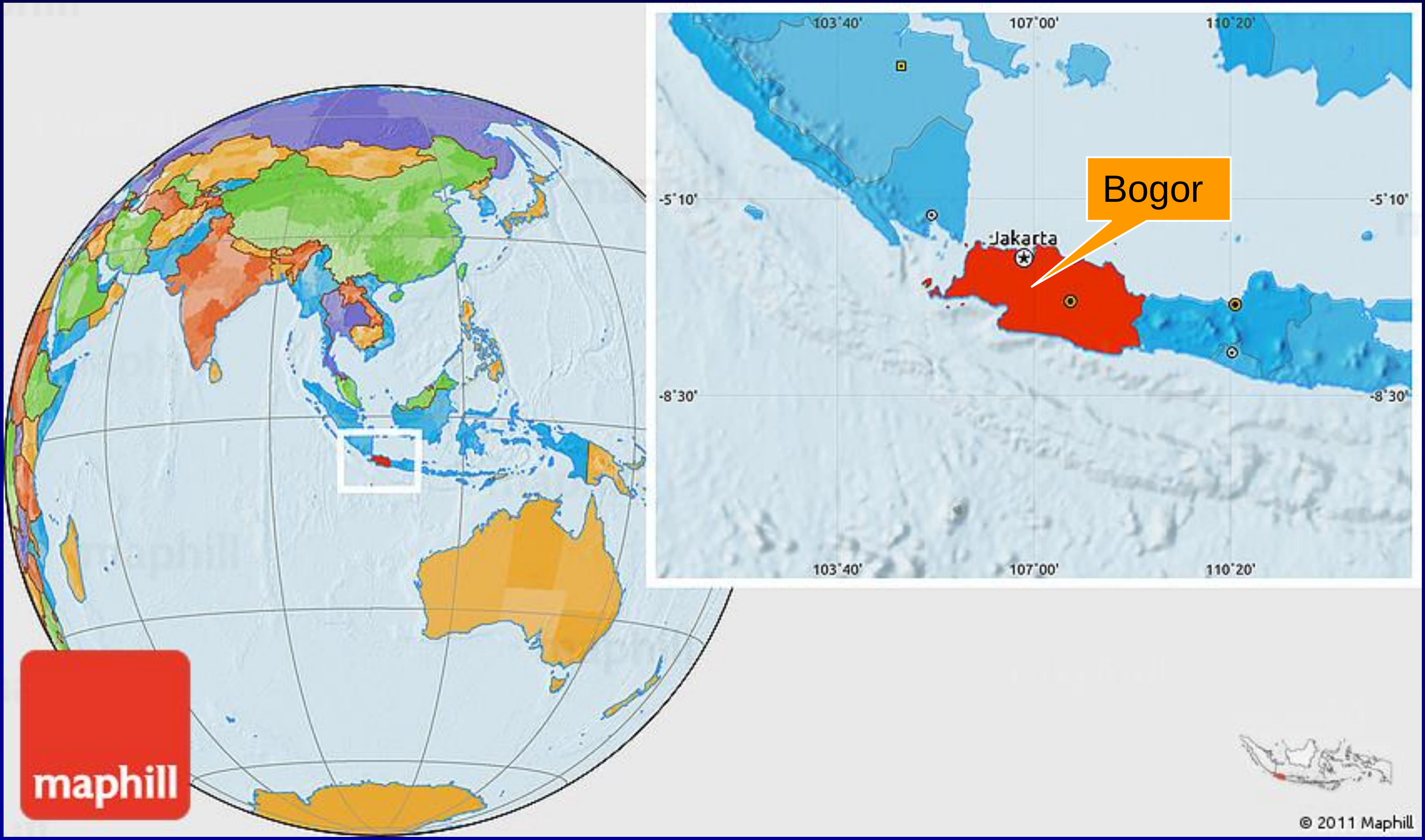
West Java, Indonesia, Dec 2015



http://www.maphill.com/indonesia/west-java/location-maps/political-map/

Bogor Agricultural University

West Java, Indonesia, Dec 2015

Project Collaborators
Bogor Agricultural University



Cianjur District

West Java, Indonesia, Dec 2015

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Galled Stems of Cogongrass

Figure 1. Galled stems of *I. cylindrica* induced by *O. javanica* in Cianjur, West Java, Indonesia (Source: Buhl and Hidayat 2016).

Overholt et al. (2016)

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Galls w/ Emergence Holes

Photo credits: Ragil Irianto, Ministry of Forestry, Bogor, Indonesia

Orseolia javanica
(Diptera: Cecidomyiidae)

Life stages of *Orseolia javanica*. 4th instar larva (far left), prepupa (left), pupa (center), adult male (right, top), egg (right, bottom) (Photo credit: Purnama Hidayat).

Overholt et al. (2016)

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Orseolia javanica Life Cycle

Mangoendihardjo (1980)

- Adults crepuscular
- Females deposit ~ 540 eggs on soil surface
- Neonates bore into tender leaf sheaths near apical meristem
- Induce formation of pink / white linear gall 2 days before adult emergence
- Complete development (egg-adult) in 35 days; soil moisture dependent

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Orseolia javanica Host Range

Mangoendihardjo (1980)

PLANTS TESTED		RESPONSE
Oryza sativa	Cultivated Rice	–
Oryza sp. 1	Wild Rice	–
Oryza sp. 2	Wild Rice	–
Sorghum bicolor	Sorghum	–
Paspalum conjugatum	Native Grass	–
Penisetum polystachyon	Native Grass	–
Imperata cylindrica	Cogongrass	+

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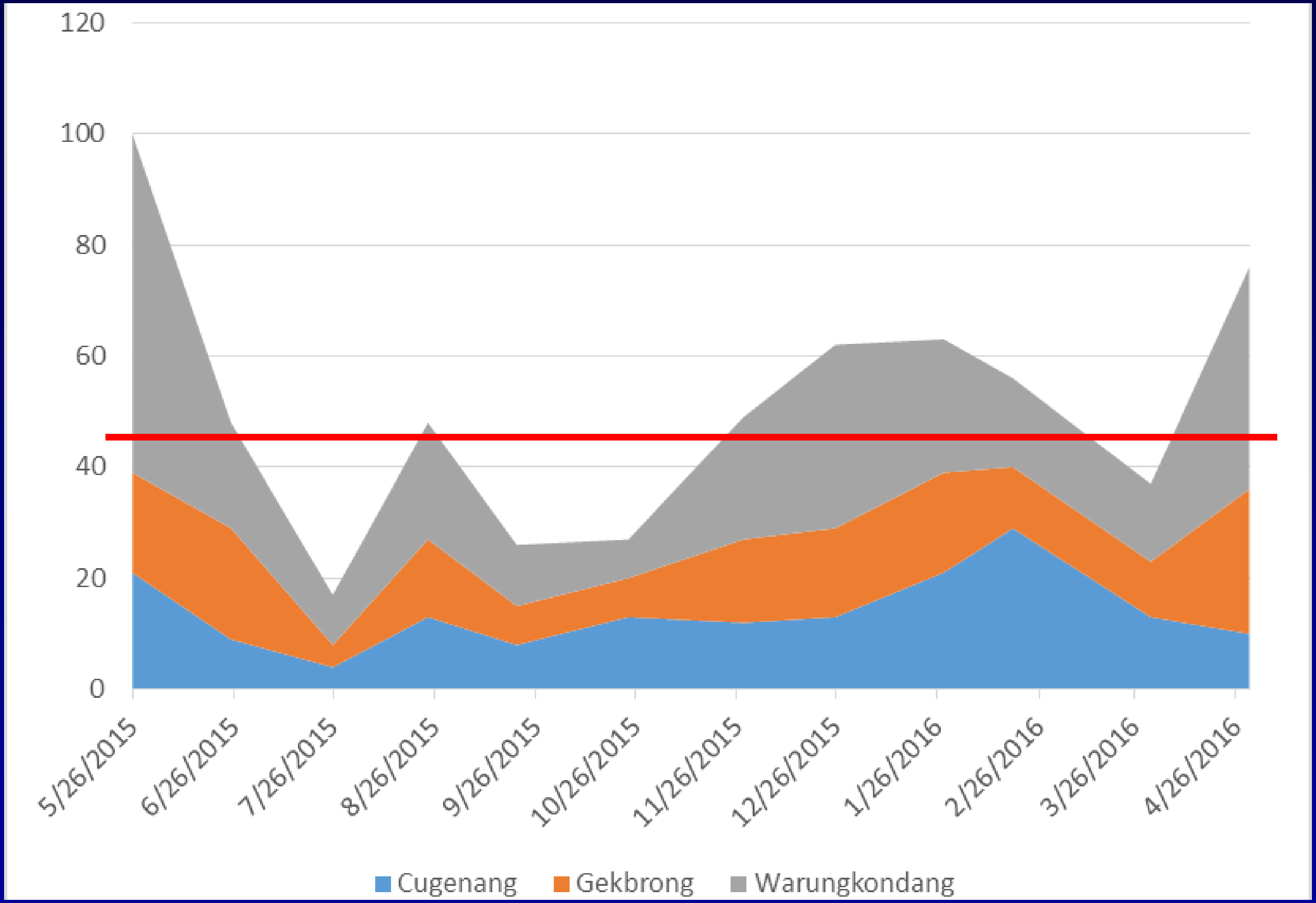
Orseolia Galls / m²

West Java, Indonesia, 2016



Overholt et al. (2016)

Parasitoids of *O. javanica*

Platygaster orseoliae Buhl
Hymenoptera: Platygasteridae

Buhl and Hidayat (2016)

Project Activities- Indonesia

- On-going studies at Bogor Agricultural University
  - Testing compatibility of midge with Florida and Gulf Coast clones
  - Develop laboratory rearing procedure for *Orseolia javanica*
- Conduct field and laboratory impact studies

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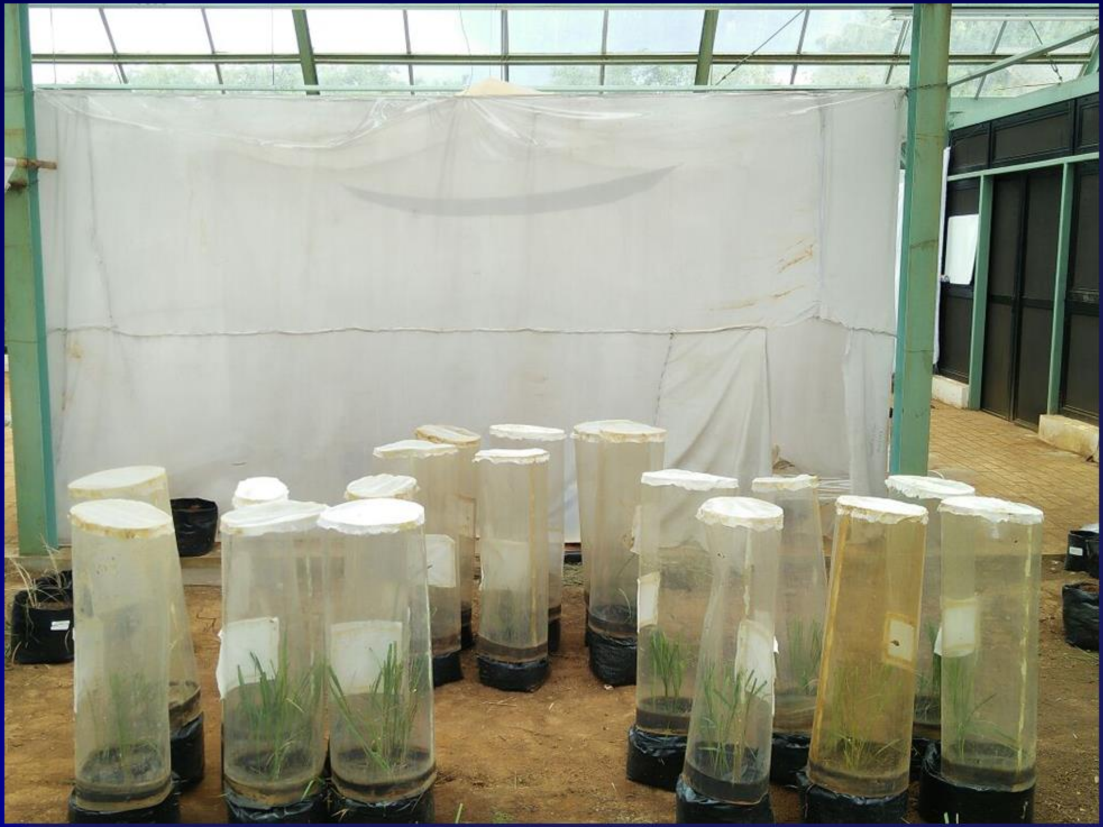
Project Activities- Indonesia



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Project Activities- Florida

Cogongrass plants propagated from rhizomes obtained from Avon Park and Crestview, FL, 20-30 June 2017.

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Future Activities- Florida

- Establish *O. javanica* laboratory colony at the BCRCL, Ft. Pierce
- Perform molecular characterization of *O. javanica* populations (initiated)
- Demonstrate *O. javanica* is cogongrass specialist
  - Extensive host range tests
  - Test plant list under development

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Laboratory Rearing

Cages for rearing *Orseolia javanica* and conducting host range tests, BCRCL, Ft. Pierce, FL (Photo credit: Patricia Prade).

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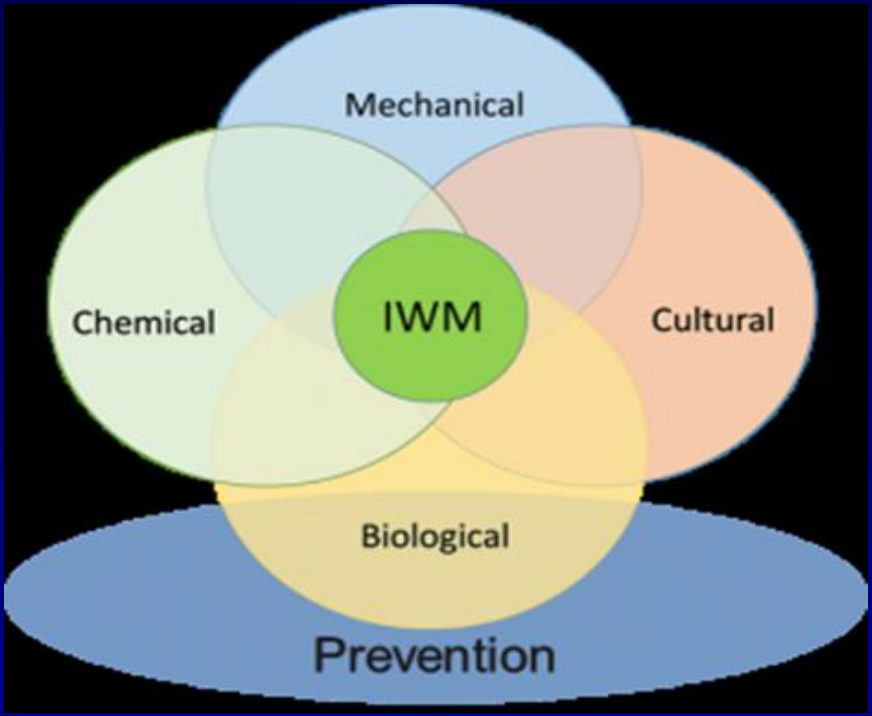
Integrated Weed Management

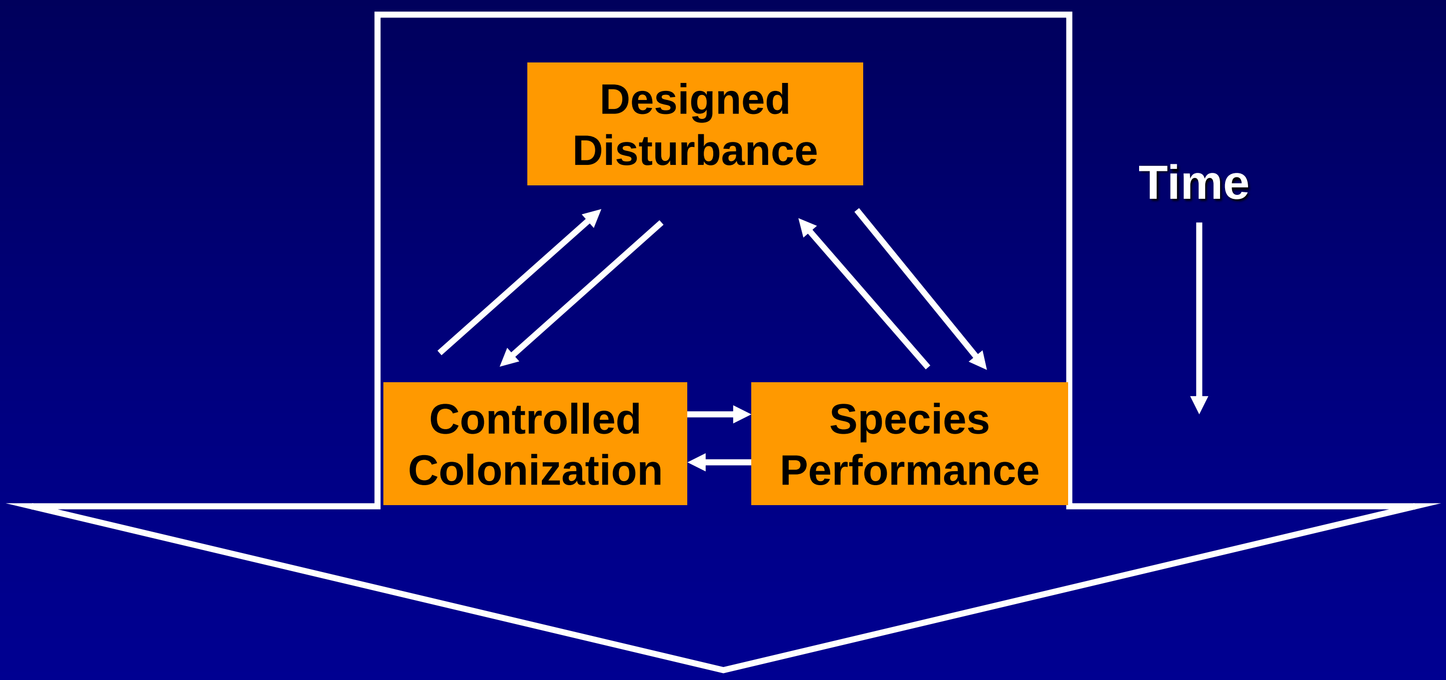
- **Integrating multiple methods to manage weeds, using the combination of practices that is most effective for solving the weed problem**
- **Common methods include cultural, chemical, mechanical, and biological practices.**



Credit: A. Klodd
http://integratedweedmanagement.org/

Components of Integrated Weed Management Model

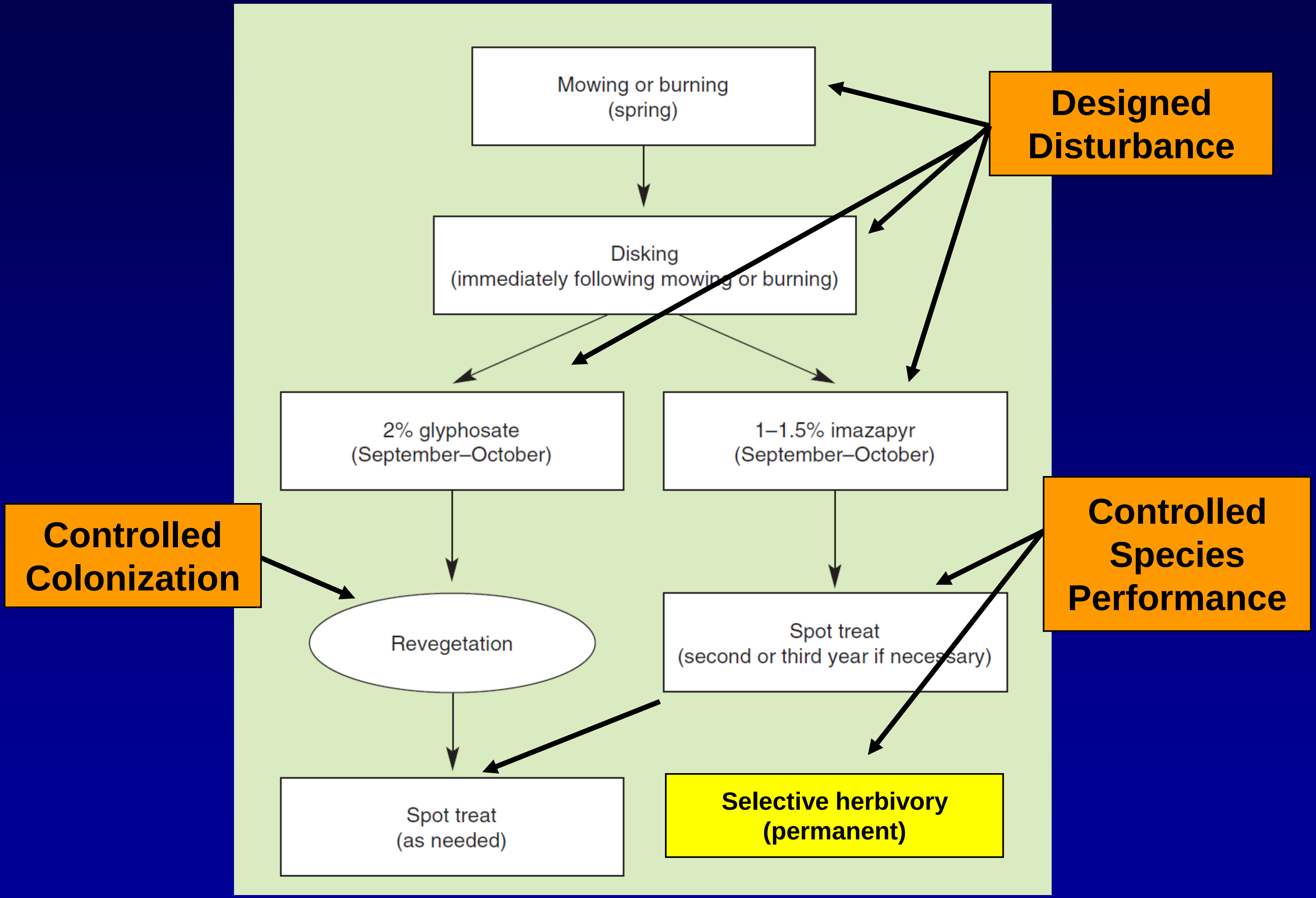
Plant Community *Undesired* State



Plant Community *Desired State*

Sheley & Mangold (2003)

Cogongrass IWM Model



Jose et al. (2002)

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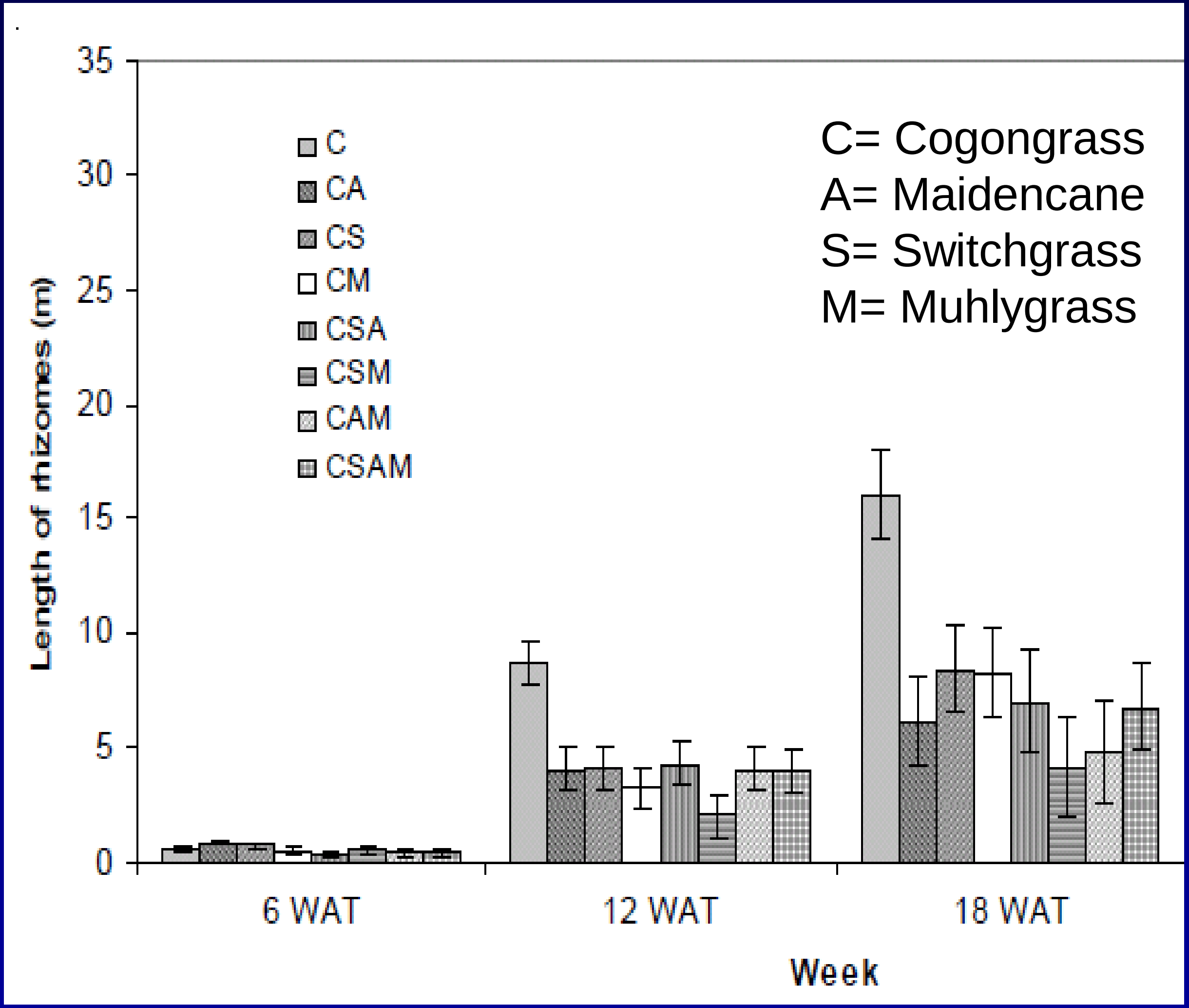
Controlled Colonization



Onokpise et al. (2002)

Conclusions

- Difficult to control cogongrass with herbicides and mowing
- Risk to native grasses from introduced cogongrass biocontrol agent(s) is low
  - *O. javanica* cogongrass specialist?
- Incorporating biological control agents with conventional physical & chemical tools can provide more complete and sustainable control of cogongrass

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Food for Thought*

"Are we as a weed science discipline choosing to ignore true integrated solutions to the herbicide resistance problem?"

"More research on herbicide alternatives is required."

"Combinations of a diversity of tactics in [IPM] systems augment herbicide-based weed control . . . and lengthen the useful life of valuable herbicide tools."

*Harker et al. 2012. Our view. Editorial, Weed Sci. 60: 143.

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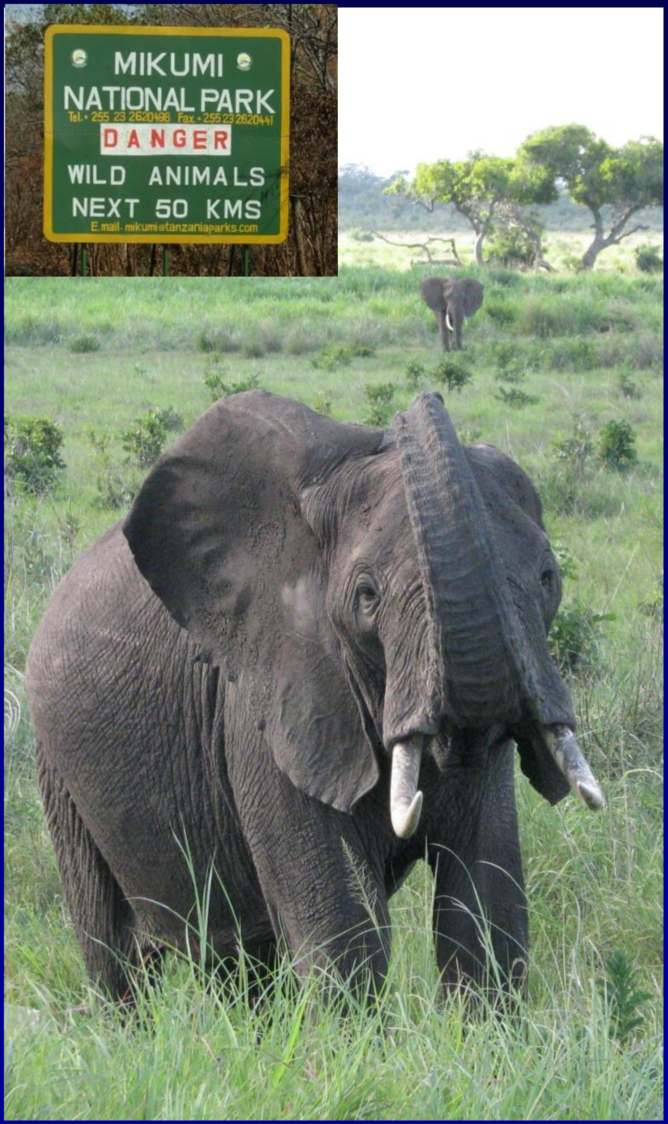
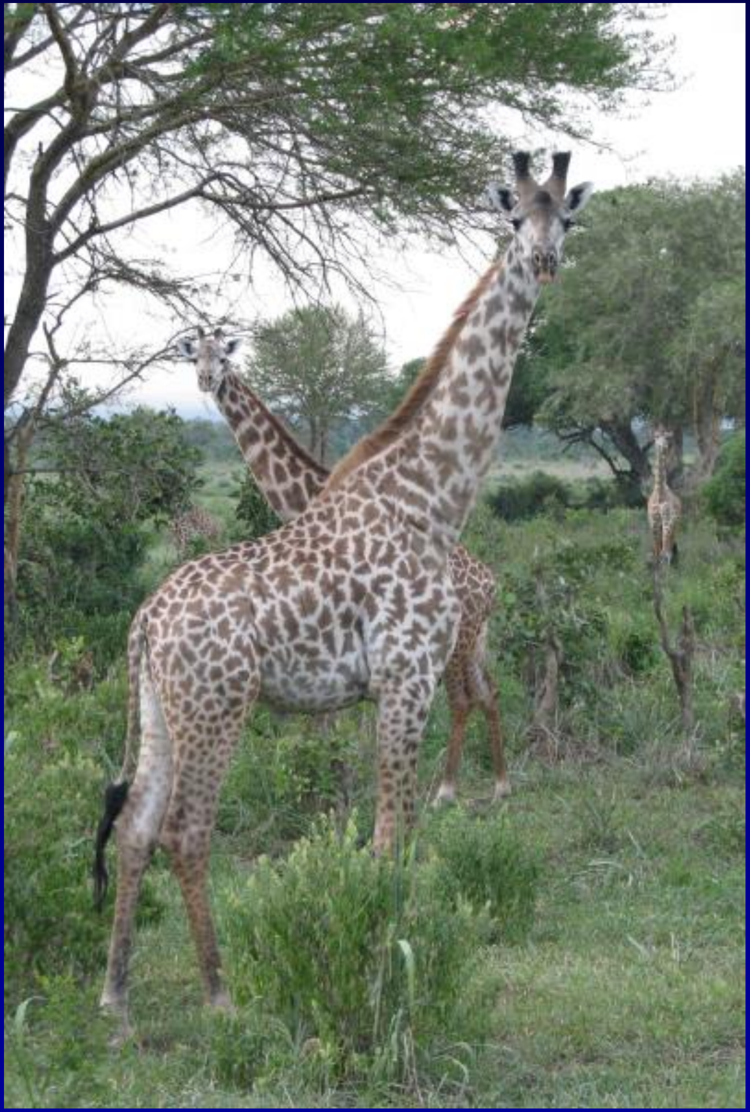
Thanx !





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