Integrating Biological Controls and Herbicides

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Outline

- Basic Concepts of IPM
- Specific Examples
  - Aquatic
  - Terrestrial
- Questions and Comments

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Outline

- **Basic Concepts of IPM**
  - **Integrated Pest Management**

    or
  - **Invasive Plant Management**
    - **The “Other IPM”**

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What is IPM?

- **Sustainable Approach to Managing Pests by Combining Appropriate *Biological*, Cultural, Physical & Chemical Tools;**
- **Control Methods Selected & Applied in Manner that Minimizes Risks to Human Health, *Beneficial* Non-target Organisms, & Environment**

(USDA ERS Definition)

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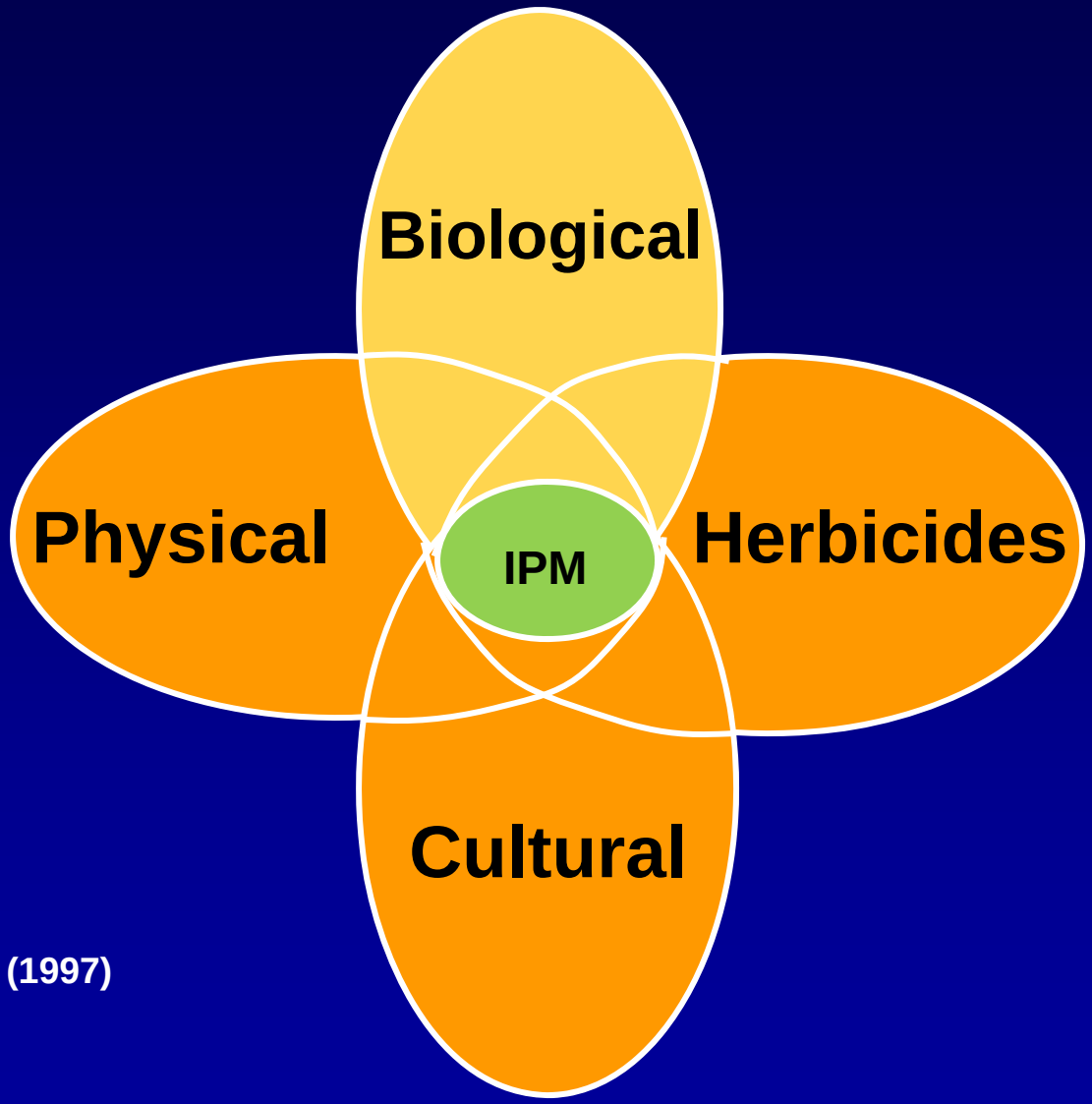
Invasive Plant Management- The Other IPM



Adkins (1997)

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History of IPM

- **Monitoring Sticky Traps at Texas A&M, 1940s**

Cotton Boll Weevil, *Anthonomus grandis*

http://nercrd.psu.edu/Newsletter/sept98/bollweevil2.jpg

http://entohistory.tamu.edu/timeline/timeline.html

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History of IPM

- **Publication of *Silent Spring* (1962)**
  - **Raised Public Awareness About Overuse of Pesticides**
  - **Credited for Environmentalism**
  - **IPM in Florida Dates Back to Mid- 20th Century**
    - **Statewide Ecological Surveys of Citrus Groves, 1950- 1972 (Simanton 1996)**

Rachel Carson
27 May 1907- 14 Apr 1964

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Fundamental IPM Principles

- Proper Identification of Weed
- Understand the Weed's Biology, Ecology and Impact
- Routine Monitoring of Weed Populations
- Select Appropriate Cultural, Mechanical, Biological, and Chemical Control Techniques
- Evaluate IPM Program and Make Adjustments

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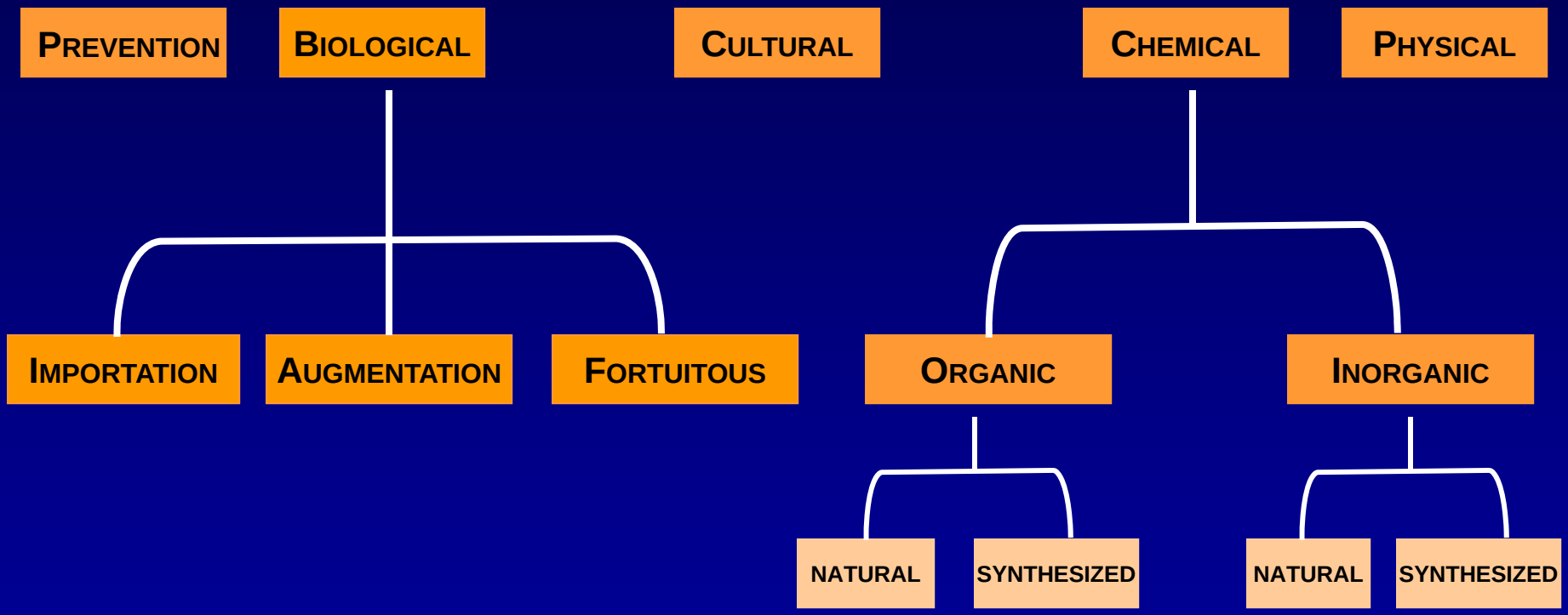
TACTICS OF INVASIVE PLANT MANAGEMENT



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Rationale for IPM

- Reduces Invasive Plant Problems More Effectively by Saving $$ and Protecting the Environment
- How ??
  - Decreases Herbicide Use
  - Minimizes Resistance Problems
  - Promotes Successful Establishment & Impact of BioControl Agents

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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 (Arthropods, Pathogens)
- 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 in Florida
- Why?
  - Suitable Climate & Geography
  - Escape From Natural Enemies That Regulate Plants in Native Range
    - 'Enemy Release' Hypothesis

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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 Caveat
  - Biological Control is ***NOT*** Eradication
  - Creates Opportunity to Combine w/ Other Tactics

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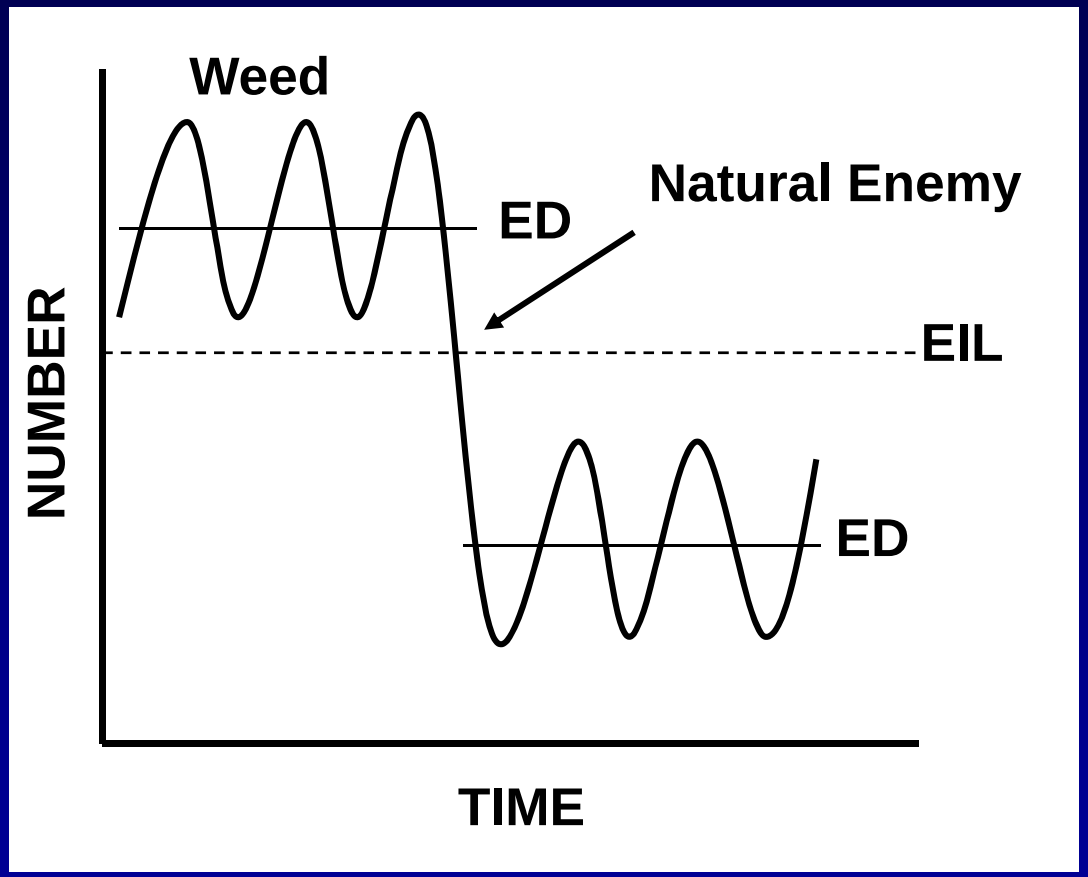
How Does BioControl Work ?

- 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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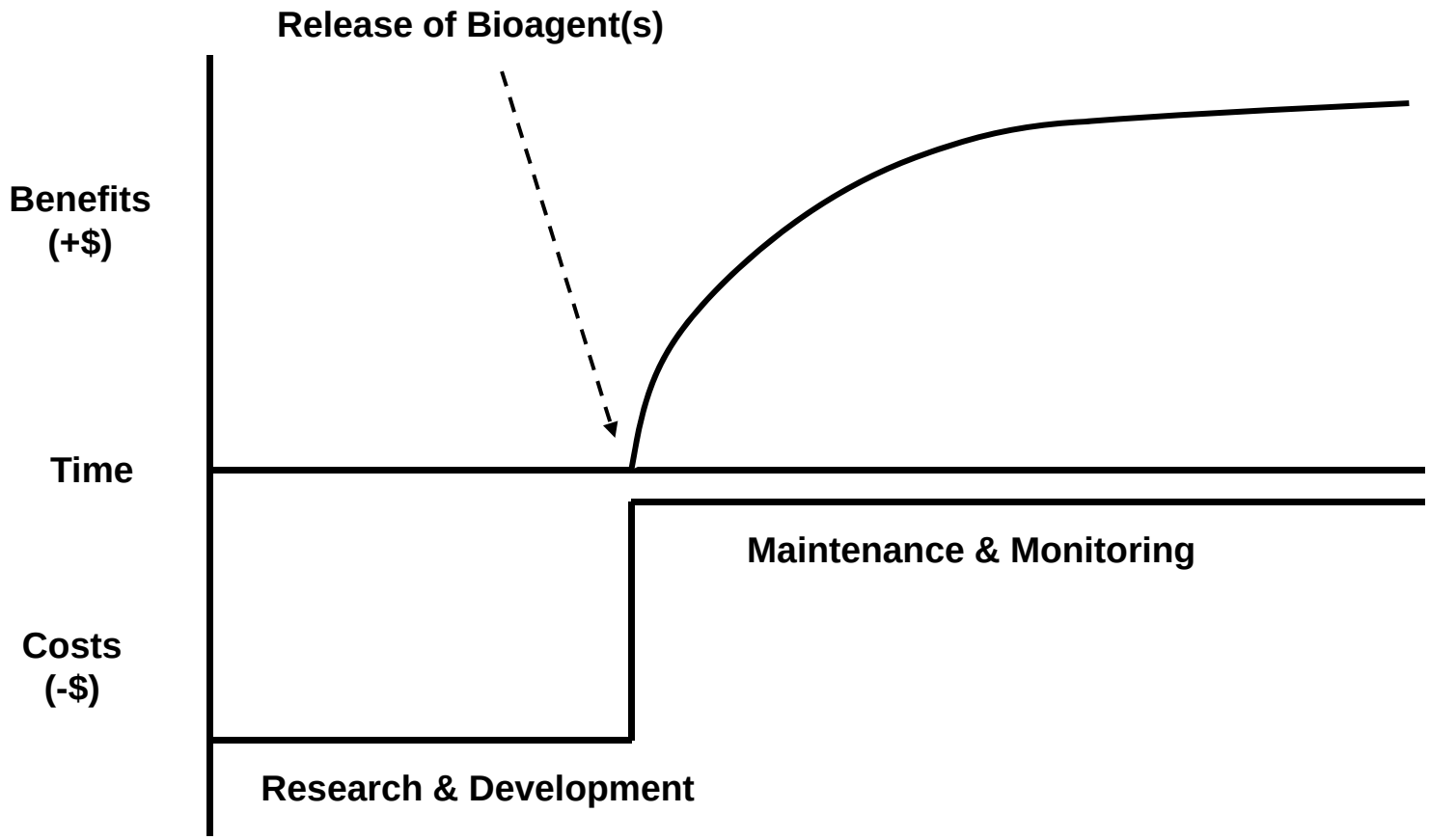
Costs / Benefits of BioControl



(after Mentz 1987)

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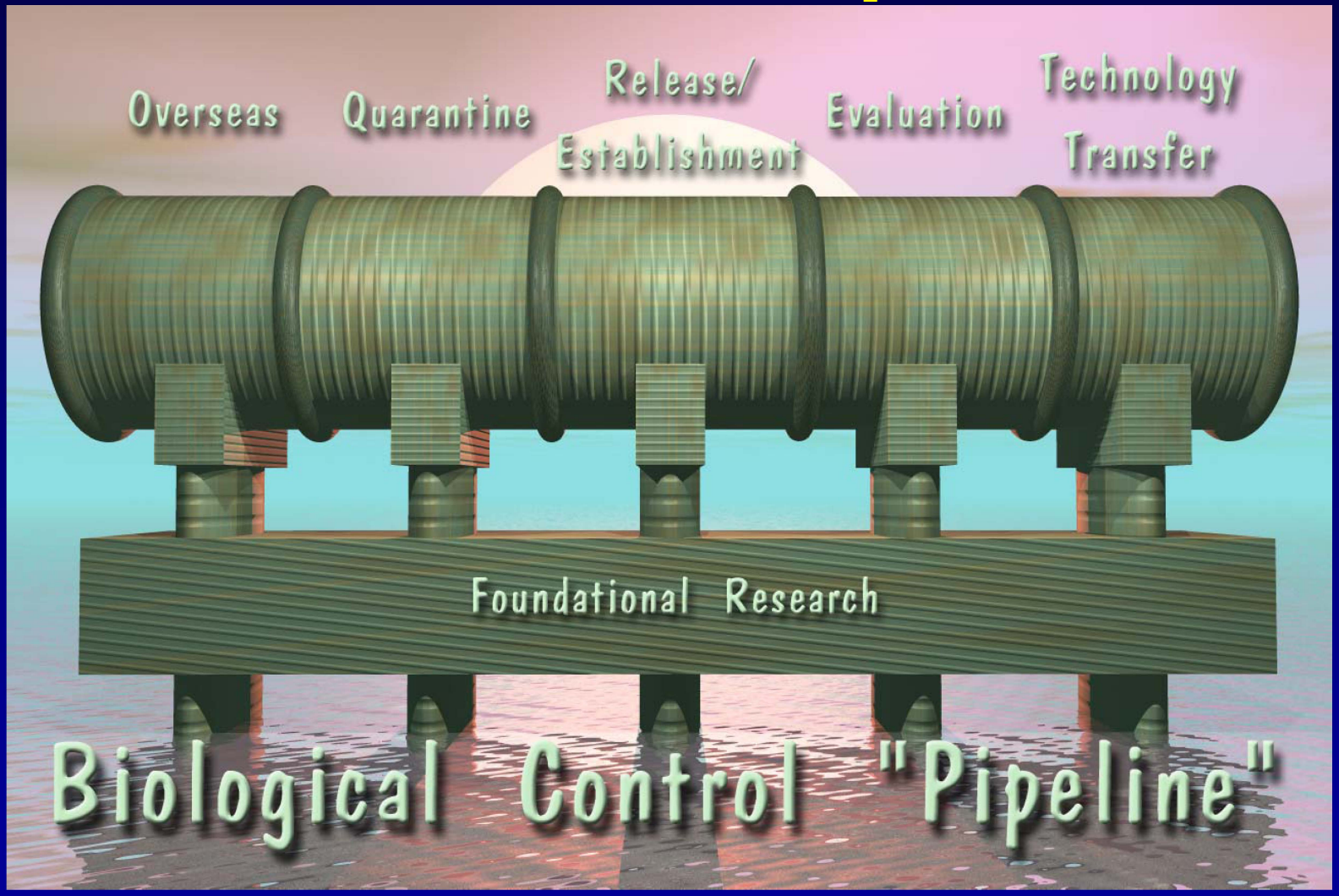
BioControl “Pipeline”



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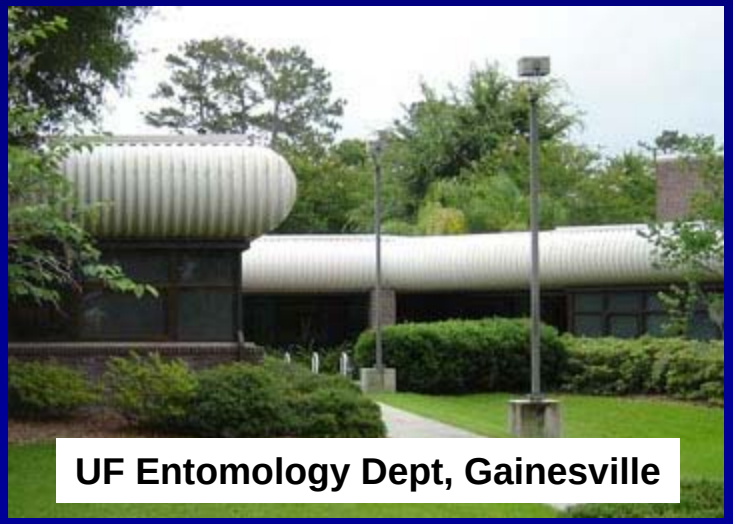
Credit: USA ,COA

FL Quarantine Facilities



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Defining BioControl Success
(in Operational Terms)

- **Complete- No Other Control Methods Are Needed**
- **Substantial- Other Methods Needed But at Reduced Level**
  - *** Goal of IPM**
- **Negligible- Other Methods are Required**

(Hoffmann 1998)

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Rationale for Integrating BioControl with Herbicides

- Biological Control is Not Immediate
- Unpredictable
  - Some Natural Enemies Fail to Establish
  - Some Natural Enemies are Ineffective
    - Abiotic and Biotic Interference

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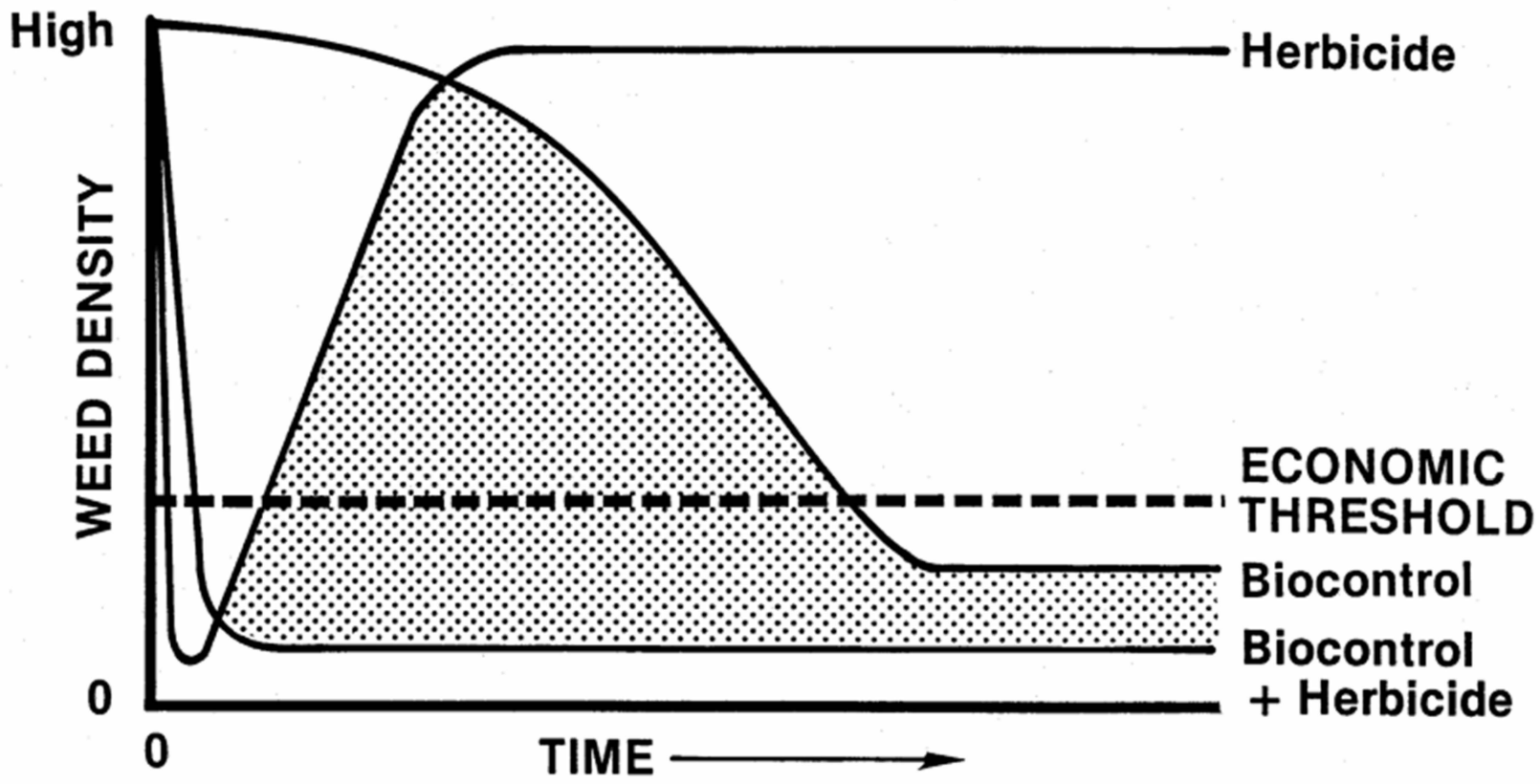

Messersmith and Adkins. 1995. Weed Technol. 9:199-208.

Integrating BioControl Agents with Herbicides

- Must Be Sure That Herbicide (or BioHerbicide) Does Not Negatively Impact BioControl Agent
  - Directly- Causes Mortality
  - Indirectly- Herbicide Reduces Plant Density (= Food Source) Below Critical Level
- Consider Applying Herbicides to Maximize BioControl Agent Impact
  - Location
  - Timing

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Herbicide Escape Mechanisms

Brazilian Peppertree Seed Wasp

Megastigmus
(Hym: Torymidae)

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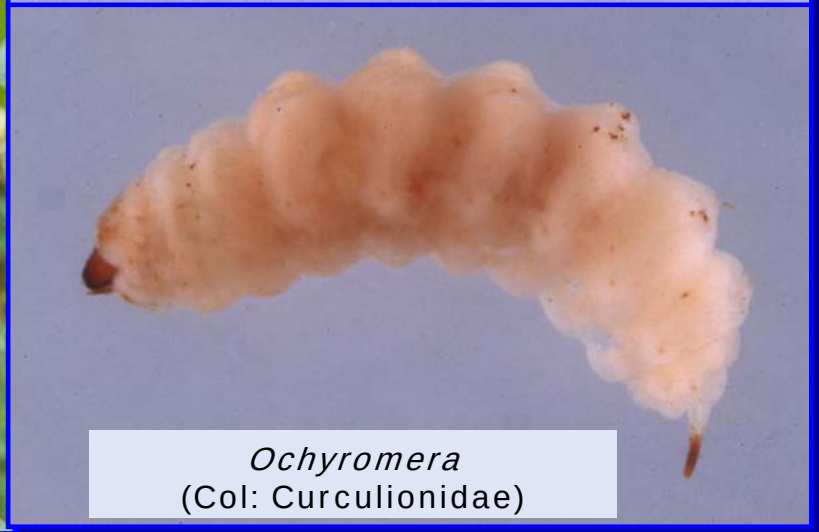
Herbicide Escape Mechanisms

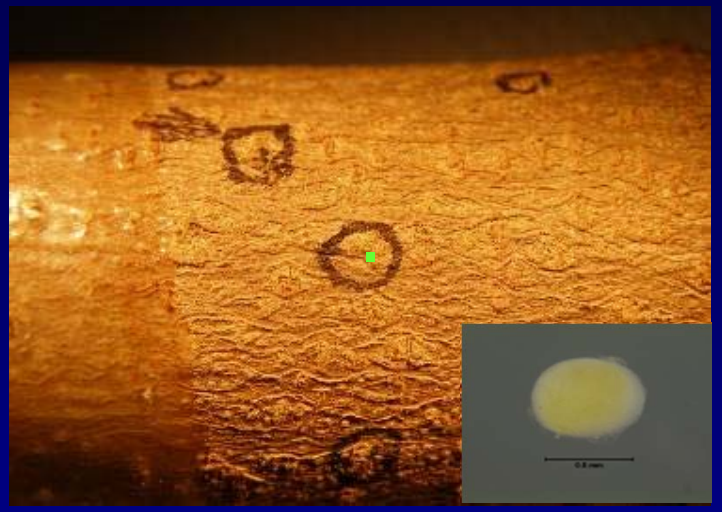
Chinese Privet Seed Weevil



Ochyromera
(Col: Curculionidae)

Herbicide Escape Mechanisms

Brazilian Peppertree Stem Weevil



Apocnemidophorus pipitzi
(Col: Curculionidae)

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Waterhyacinth

Neochetina spp.
(Col: Curculionidae)

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Water Hyacinath Fungus
Cercospora piaropi

(Photo Credit: R. Charudattan)

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Integrating BC with Other Tactics

- ***Neochetina* Weevils with *Cercospora* Fungus**

  (Courtesy of R. Charudattan)

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Hydrilla

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Augmentative Hydrilla BioControl

- Sterile (Triploid) Grass Carp Used to Manage Hydrilla
  - Diploid Grass Carp in Suwannee River (Jaggers et al. 2011)
- BUT- They Are Not Selective Feeders
- Can Only be Used in Closed Water Bodies

GRASS CARP

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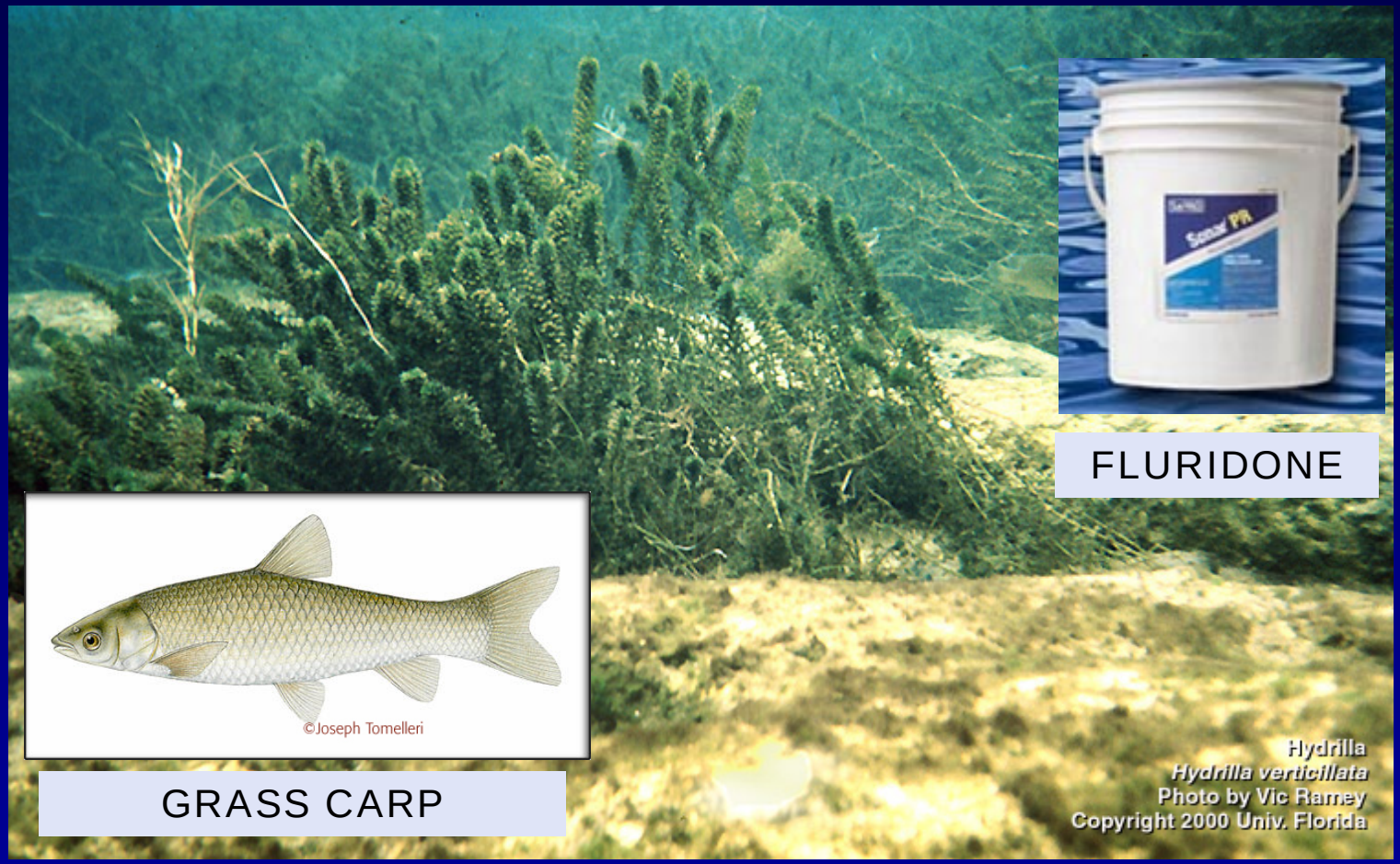
Integrating Fish with Herbicide



Kracko and Noble (1993)

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Hydrilla Bioherbicide

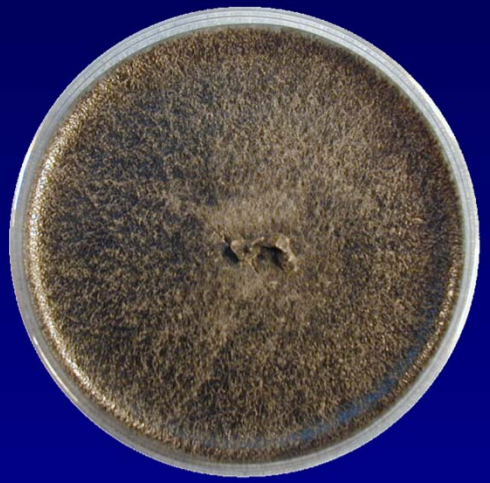
ERDC
US Army Engineer Research and Development Center

SePRO

Mycoleptodiscus terrestris
(Native Fungal Pathogen)

Integrating Fungus w/ Herbicide

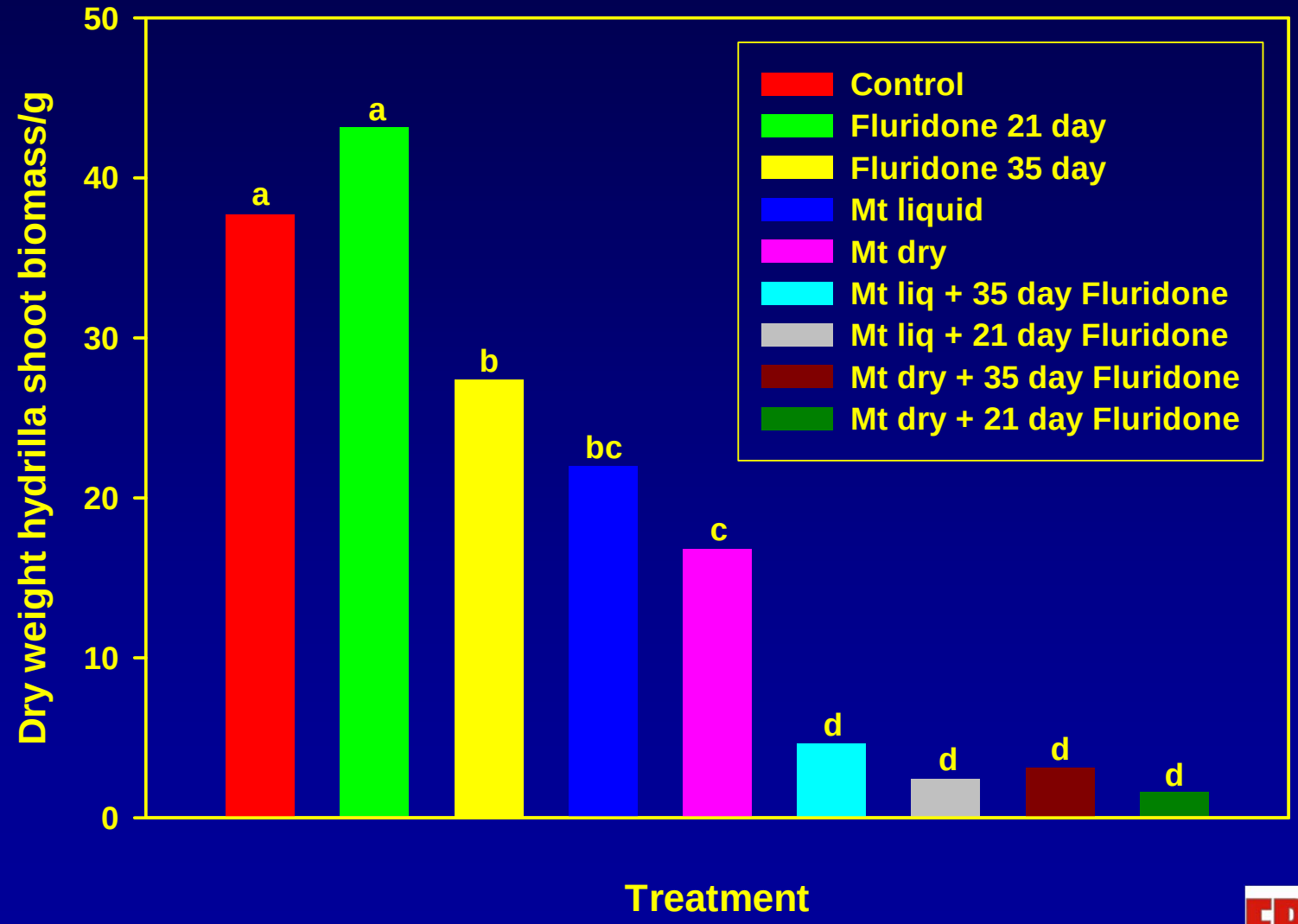
- Combined fungus *Mycoleptodiscus terrestris* (Mt) with fluridone
- Hydrilla control > 90%
  - 2 ppb fluridone + 100 cfu ml^{-1} *Mt*
  - Rapid biomass reduction
  - Long-term control
  - Reduced contact time – approximately by 50%
- *Mt* compatible with many herbicides



Netherland and Shearer (1996)

ERDC
US Army Engineer Research and Development Center

Integrating Fungus w/ Herbicide



ERDC
US Army Engineer Research and Development Center

Fortuitous (Adventive) BioControl

- **Regulation of a Weed Population by a Natural Enemy that Has Arrived from Elsewhere *Without* Deliberate Introduction**
- **No Active Human Involvement**

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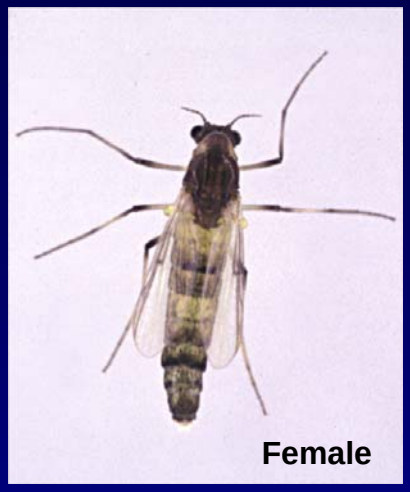
The Hydrilla Miner- *Cricotopus lebetis*

- Tip- mining Midge
  - Larvae Feed on Living Plant Tissue
  - Rare Occurrence
- Prevents “topping out”
- Naturalized in Florida
  - No Swarms
  - Low Dispersal Distance
  - Easily Mass Reared


Female


Male


Larva

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Block 1: Control

Block 1: Midge

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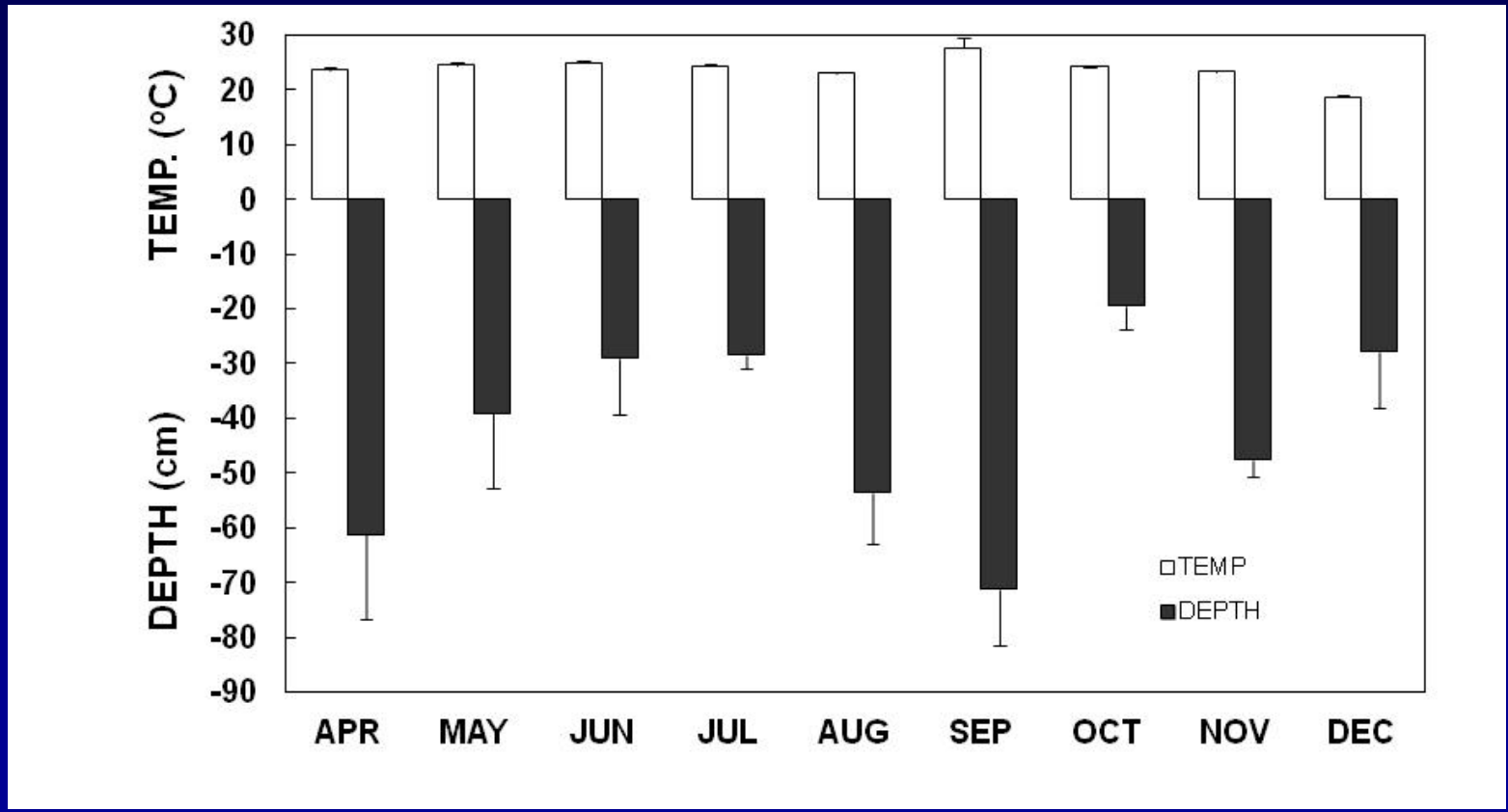
Crystal River, Citrus Co.

Apr- Dec 1998



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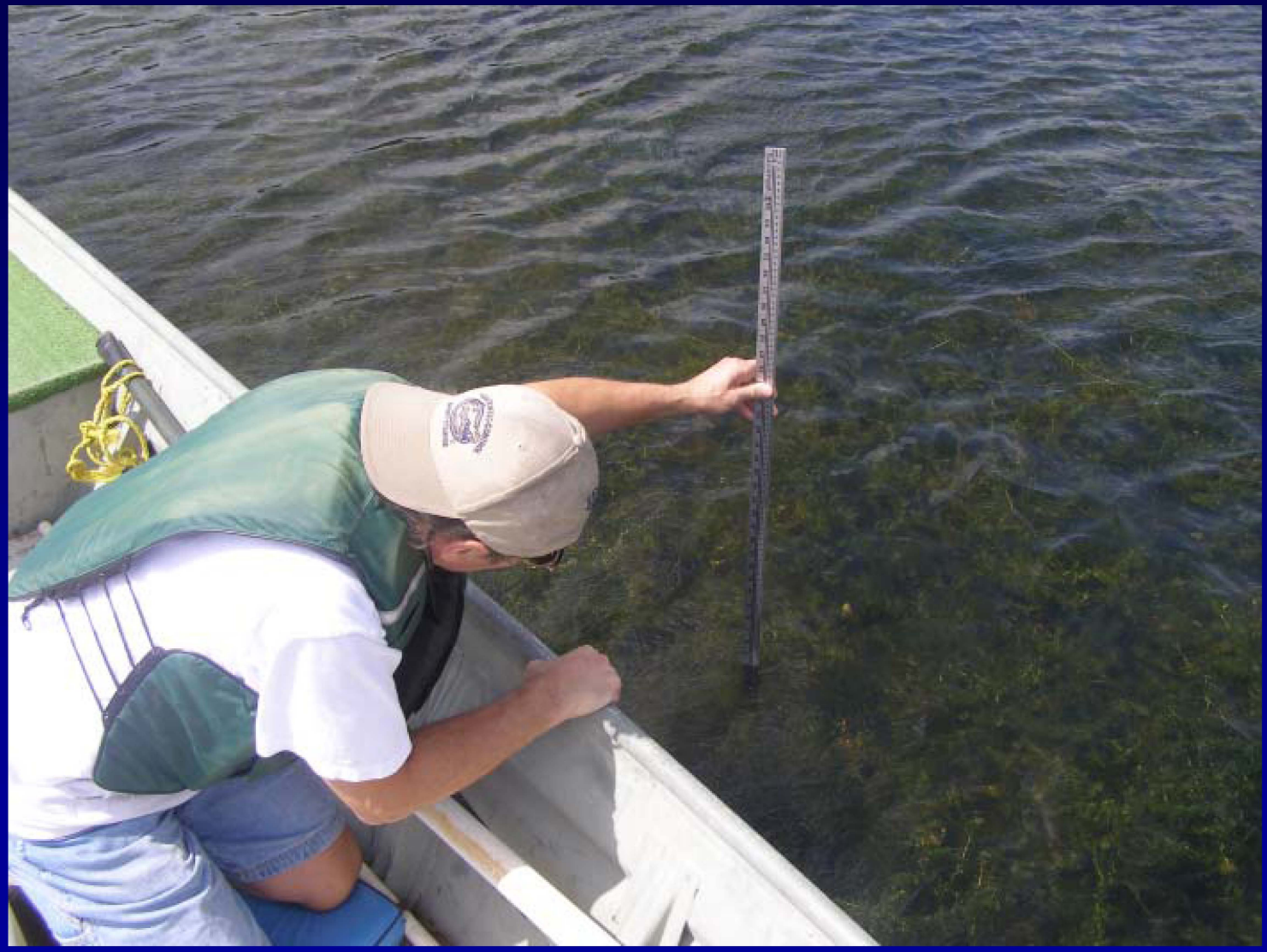
Lake Rowell, Bradford Co.

September 2010



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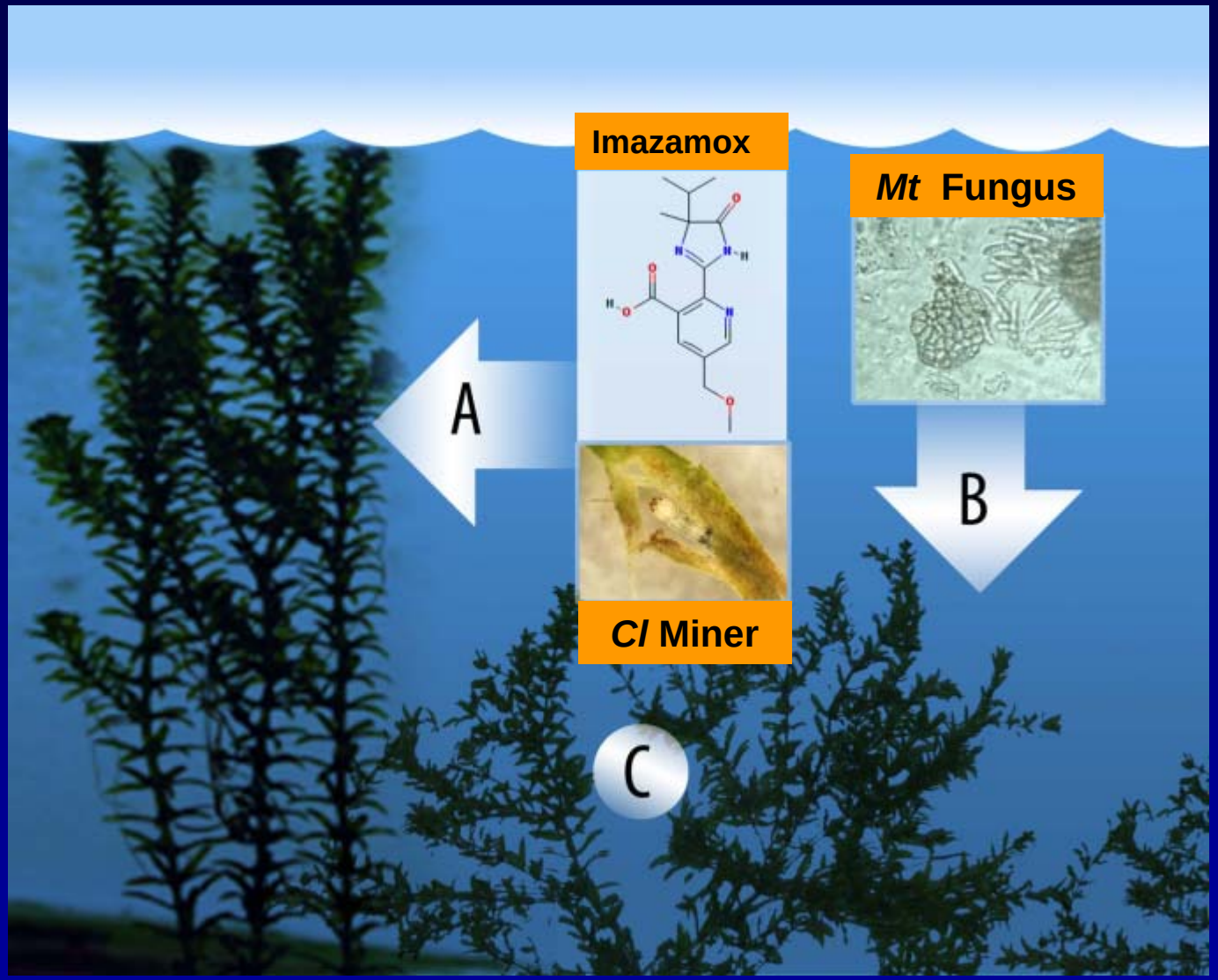
Changing Hydrilla's Architecture



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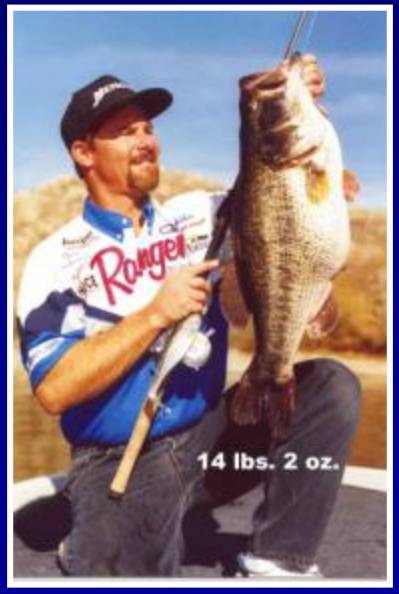
Hydrilla Management Goals

- Integrate Insect, Fungus & Herbicide = IPM
- Eliminate Adverse Effects of Surface Mats
- Reduce Reliance on Herbicides
- Create More Favorable Habitat



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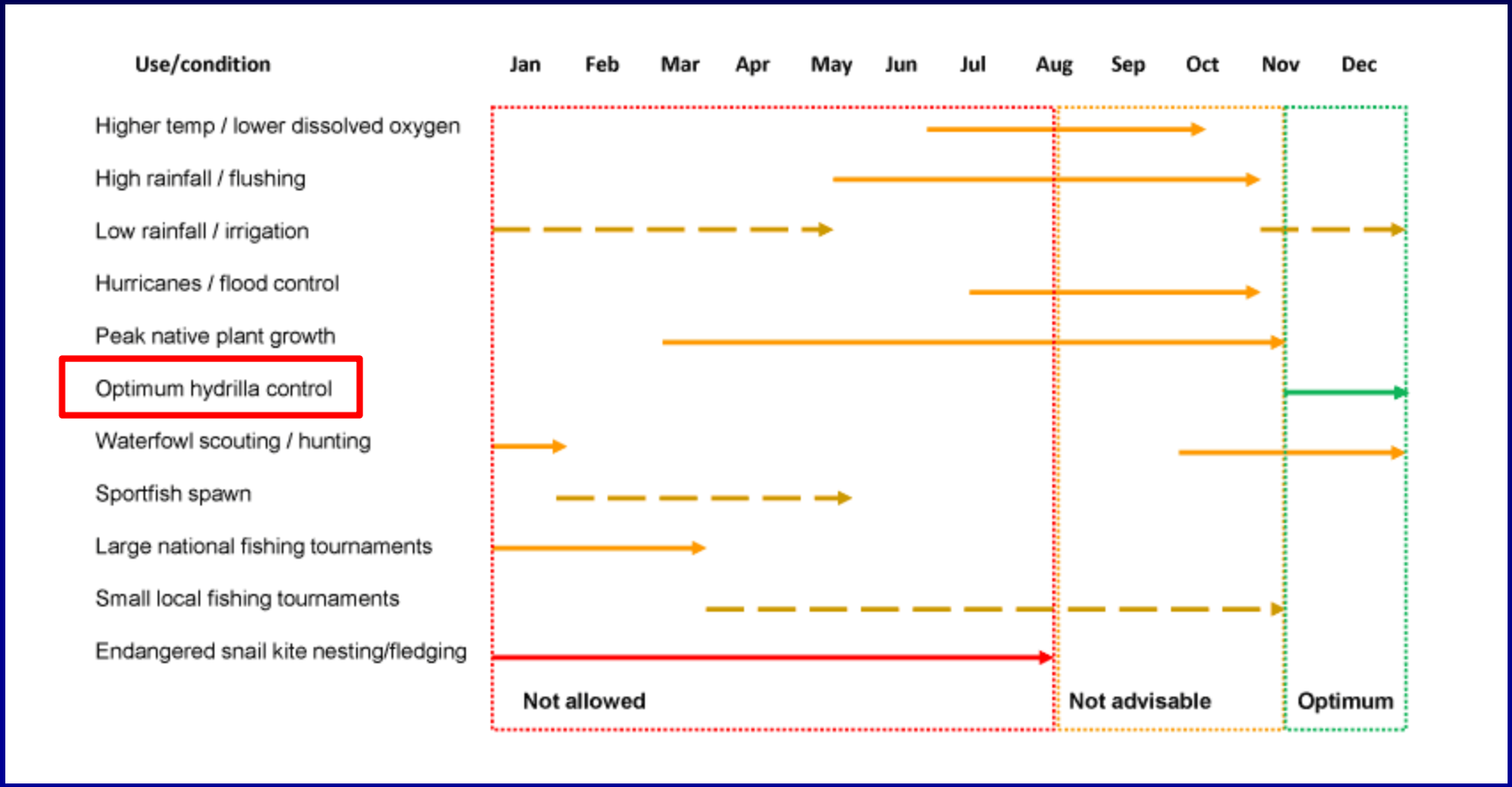
Lake Toho Hydrilla Control Issues: Small Window of Opportunity



http://plants.ifas.ufl.edu/manage/developing-management-plans/scope-of-aquatic-plant-management-in-florida-waters/window-of-opportunity

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Tropical Soda Apple

Tropical soda apple (TSA), "The Plant From Hell"

- A member of the Solanaceae
- Noxious weed (under both federal and state designations)
- Originally from South America
- Invasive weed in Florida and seven southeastern states and spreading
- Primarily a problem in pastures, but also in sod-production, citrus, and natural areas

TSA's needle sharp prickles pose a serious danger to cattle and humans

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Tropical Soda Apple

Photo Credit: Jeff Mullahey

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Gratiana boliviana (Chrysomelidae)

First insect approved in 2003 for Field Release in the USA

Adult Egg Larva Pupa

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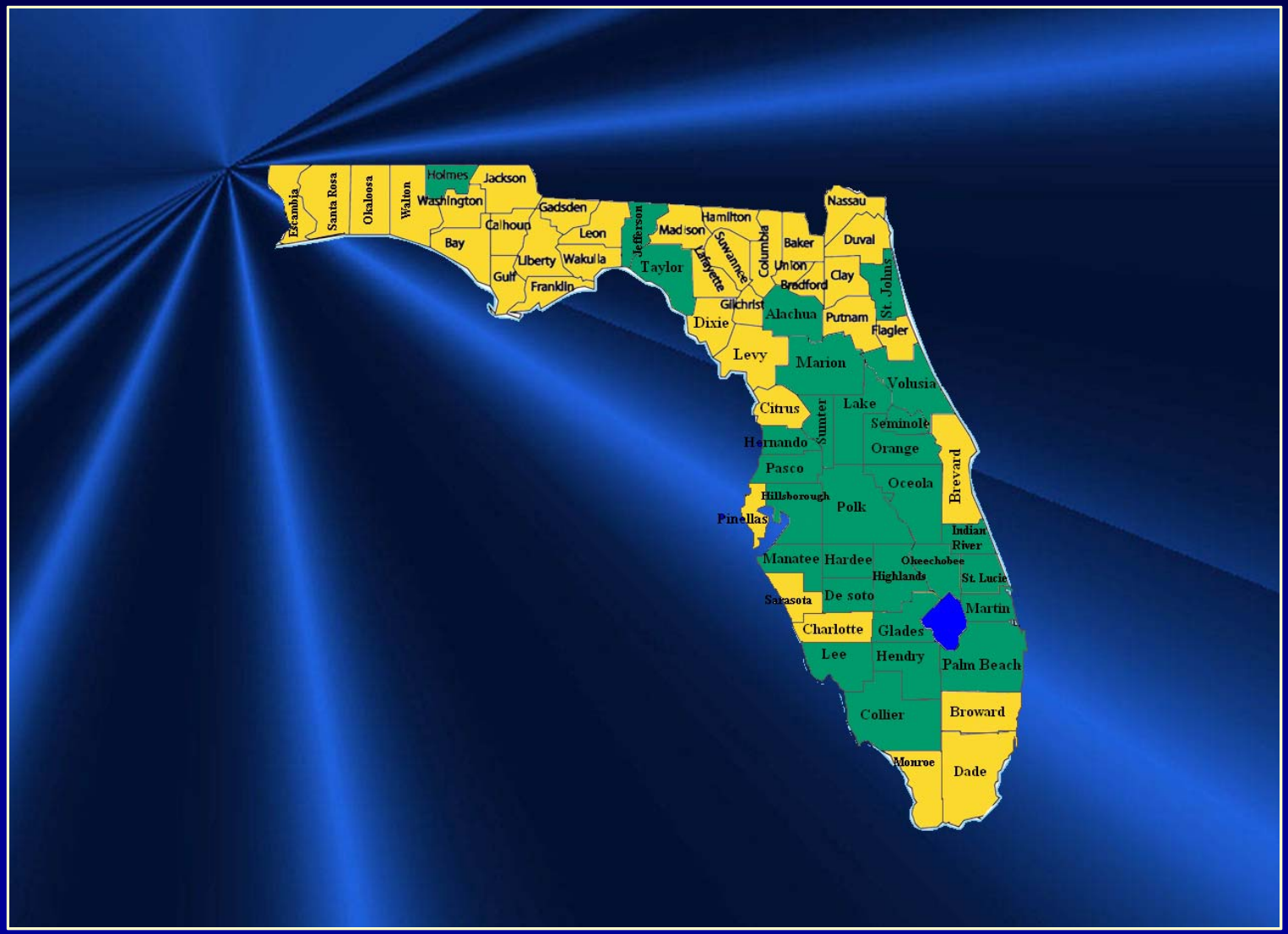
TSA Beetle Releases in FL



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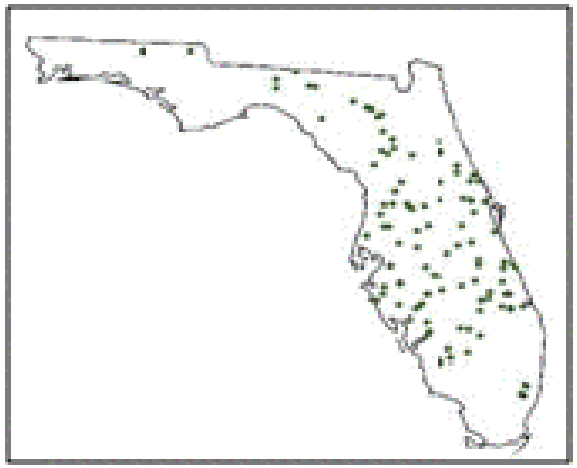
Post Release Monitoring

3 years after release, statewide surveys conducted to monitor the establishment and impact of beetles



38 counties with a total 113 of random sites

Plant and beetle variables collected

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Solutions for Your Life

USDA

Florica Department of Agriculture and Consumer Services

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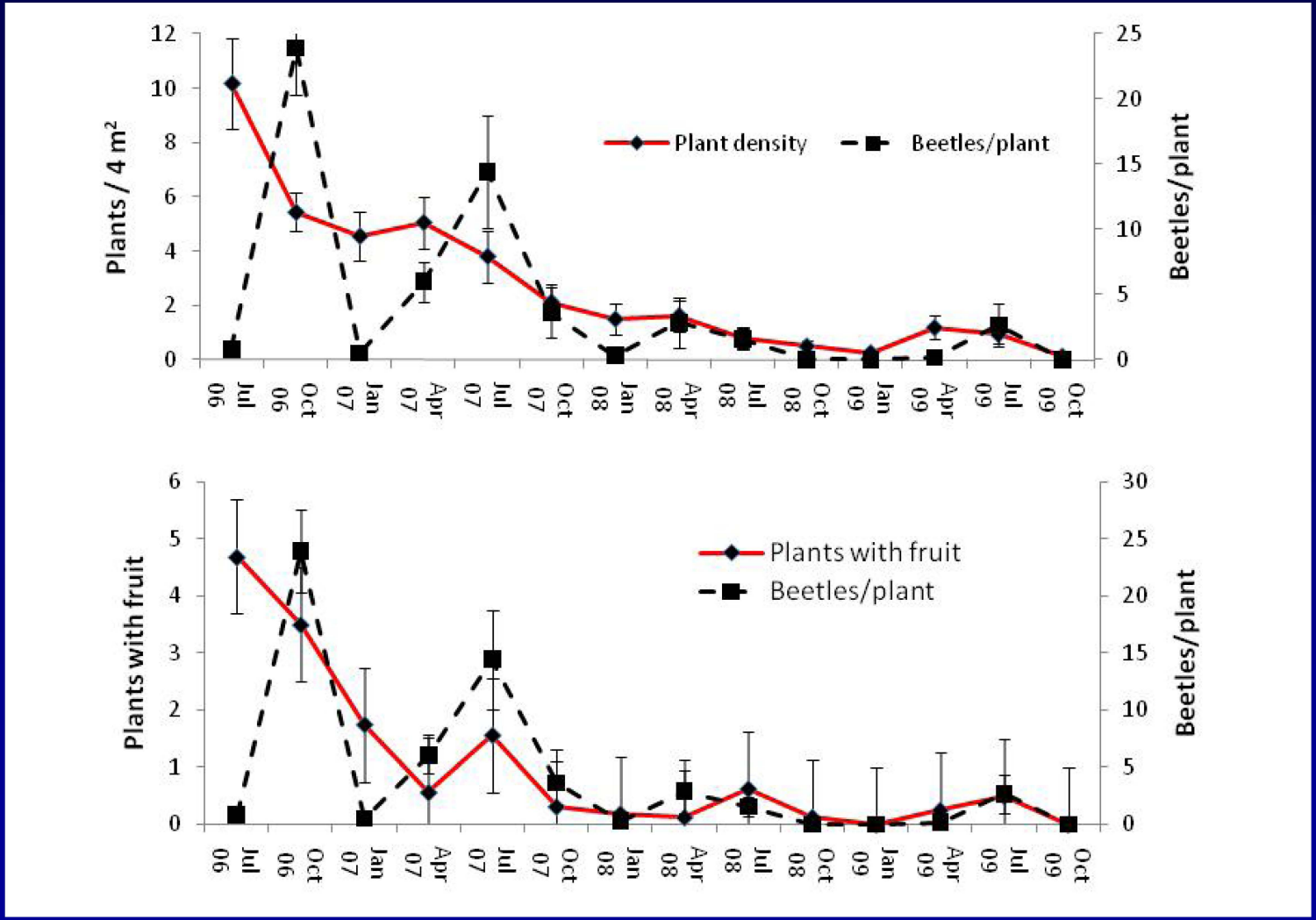
TSA Beetle Impact Study

Jul 2006- Oct 2009



Overholt et al. (2009)

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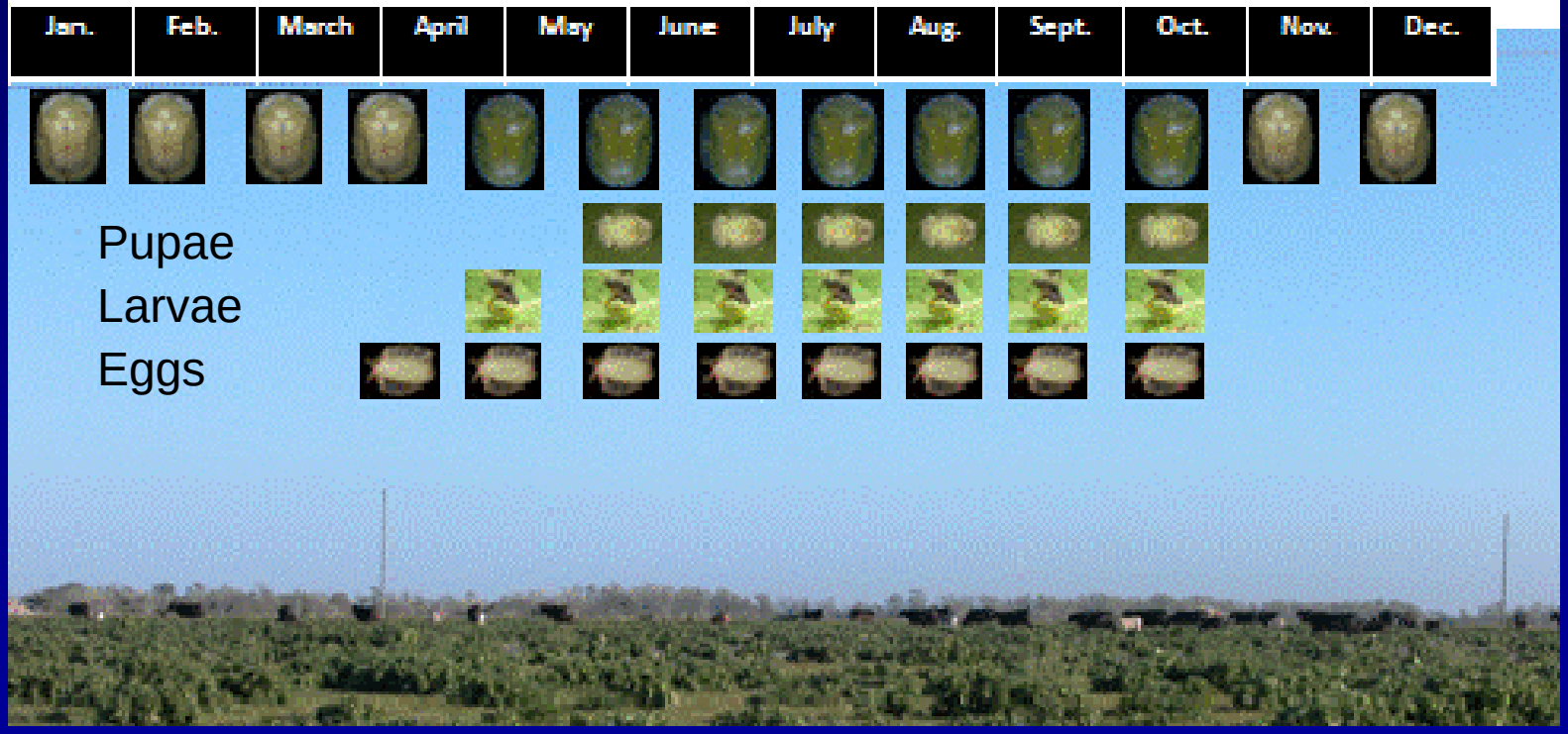
TSA Beetle Phenology

Adults are reproductive from April to October and migrate to the ground during winter



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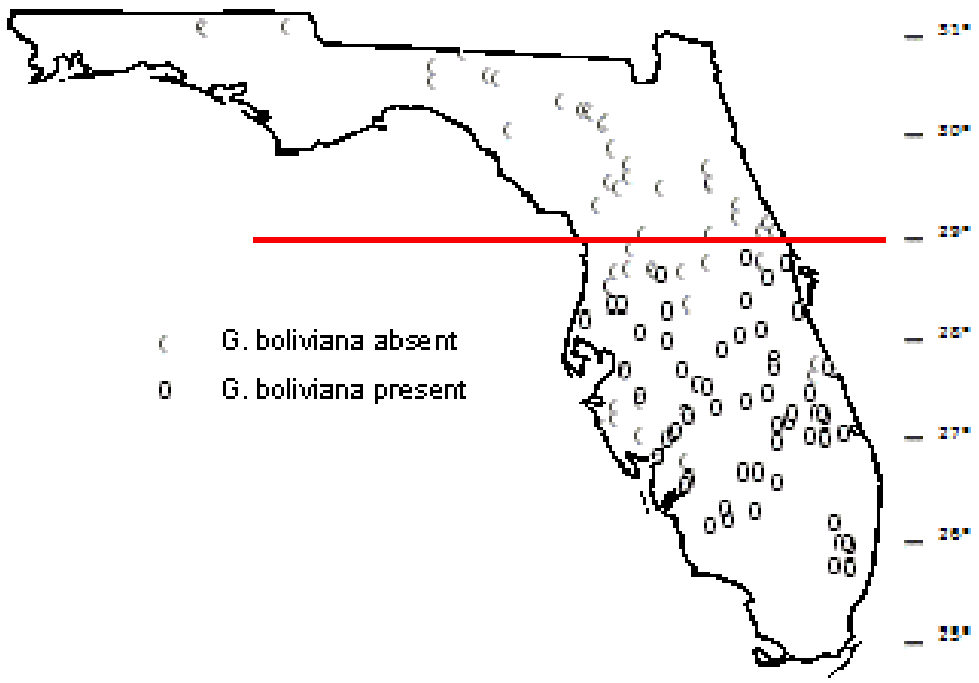
TSA Beetle Current Distribution

The beetle is established below the 29°N latitude ONLY



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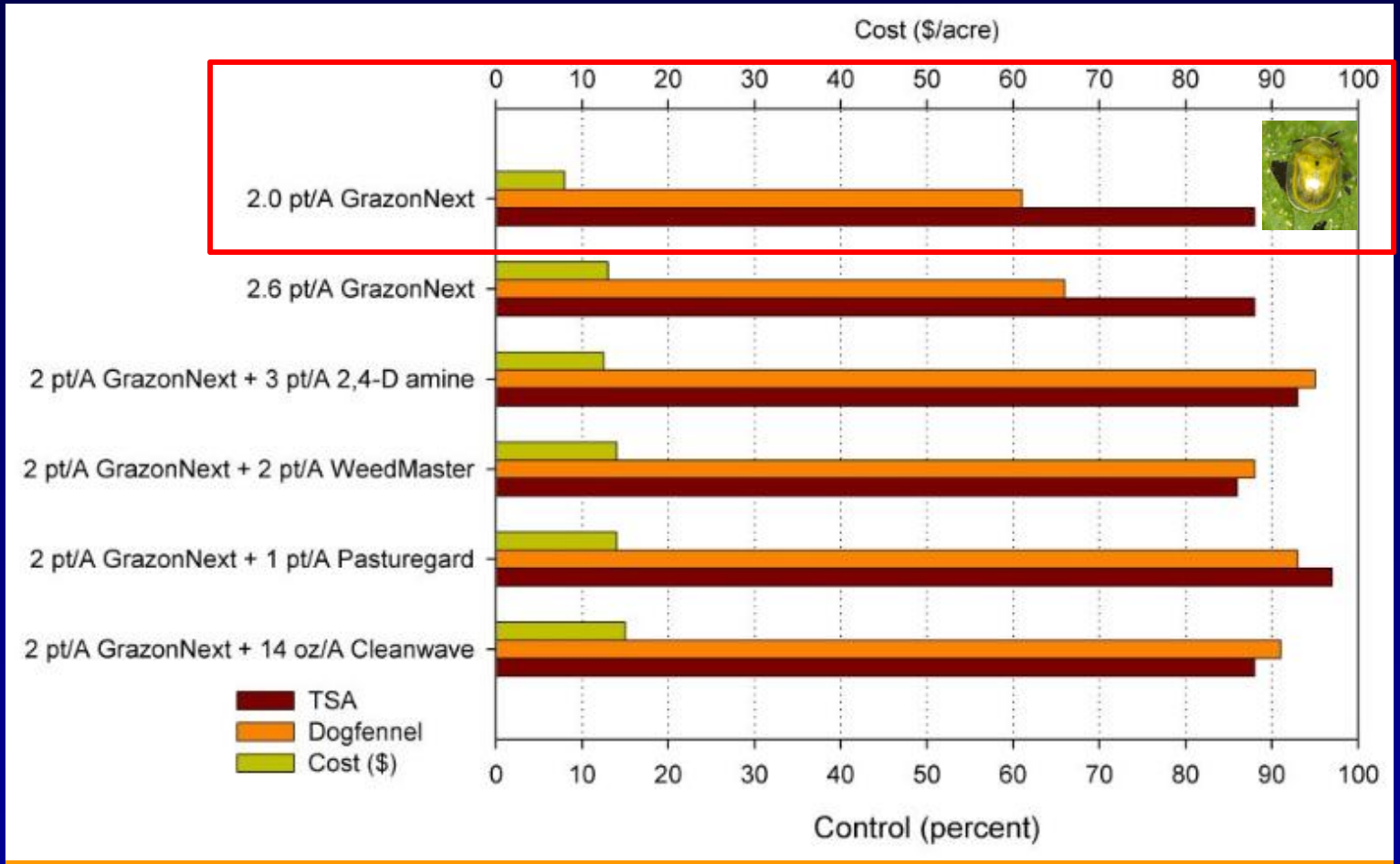
Chemical Control



Response of TSA with 2.0 and 2.6 pt/acre of GrazonNext alone and 2 pints/acre of GrazonNext plus 2,4-D amine, WeedMaster, Pasturegard, or Vista. Herbicide prices shown are approximate and do not include application costs

Source: B. Sellers

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Augmentative BioControl

- Release of Large Numbers of a Biological Control Agent to Achieve a Rapid Effect
- There is No Expectation the Biological Control Agent will Establish a Permanent (= Reproducing) Population

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SolviNix™ Bioherbicide

Tobacco Mottled Green Mosaic Virus

The use of TMGMV as a bioherbicide for TSA has been patented by the University of Florida (U.S. Patent No. 6,689,718 B2, issued Feb. 10, 2004)

BioProdex, Inc., has licensed this technology from the University of Florida Research Foundation (UFRF) to develop and register the virus as a bioherbicide

The proposed name of the bioherbicide is ***SolviNix*** (***Solvi*** = ***Solanum viarum***; ***Nix*** = to put an end to)

Inventor- R. Charudattan and colleagues

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SolviNix™ Bioherbicide

- SolviNix™ effective at concentrations as low as 200 mg / acre
- TSA plants of all ages highly susceptible & die within 3 weeks post-treatment
- Two formulations: liquid concentrate(LC) & wettable powder(WP)

Photo Credit: R. Charudattan

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Components of Melaleuca IPM Program

- **Mechanical Removal-** Immediate Effect
- **Herbicidal Control-** Temporary Effect
- **Biological Control-** Sustained Effect

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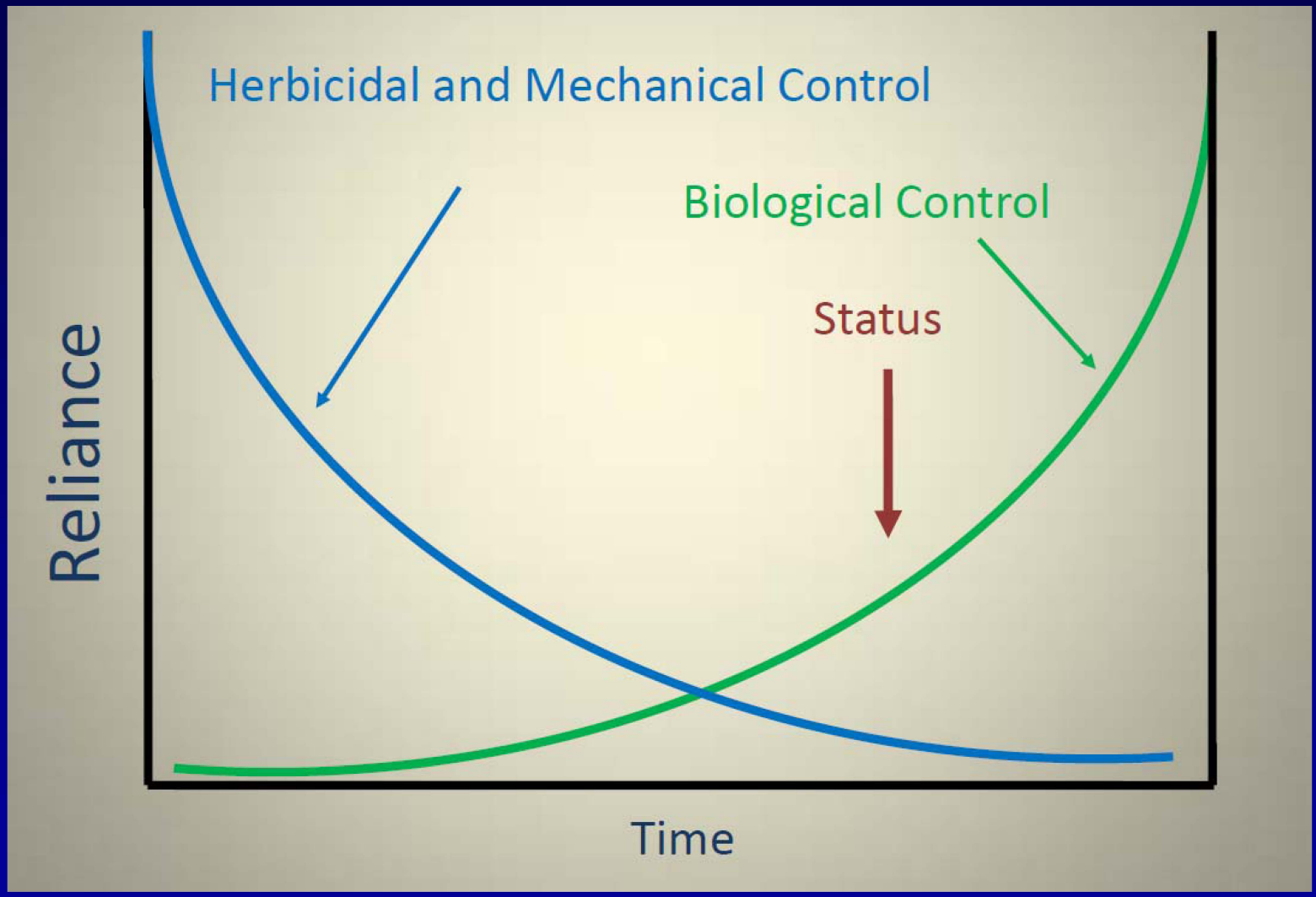
Mechanical Removal

Herbicidal Control

Biological Control

Melaleuca IPM



Source: http://biocontrolfornature.ucr.edu/2010_conferences_resources.html

Summary

- Integrated Systems Result in More Rapid and Economical Weed Control
- More Complete Control than with Any Method Used Alone
- Difficult to Control Invasive Weeds with Only One Tool

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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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Web Sites

http://plants.ifas.ufl.edu/manage/control-methods/introduction

http://ipm.ifas.ufl.edu/

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IPM Integrated Pest Management Florida

http://ipm.ifas.ufl.edu/

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