Simulation of bio-control on *Melaleuca quinquenervia* in south Florida by using JABOWA model

Bo Zhang[1], Don DeAngelis[2], Min Rayamajhi[3]

1. University of Miami

2. United States Geological Survey

3. USDA Invasive Plant Research Laboratory

Greater Everglades Ecosystem Restoration
Coral Springs, FL
April 21-23, 2015

USGS

This study will help understand:

- How Melaleuca invades in two habitats.

  Cypress swamps and Bay swamps
- How biological control influences Melaleuca's invasion.
- How native species will respond as a result of biological control of Melaleuca.

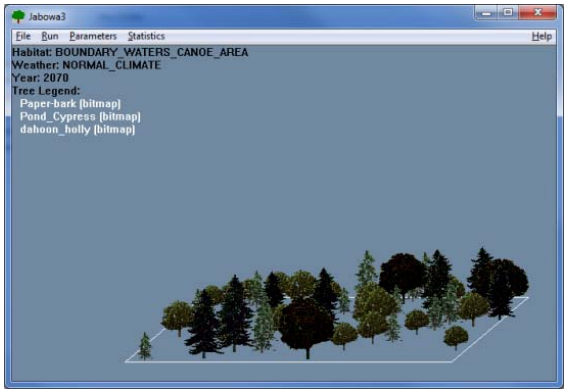
USGS

Outline

Current problem: Melaleuca's invasion

Field work of biological control (USDA)

Forecasts long term effects of biological control (JABOWA)



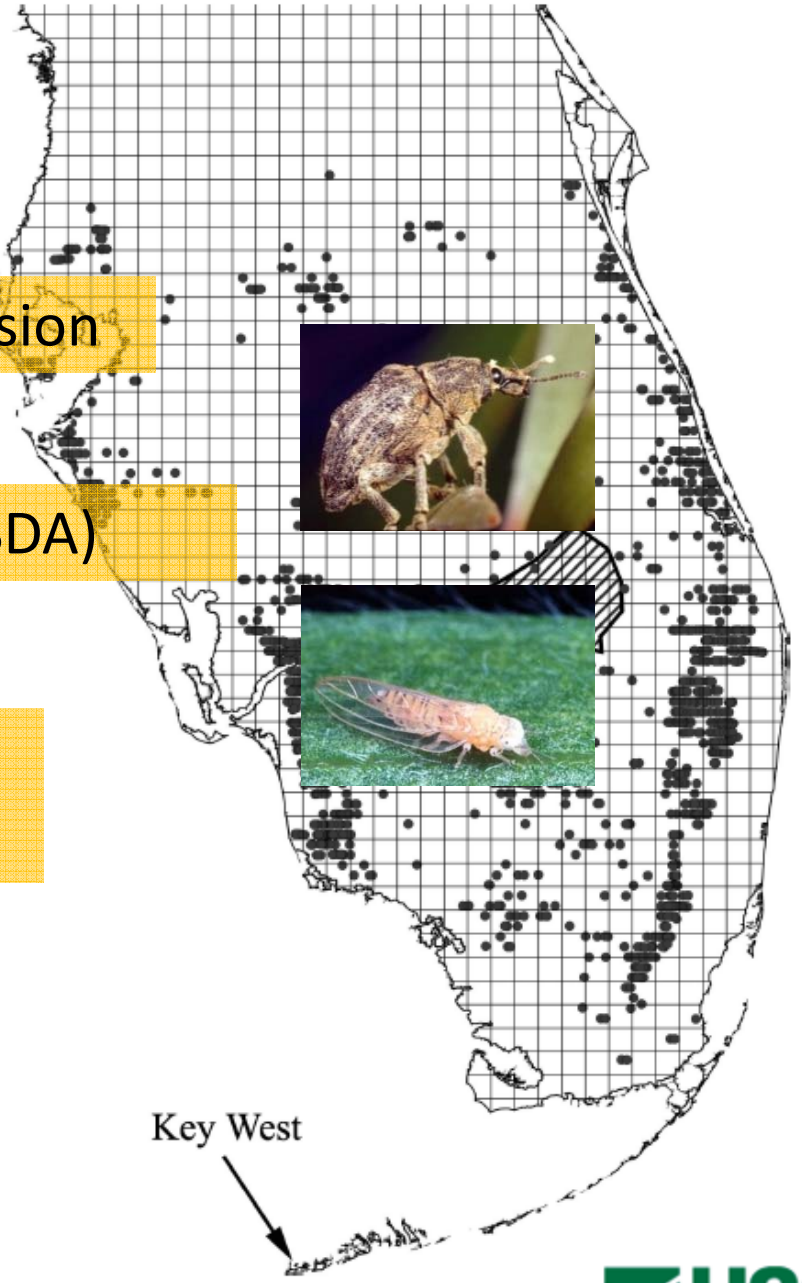


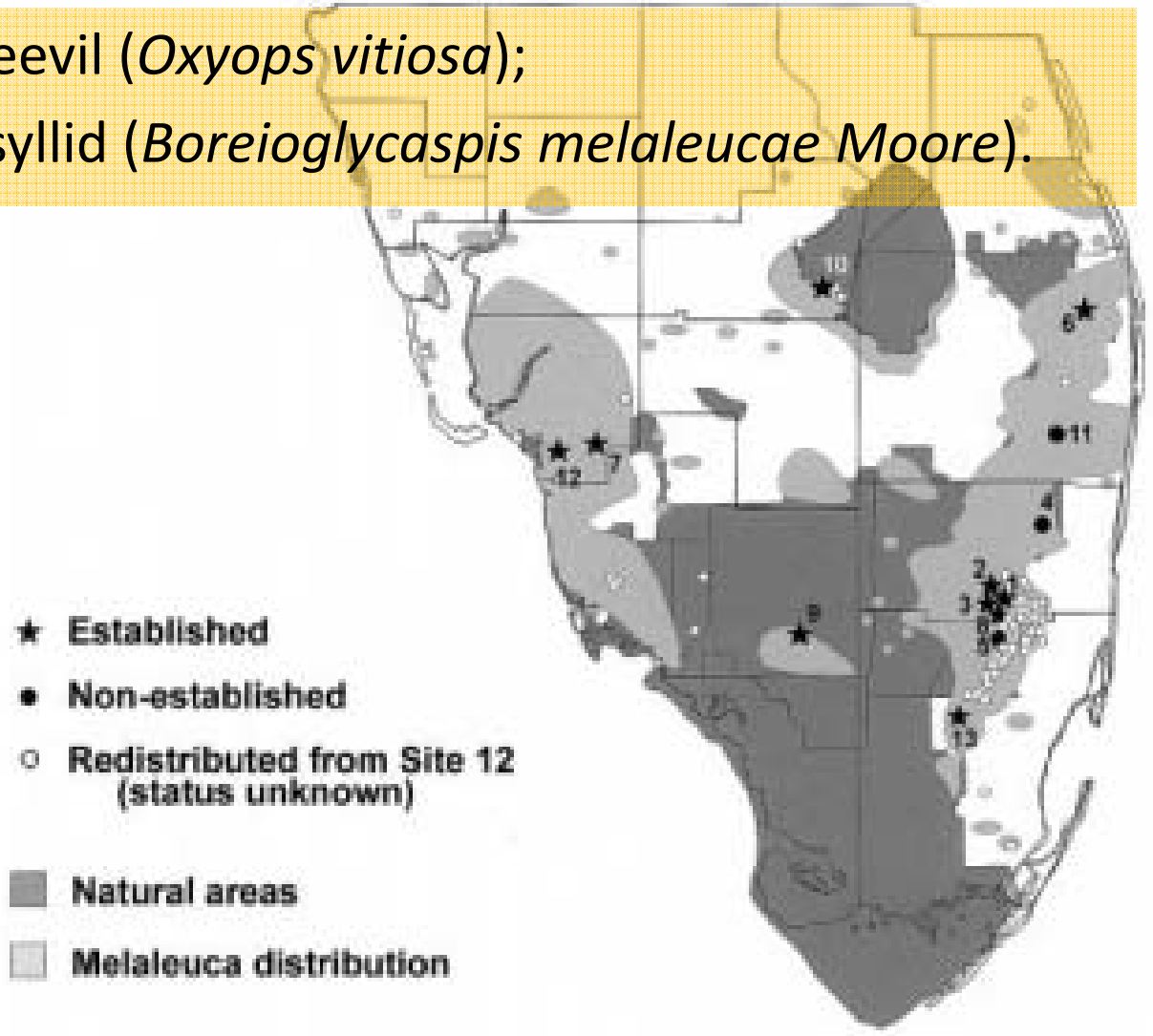
Fig. 1. Geographic range of the invasive tree *M. quinquenervia* for the penins observations from systematic reconnaissance flights conducted in 2003–2005. Grid delineated by 5′ longitudinal and latitudinal lines.

USGS

Current problem

- The value of services provided by wetlands: **$14,785** per hectare.
- The lost value arising from current Melaleuca infestations: nearly **$30** million per year.

- 1997: Australian weevil (*Oxyops vitiosa*);
- 2002: Melaleuca psyllid (*Boreioglycaspis melaleucae Moore*).



3.3 million individual biological control agents
407 locations
15 Florida counties

USGS

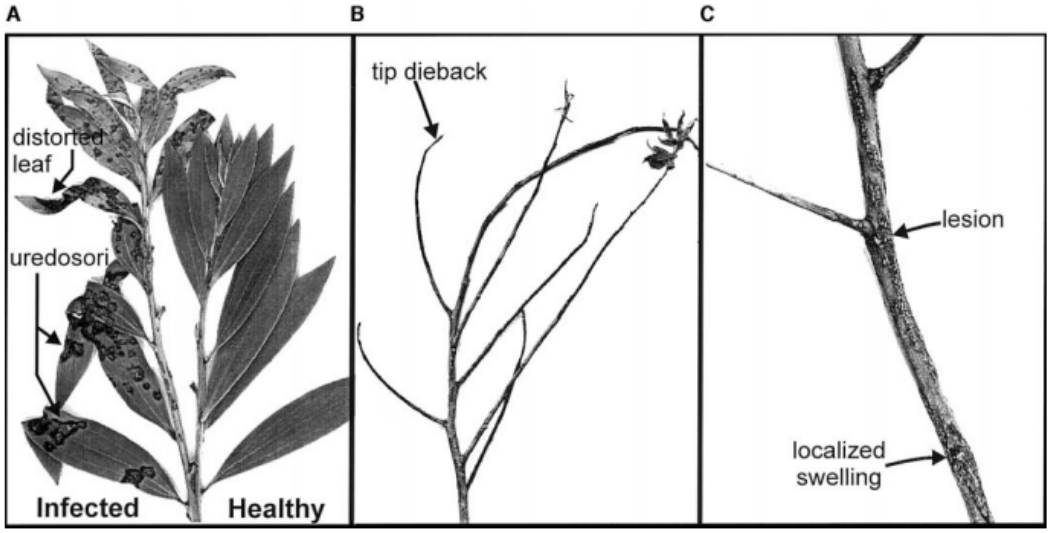


FIG. 1. Effects of *Puccinia psidii* on *Melaleuca quinquenervia* plants. (A) Healthy (right) and infected (left) shoot tips; (B) a severely defoliated twig showing tip dieback; (C) a portion of defoliated twig showing localized swellings and lesions.

Rayachhetry et al, 2001

85% decrease of reproduction rate
15% decrease of growth rate

FIG. 6. An example of the damage (right) caused by *Oxyops vitiosa* feeding on melaleuca.

Center et al, 2000

USGS

Individual based model: JABOWA

- JABOWA simulates plant succession in a 0.1 hectare plot, characteristic of plants and environmental conditions.

  - Slash pine *(Pinus elliottii);*
    Pond cypress *(Taxodium ascendens);*
    Dahoon holly *(Ilex cassine);*
    Sweet bay *(Laurus nobilis);*
    Loblolly bay (*Gordonia lasianthus*)*;

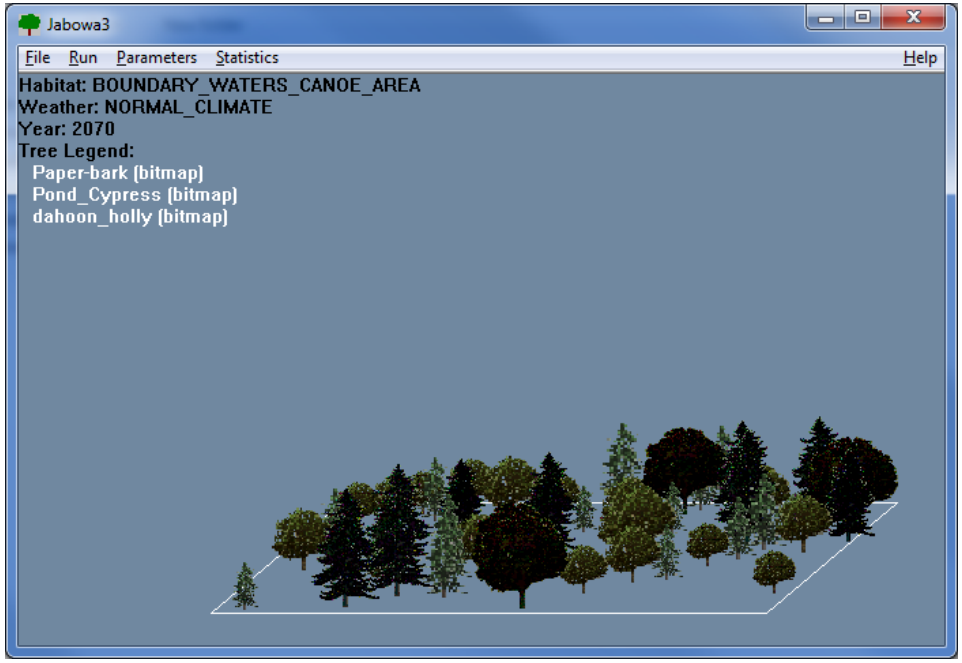
  - Melaleuca *(Melaleuca quinquenervia)*

*This is rare in south Florida, but growth data were available

USGS

Individual based model: JABOWA

- JABOWA simulates plant succession in a 0.1 hectare plot, using
  - Plant life history characteristics
  - Environmental conditions



USGS

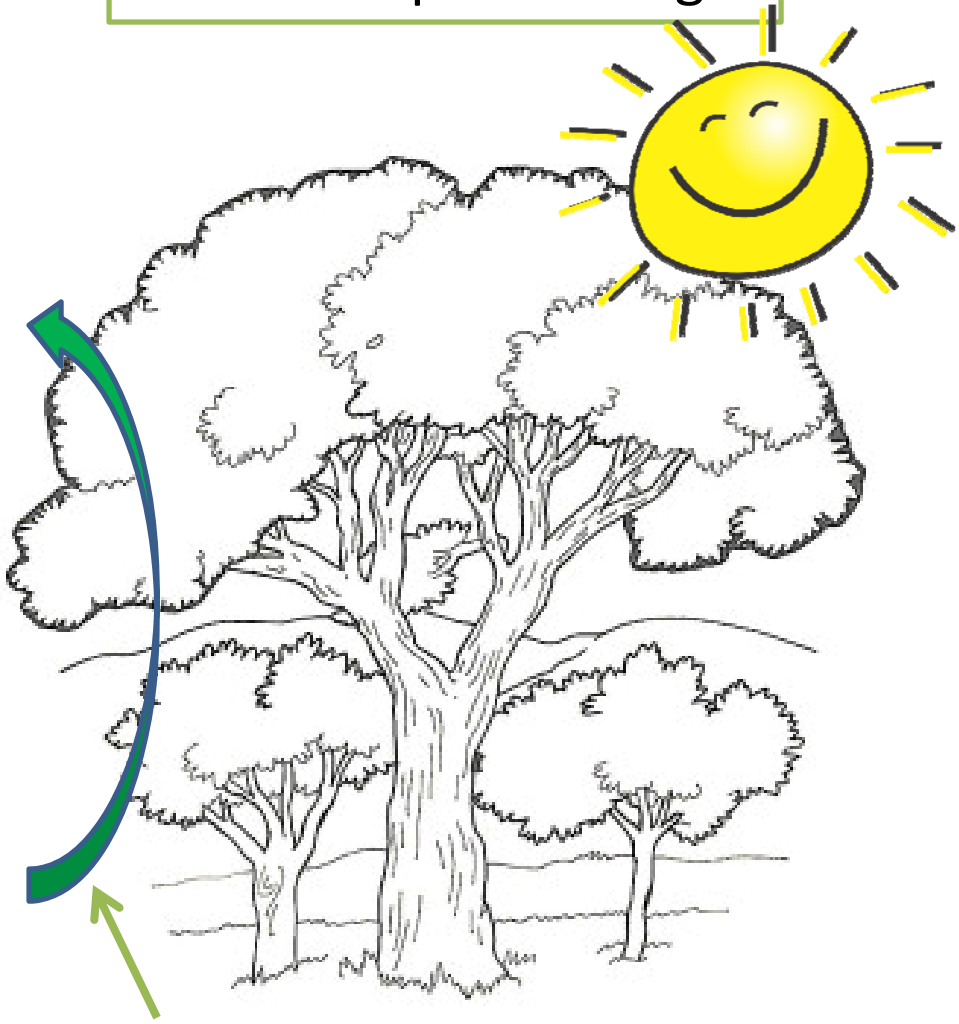
Inputs a set of plot data: estimate site quality

Introduces new saplings to stand

Kills some trees from stand

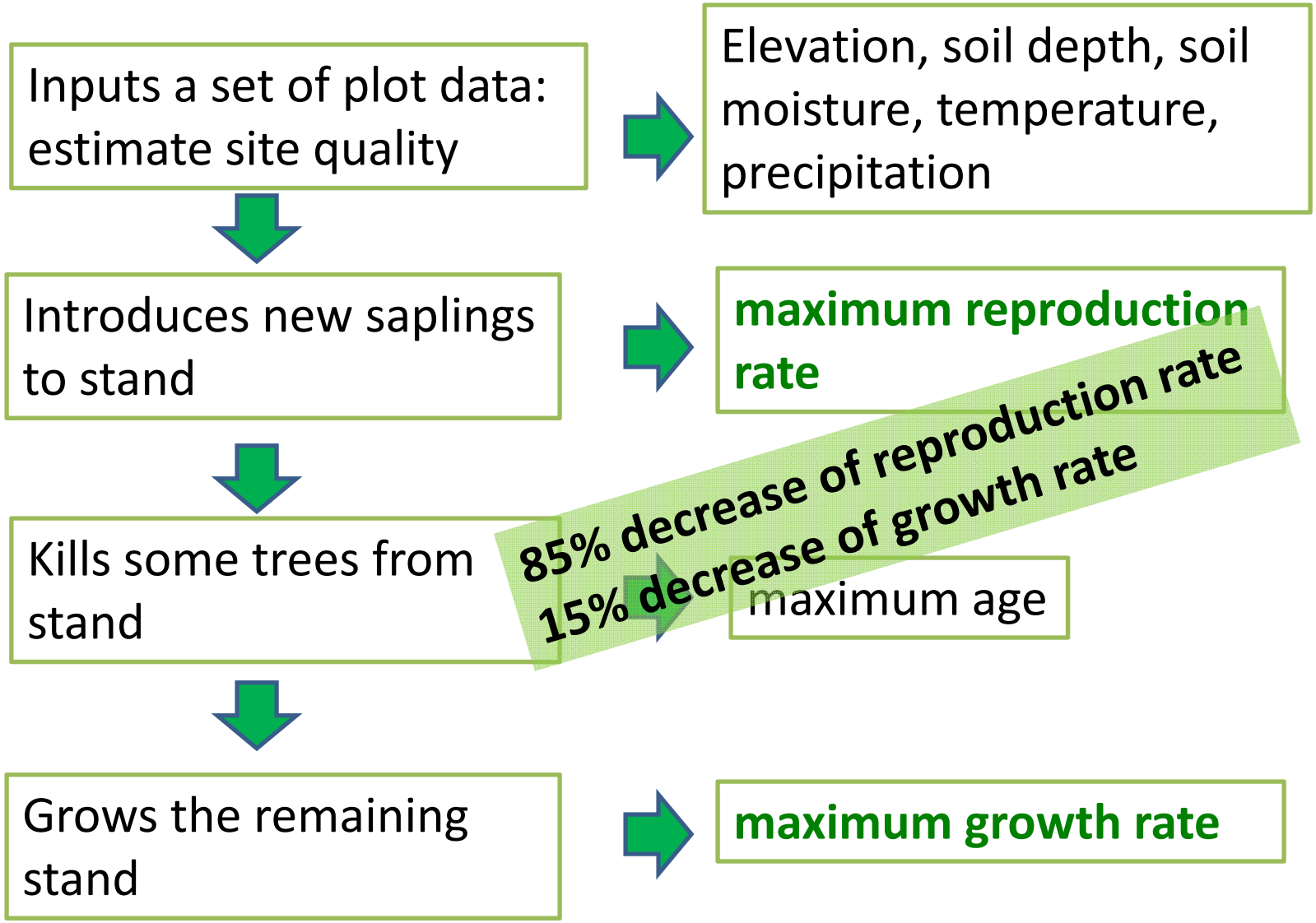
Grows the remaining stand

Direct competition: light



Reproduction

USGS


Inputs a set of plot data: estimate site quality
Elevation, soil depth, soil moisture, temperature, precipitation
Introduces new saplings to stand
maximum reproduction rate
85% decrease of reproduction rate
15% decrease of growth rate
Kills some trees from stand
maximum age
Grows the remaining stand
maximum growth rate

Results Section 1

- Two habitats: Cypress swamps and Bay swamps to describe
- 1. how native species do without *Melaleuca*'s invasion;
- 2. how *Melaleuca* invades in the two habitats;
- 3. how biocontrol works in the two habitats.

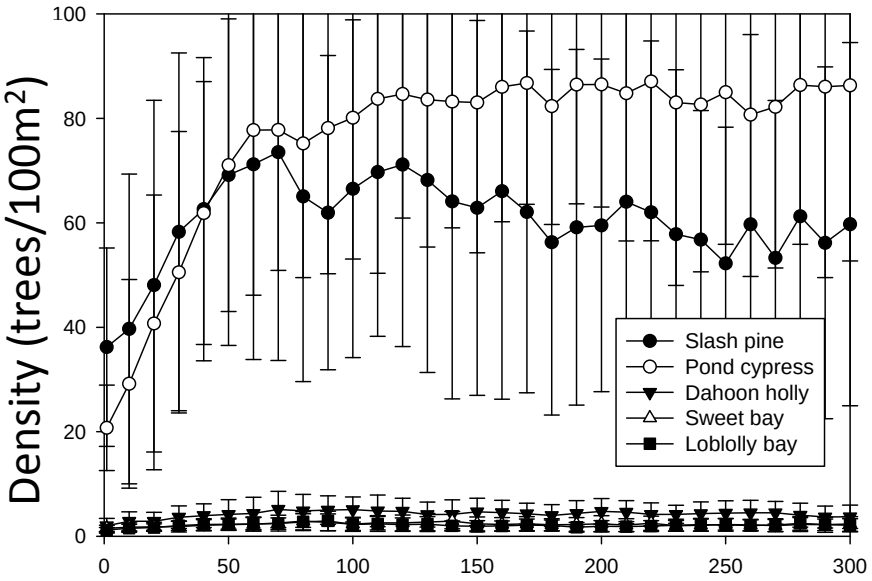
Definitions of Measures Used

- Density: The number of trees per unit area (trees/100m^2)
- Basal area: The total area of all stems measured breast height (cm^2/m^2)

USGS

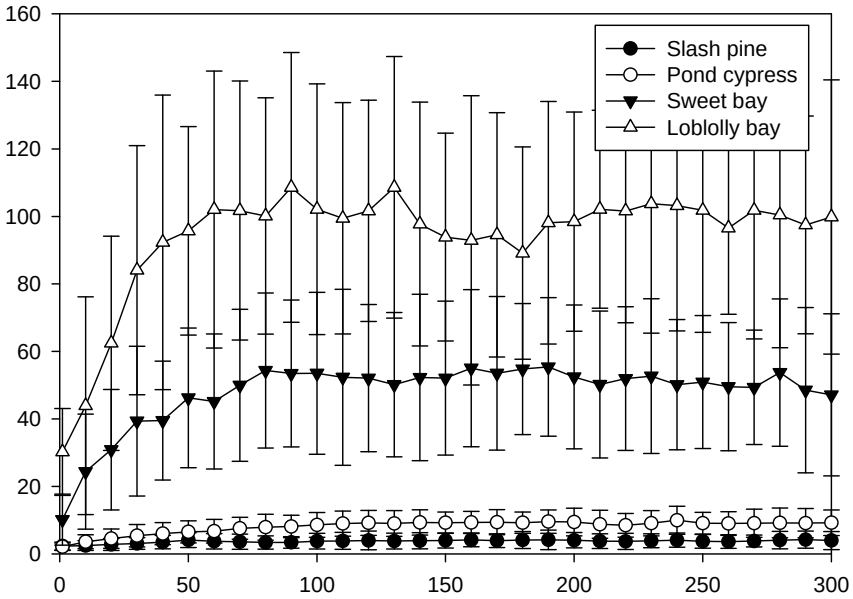
The dynamics of native species without *Melaleuca*

Cypress swamps



Simulation years

Bay swamps

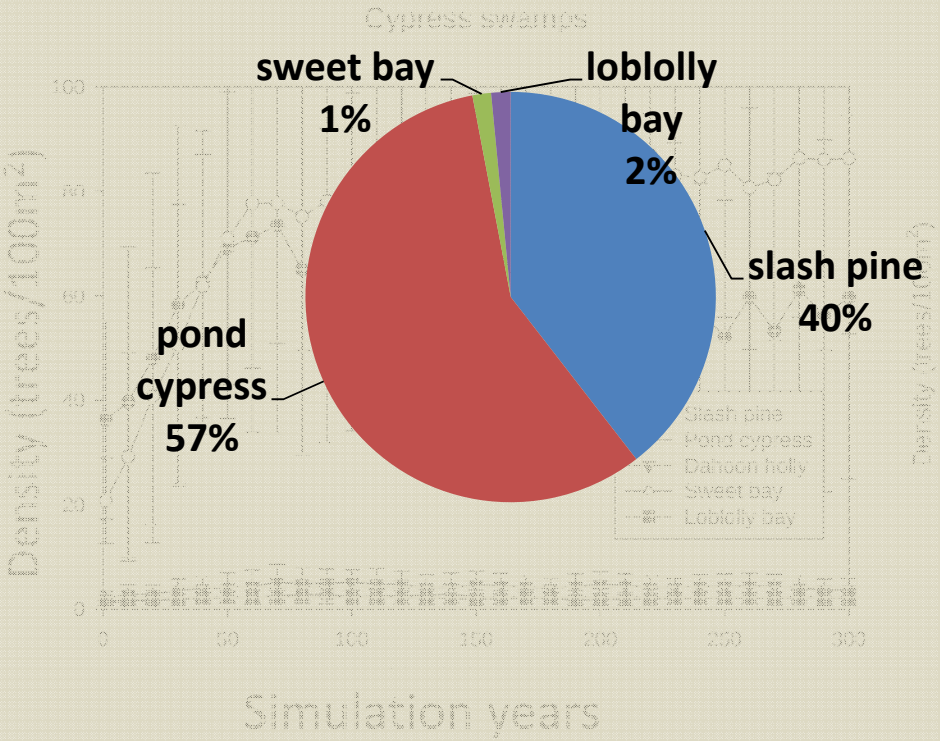


Simulation years

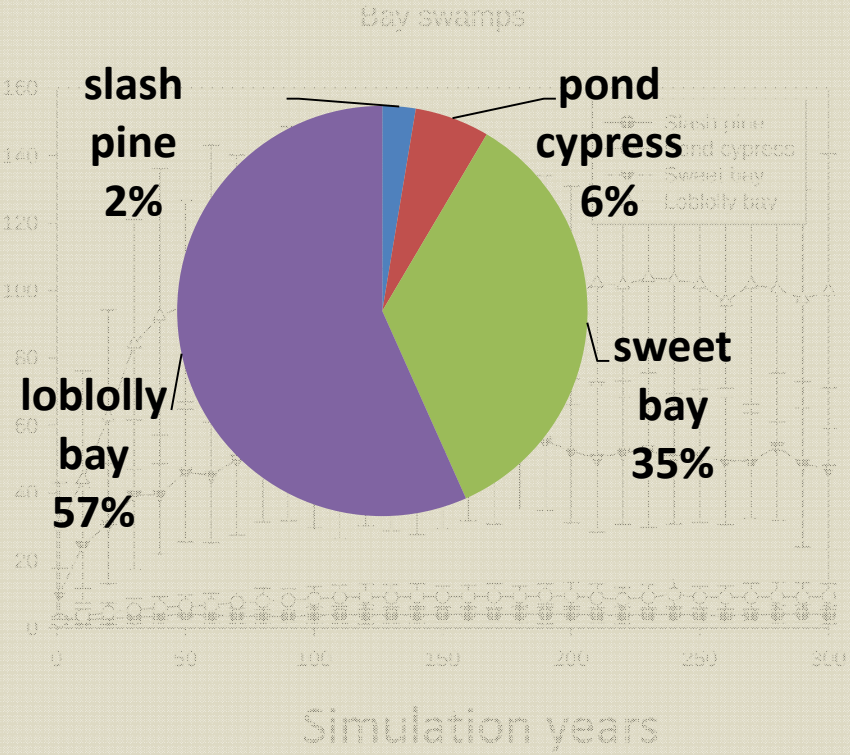
USGS

Mean steady state densities of native species without *Melaleuca*

Cypress swamps

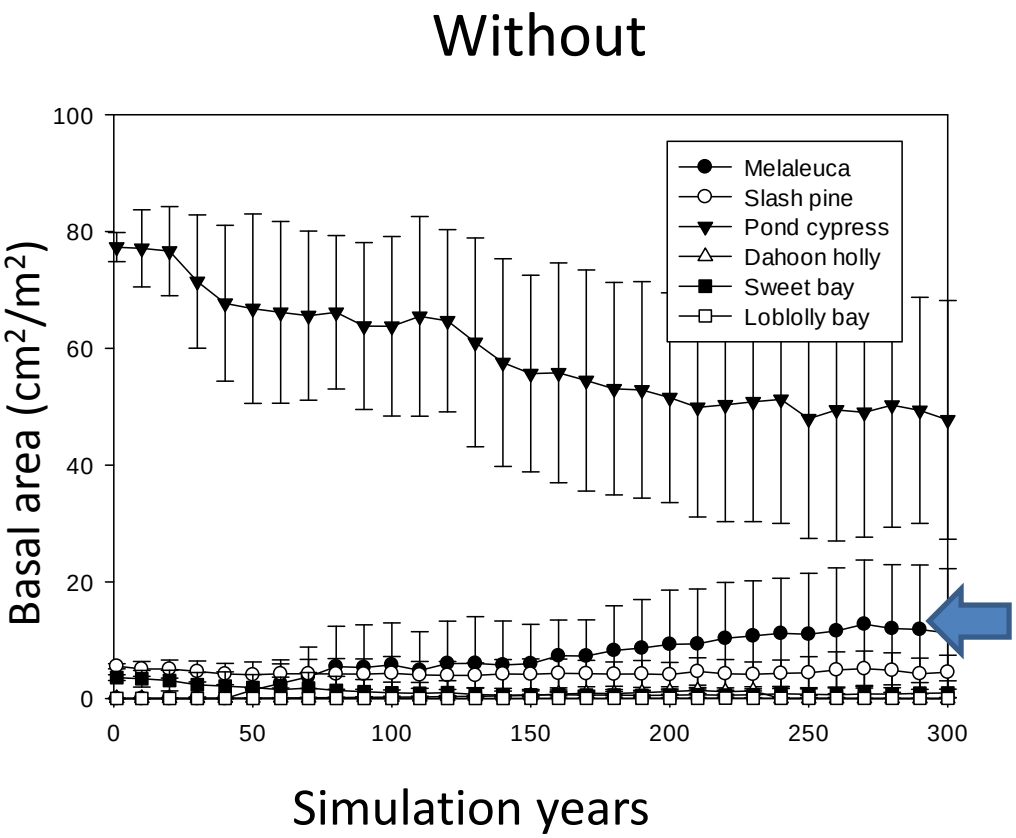


Bay swamps



Casey, W. and K. C. Ewel. 2006. Patterns of succession in forested depressional wetlands in North Florida, USA. Wetlands 26: 147-160.

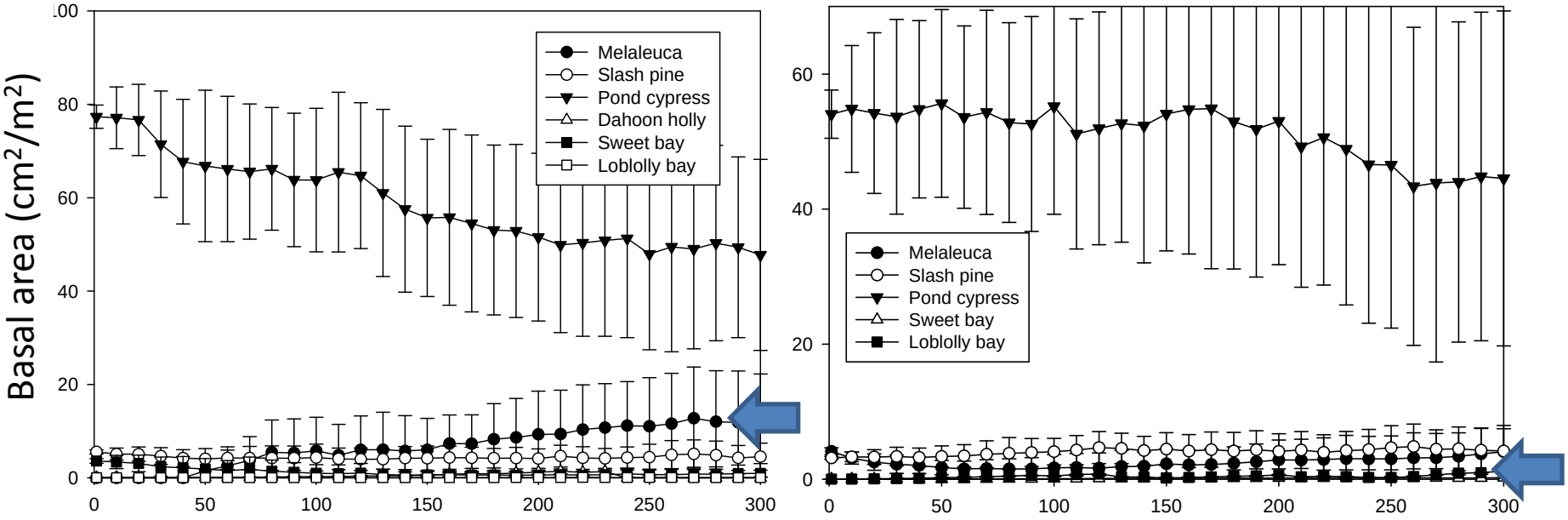
The basal area of native species with Melaleuca in Cypress swamps without bio-control



The basal area of native species with Melaleuca in Cypress swamps without and with bio-control

Without

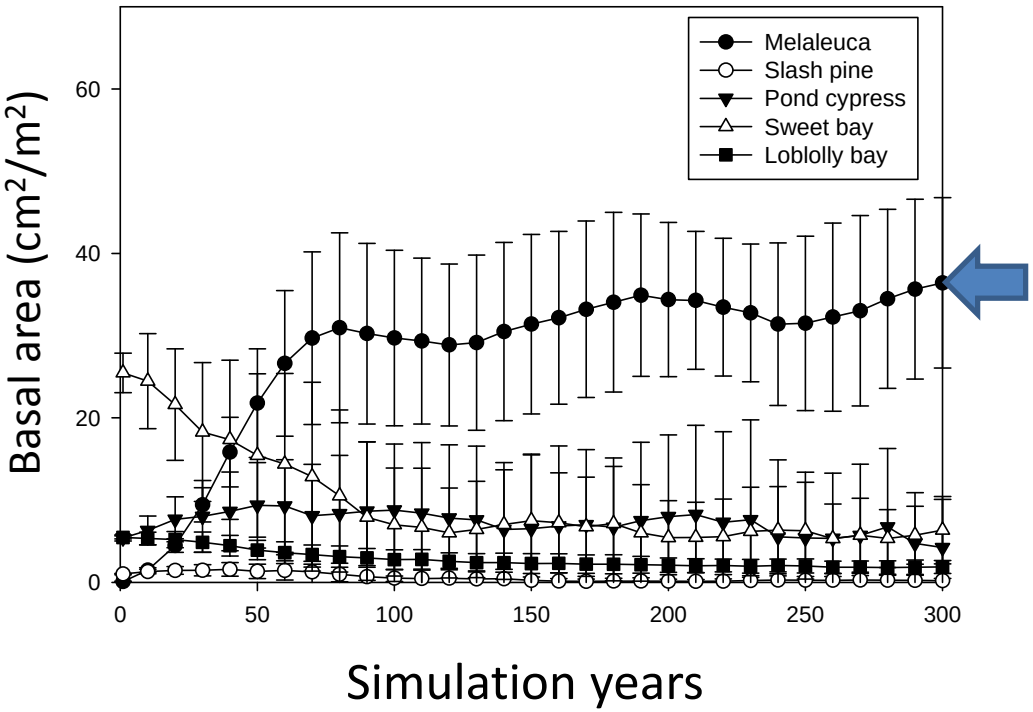
With



USGS

The basal area of native species with Melaleuca in Bay swamps without bio-control

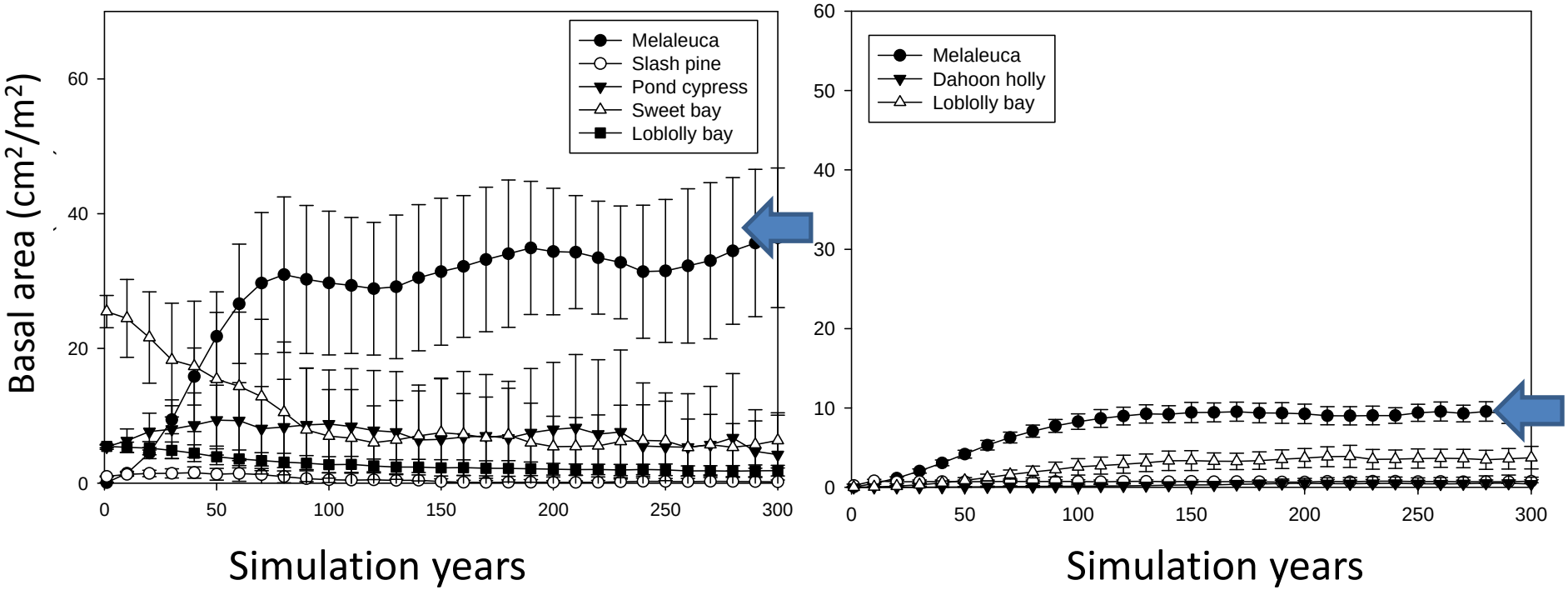
Without



The basal area of native species with Melaleuca in Bay swamps without and with bio-control

Without

With

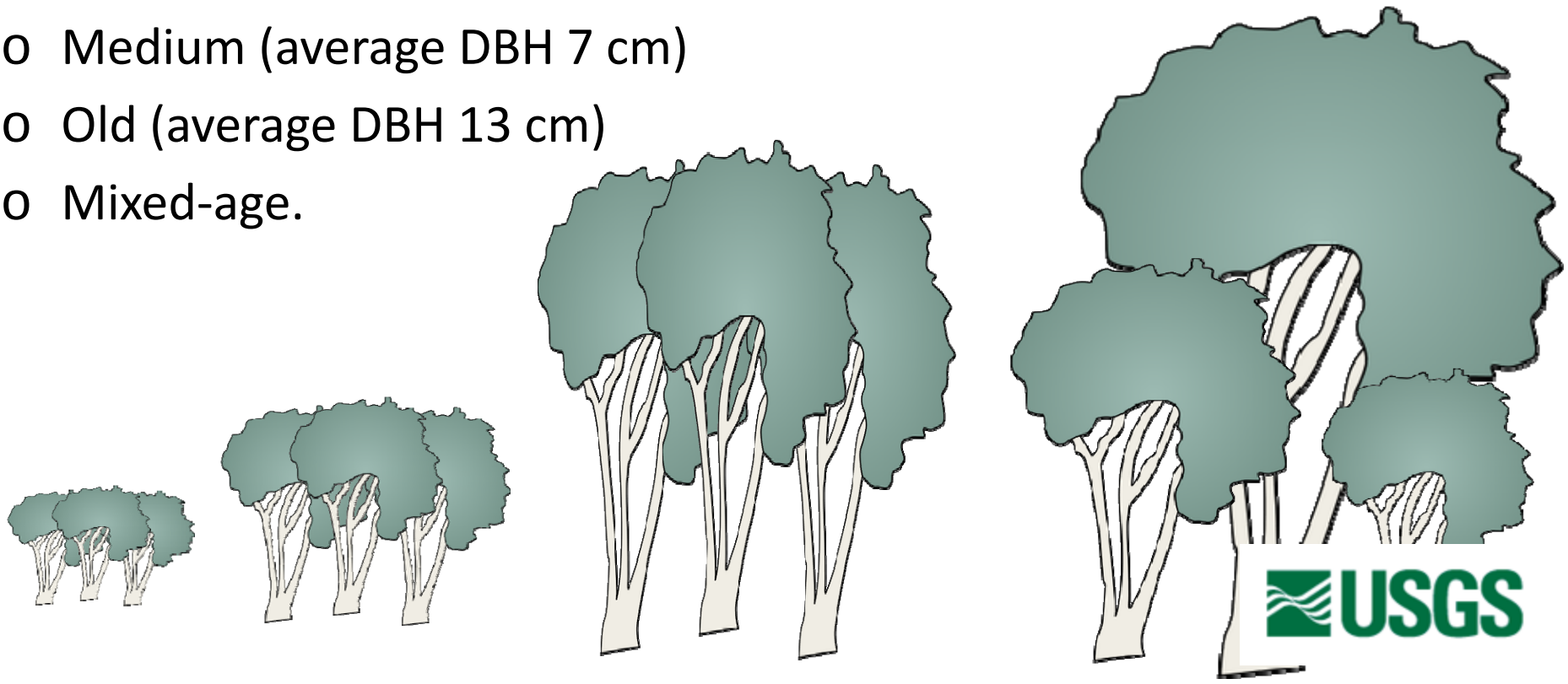


USGS

Results Section 2

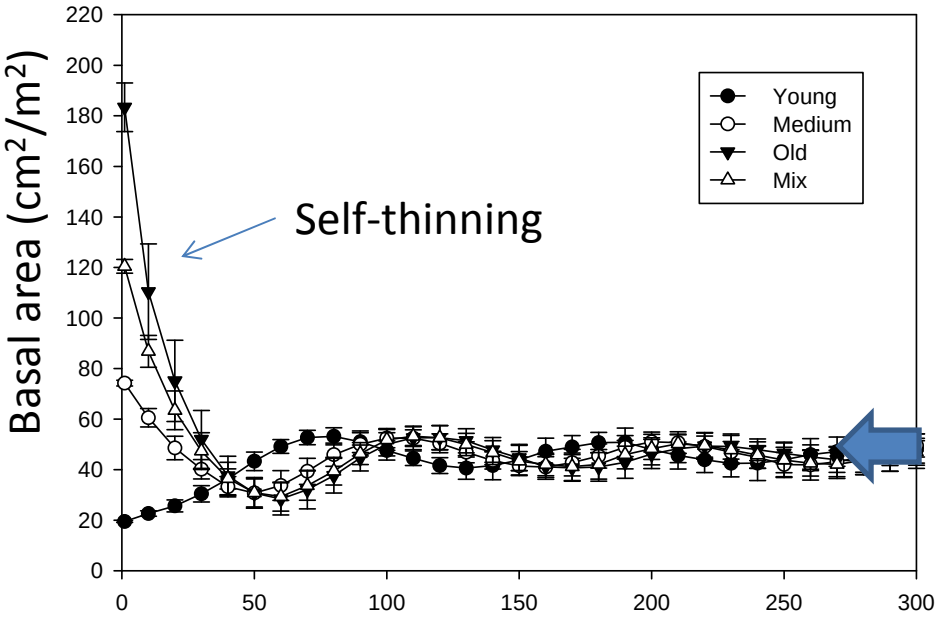
- How Melaleuca stands with different initial age distributions respond to biological control

- Young (average DBH 3.5 cm)
- Medium (average DBH 7 cm)
- Old (average DBH 13 cm)
- Mixed-age.

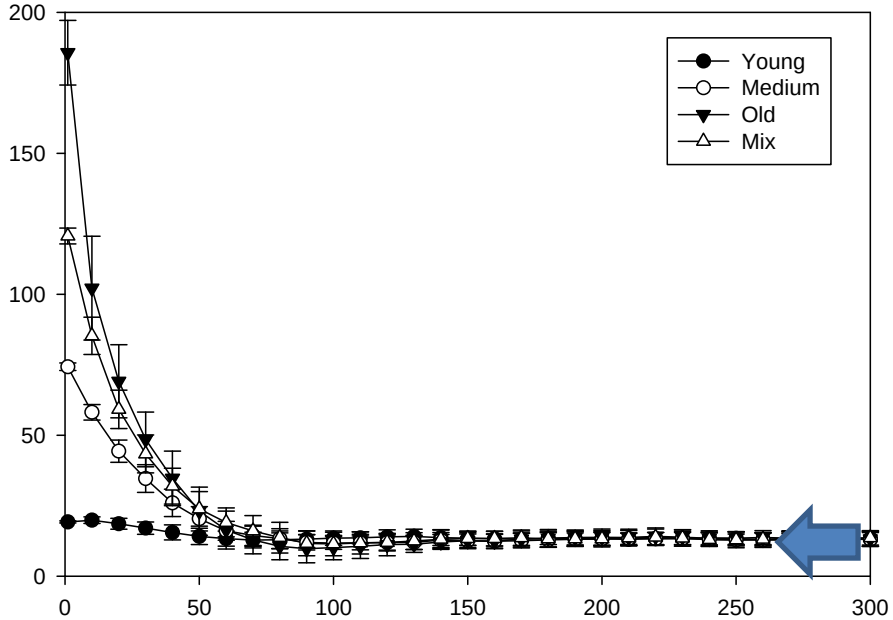


The basal area of pure Melaleuca stands without and without and with bio-control

Without



With

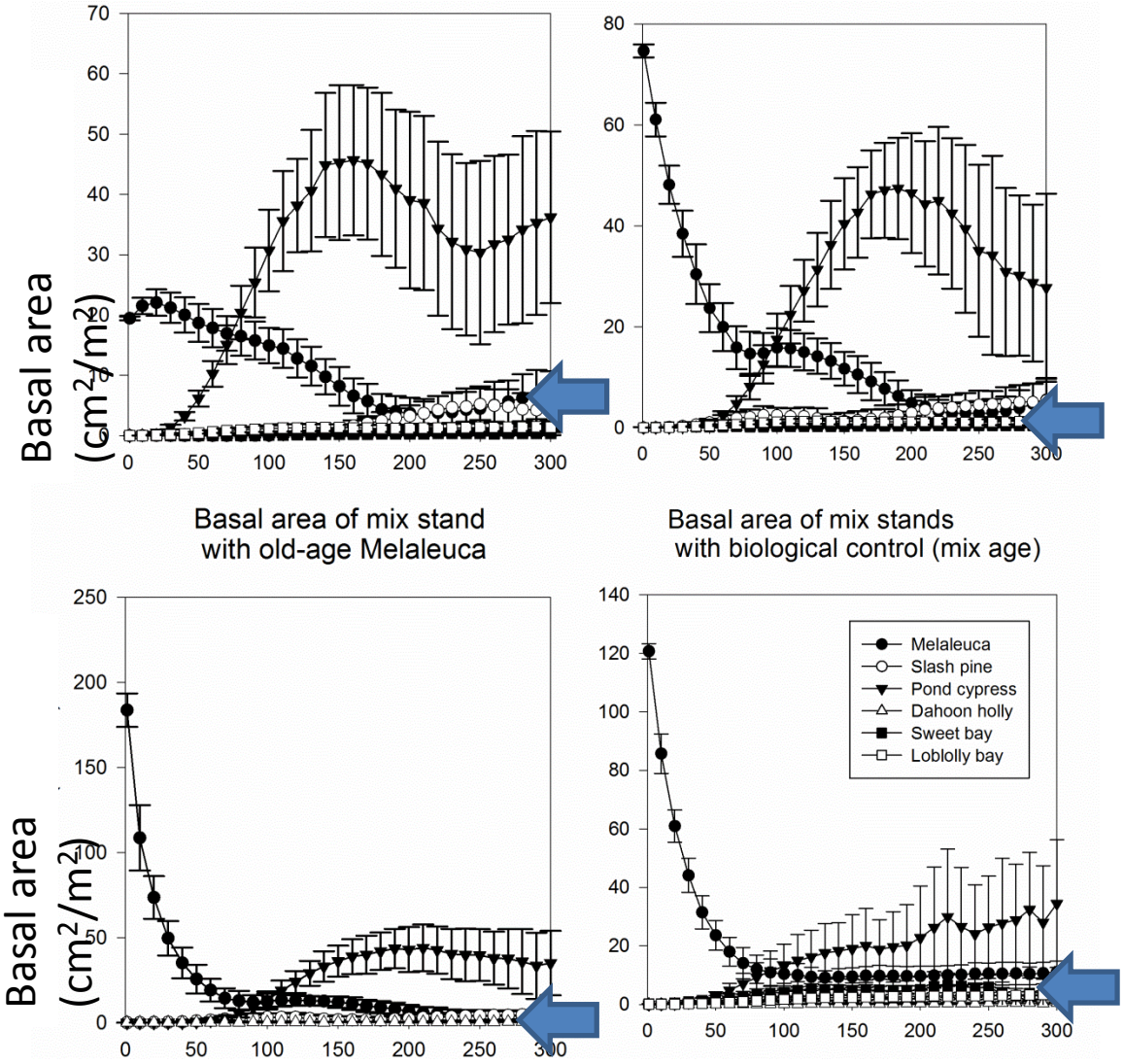


USGS

The basal area of different Melaleuca stands with native species and bio-control

Young

Medium



Old

Mixed

USGS

Conclusions

- Biological control decreased the invasion of Melaleuca.
- With biological control, native species can grow back to the habitat.
- Native species is able to shade the new saplings of Melaleuca. It is important to take care of native species.
- JABOWA could be applied to other invasive plant issues.

USGS

Acknowledgements

- Dr.Dan Botkin, creator of JABOWA
- Invasive Plant Reearch Laboratory, USDA, Davie, FL

- Funding source: USGS's Greater Everglades Priority Ecosystem Science

USGS