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

Bo Zhang¹, Don DeAngelis², Min Rayamajhi³

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
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.
Current problem: Melaleuca’s invasion

Field work of biological control (USDA)

Forecasts long term effects of biological control (JABOWA)
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.

Biological control offers the best hope.
• 1997: Australian weevil (*Oxyops vitiosa*);
• 2002: Melaleuca psyllid (*Boreioglycaspis melaleucae Moore*).

3.3 million individual biological control agents
407 locations
15 Florida counties
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. 4. An example of the damage (right) caused by *Oecophora vicina* feeding on *melaleuca*.

Center et al, 2000
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*
Individual based model: JABOWA

- JABOWA simulates plant succession in a 0.1 hectare plot, using
  - Plant life history characteristics
  - Environmental conditions
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
Inputs a set of plot data: estimate site quality

Introduces new saplings to stand

Kills some trees from stand

Grows the remaining stand

Elevation, soil depth, soil moisture, temperature, precipitation

**maximum reproduction rate**

85% decrease of reproduction rate

15% decrease of growth rate

**maximum age**

**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/100m²)
• Basal area: The total area of all stems measured breast height (cm²/m²)
The dynamics of native species without *Melaleuca*

**Cypress swamps**

**Bay swamps**
Mean steady state densities of native species without *Melaleuca*

### Cypress swamps

- **Sweet bay**: 1%
- **Loblolly bay**: 2%
- **Slash pine**: 2%
- **Pond cypress**: 40%
- **Total**: 57%

### Bay swamps

- **Pond cypress**: 6%
- **Sweet bay**: 35%
- **Loblolly bay**: 57%
- **Total**: 98%

---

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

![Graph showing basal area over simulation years without bio-control.](image)
The basal area of native species with Melaleuca in Cypress swamps without and with bio-control

**Without**

**With**

The graph shows the basal area (cm²/m²) of different species over simulation years. The bars indicate the variations in basal area with and without bio-control. The species include Melaleuca, Slash pine, Pond cypress, Dahoon holly, Sweet bay, and Loblolly bay.
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

Basal area (cm²/m²)

Simulation years

Melaleuca
Slash pine
Pond cypress
Sweet bay
Loblolly bay

Melaleuca
Dahoon holly
Loblolly bay
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

Self-thinning

With

Basal area (cm²/m²)

Simulation years

Simulation years

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

• Dr. Dan Botkin, creator of JABOWA
• Invasive Plant Research Laboratory, USDA, Davie, FL

  o Funding source: USGS’s Greater Everglades Priority Ecosystem Science