Modeling the long-term effect of bio-control on the spread of an invasive tree: melaleuca

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

1. University of Miami

2. United States Geological Survey

3. USDA Invasive Plant Research Laboratory

UNIVERSITY OF MIAMI

USGS science for a changing world

USDA

Melaleuca quinquenervia

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.

Bio-control

Dr. Min B. Rayamajhi

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

3.3 million individual biological control agents
407 locations
15 Florida counties

white circles desig-

Effects of bio-control

Rayachhetry et al, 2001

49% decrease of reproduction rate
83% decrease of growth rate

Center et al, 2000

L. Sevillano and C. C. Horvitz

83% decrease of growth rate

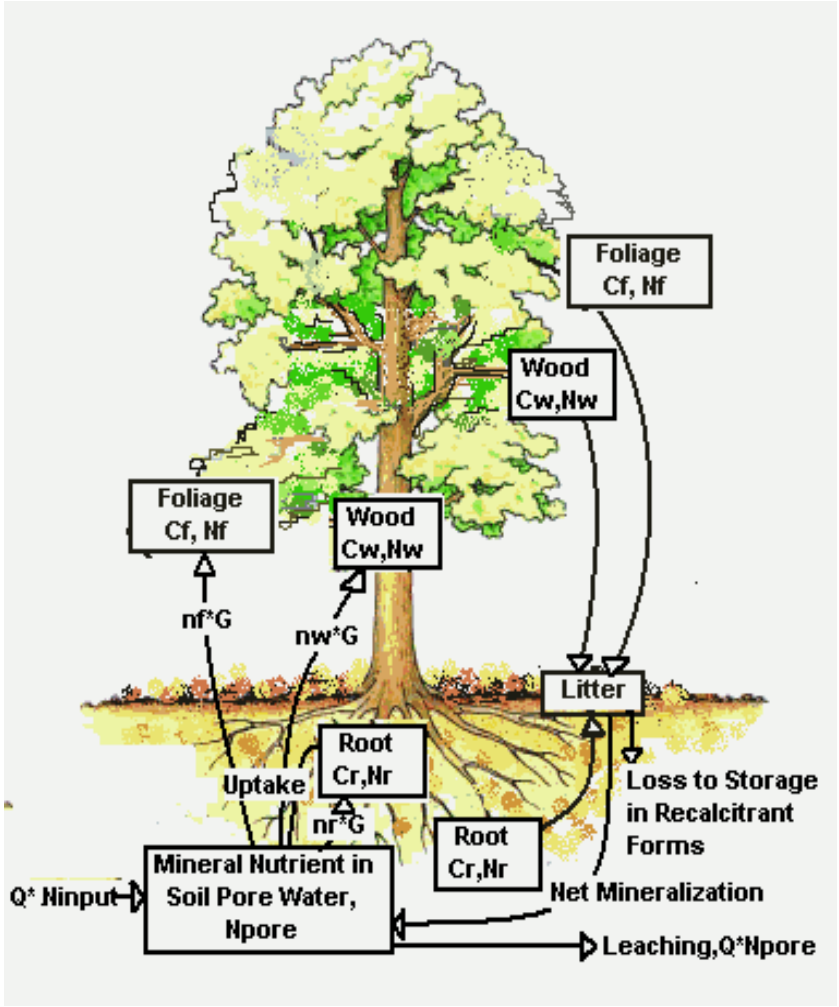
- **How will melaleuca respond?**
- **Can melaleuca tolerate?**

L. Sevillano and C. C. Horvitz

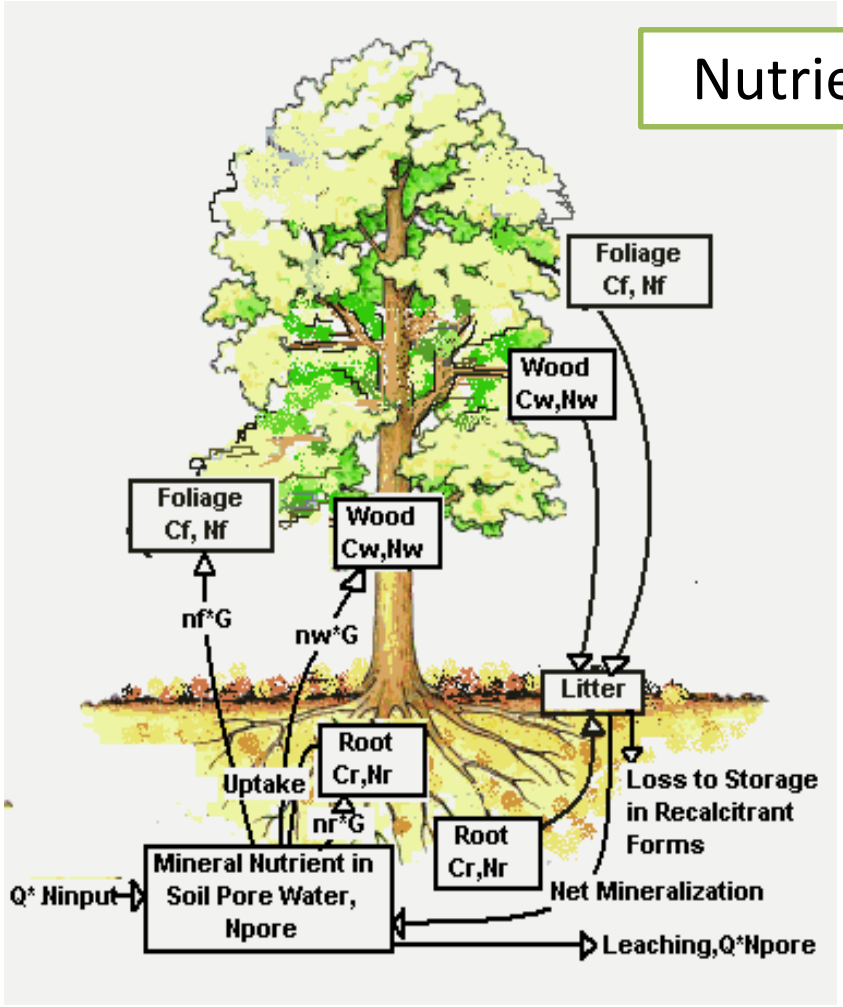
Objective1: To test a hypothesis

- Trees can change their strategies of allocating carbon and nutrient, to maintain a high growth rate. (Give more carbon to foliage)

The trade-off in investment between root and shoot (foliage).



Method: Process modeling



Nutrient uptake

Photosynthesis - carbon

Allocation: **foliage, wood and root**

$\eta foliage + \eta wood + \eta root = 1$

Goal: maximize growth rate

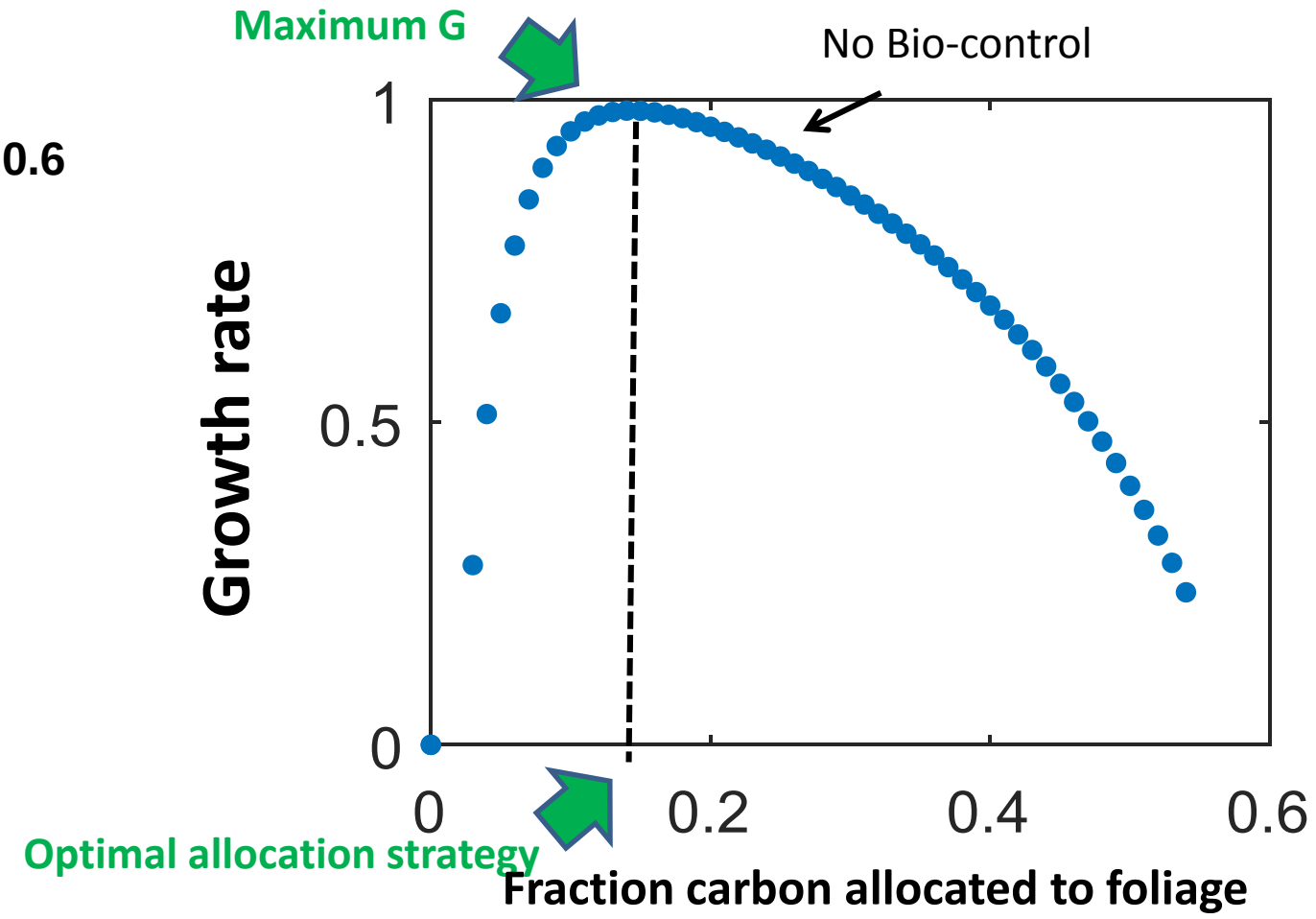
The model is based on the G'DAY model of Comins and McMurtrie (1993) , which was further developed by Ju (2008).

Optimal allocation strategy???

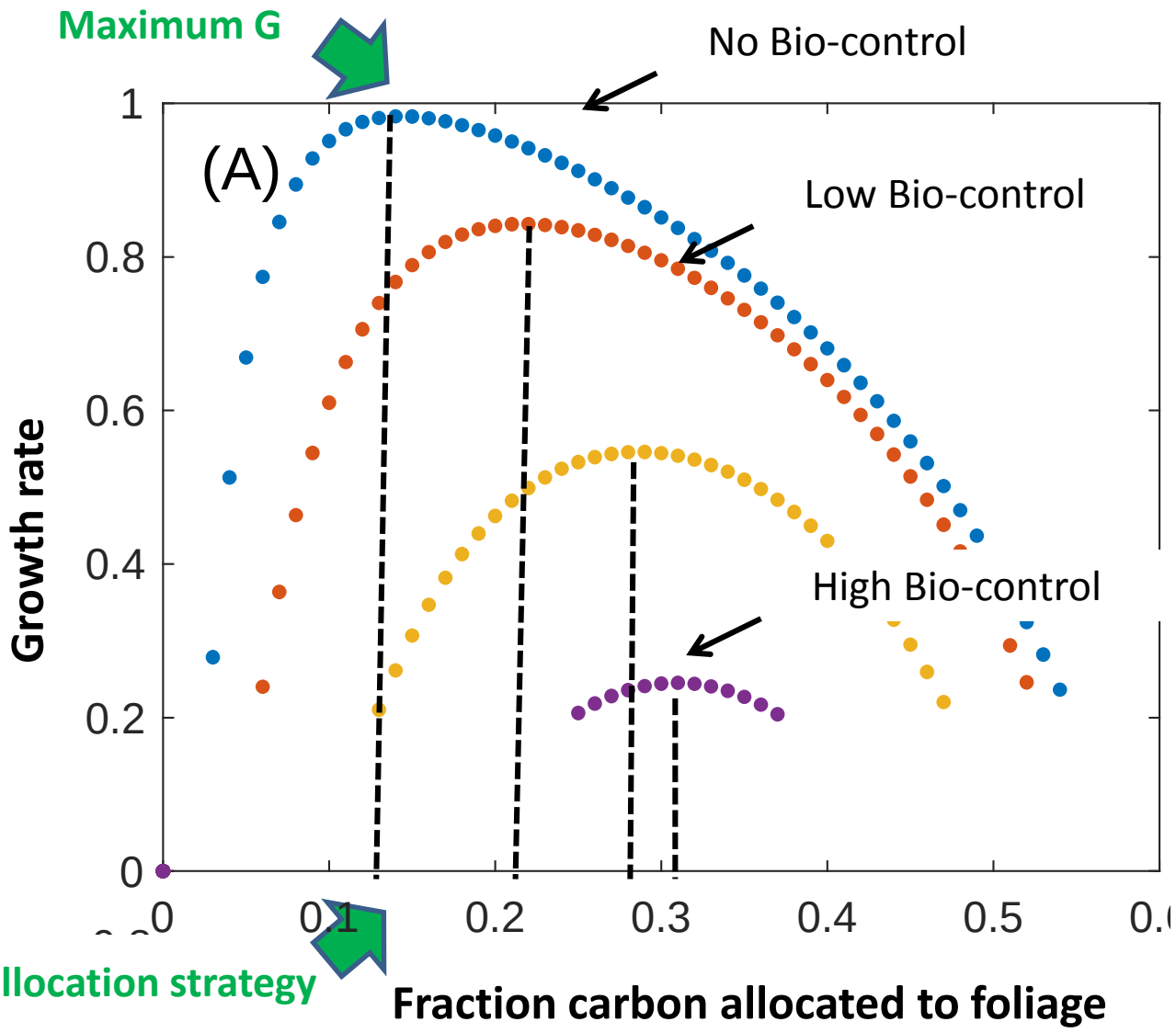
Optimal allocation strategy

ηwood = 0.4

ηfoliage + ηroot = 0.6

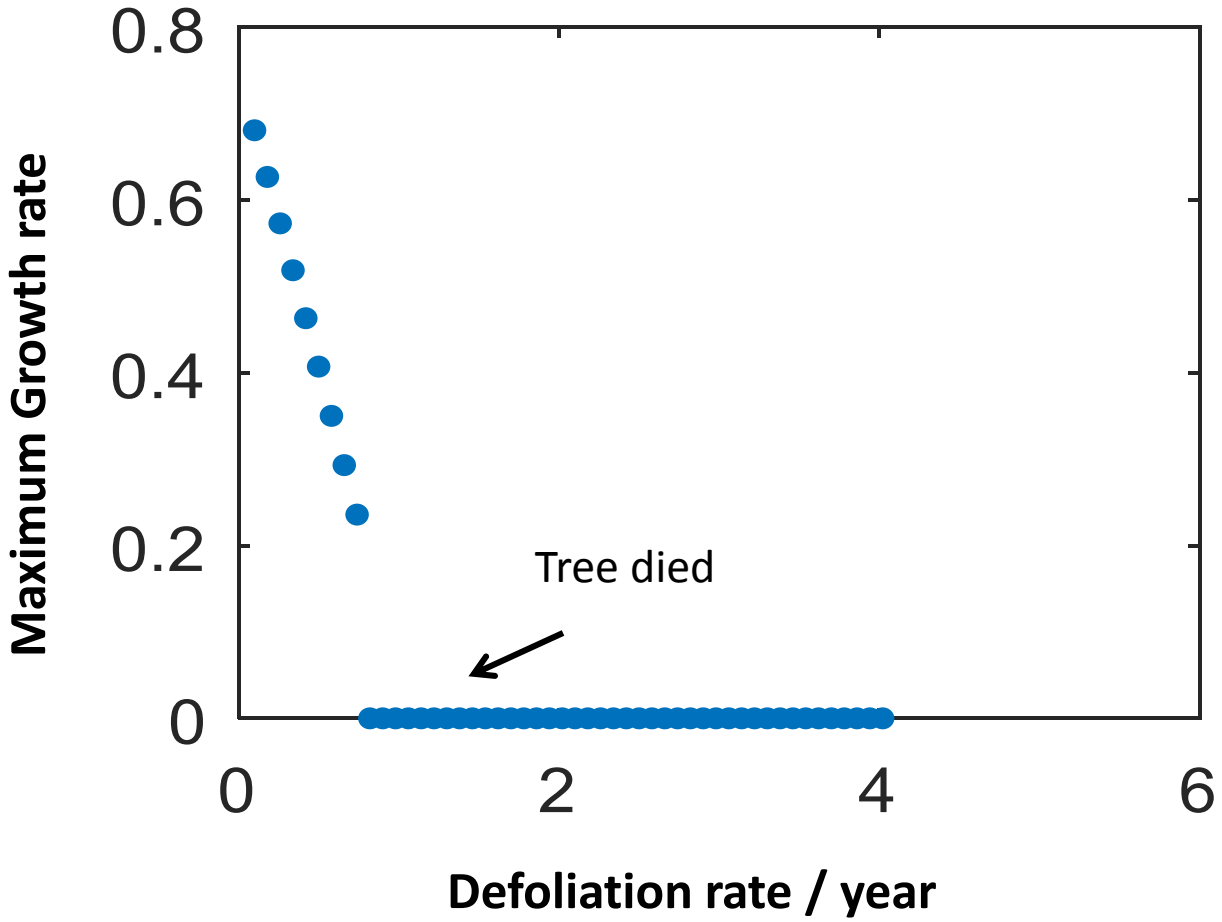


- **Growth rate** decreased with stronger bio-control;
- Melaleuca tended to allocate more carbon to foliage, especially with stronger bio-control.

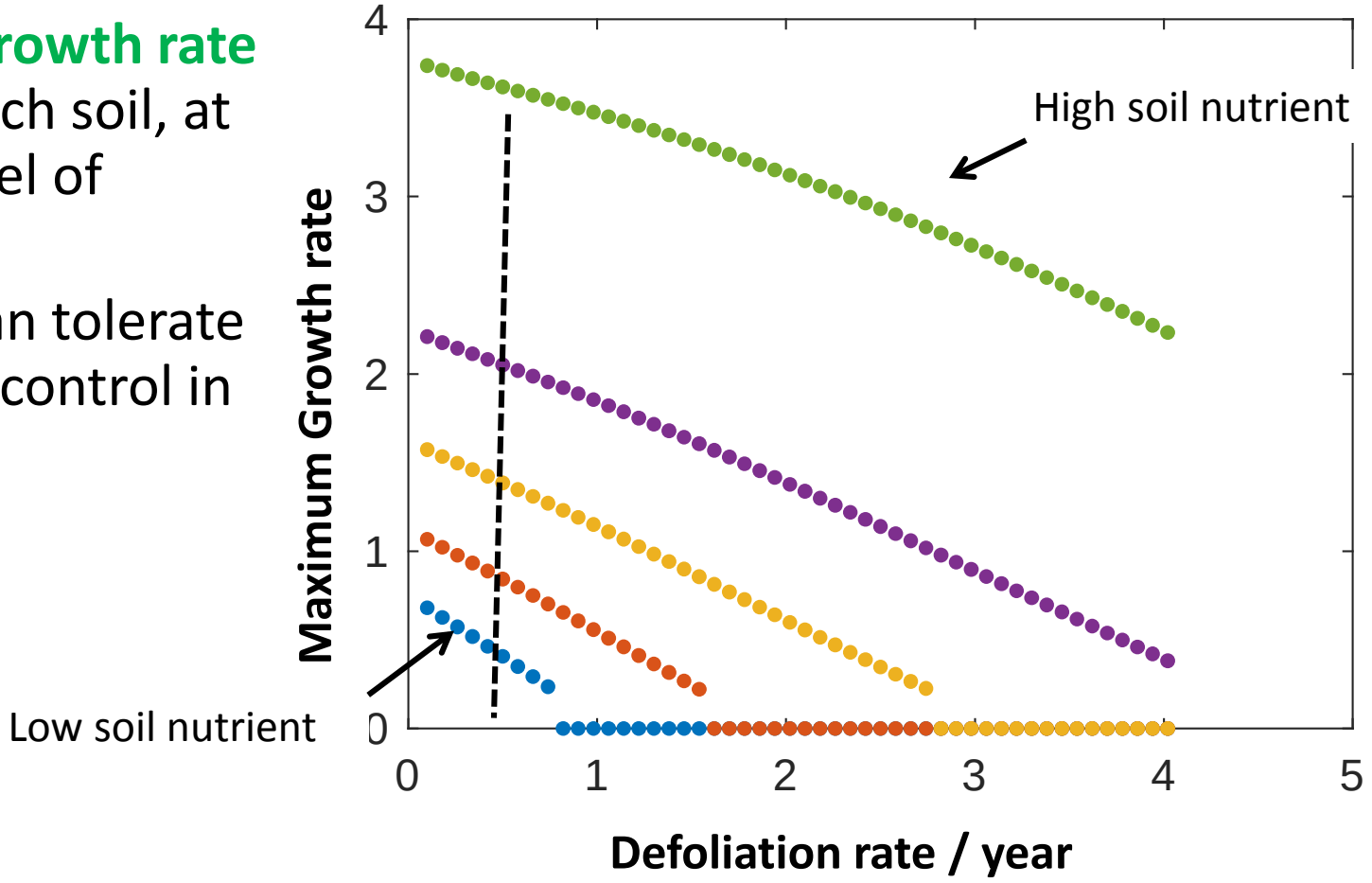


Soil nutrient level matters

Low soil nutrient



- **Maximum Growth rate** is higher in rich soil, at the same level of defoliation;
- Melaleuca can tolerate stronger bio-control in rich soil.



Objective2: Use an individual based model to help understand:

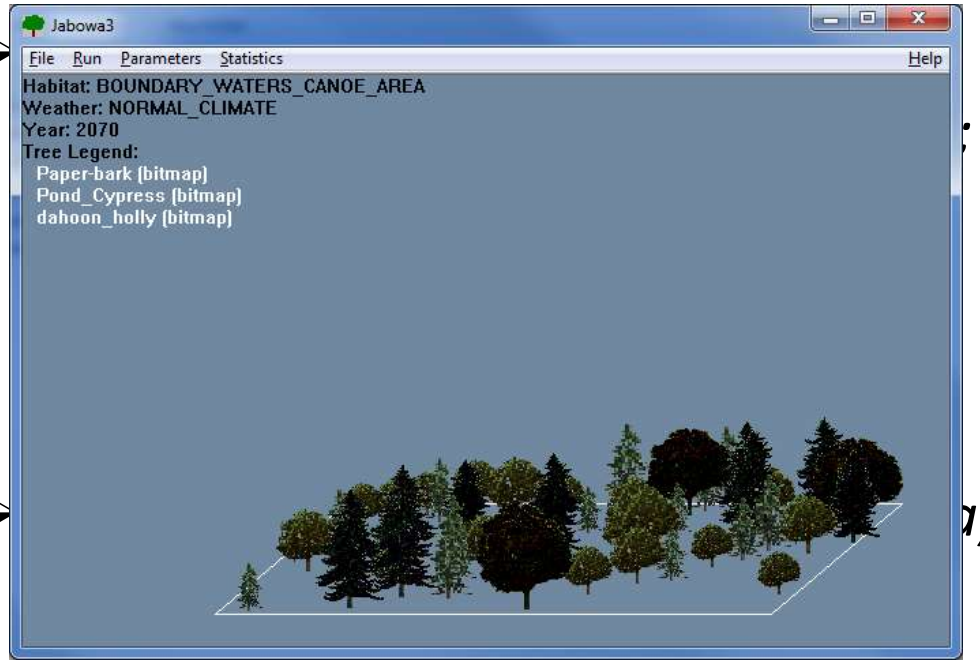
- How melaleuca invades in two habitats.

  Cypress swamps and Bay swamps
- How bio-control influences melaleuca's invasion.
- How native species will respond over the longer term as a result of bio-control of melaleuca.

Zhang et al. in press Landscape Ecology

Individual based model: JABOWA

- JABOWA simulates plant succession in a 0.01 hectare plot, characteristic of plants and environmental conditions.



Dr. Daniel Botkin

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

Zhang et al. in press Landscape Ecology

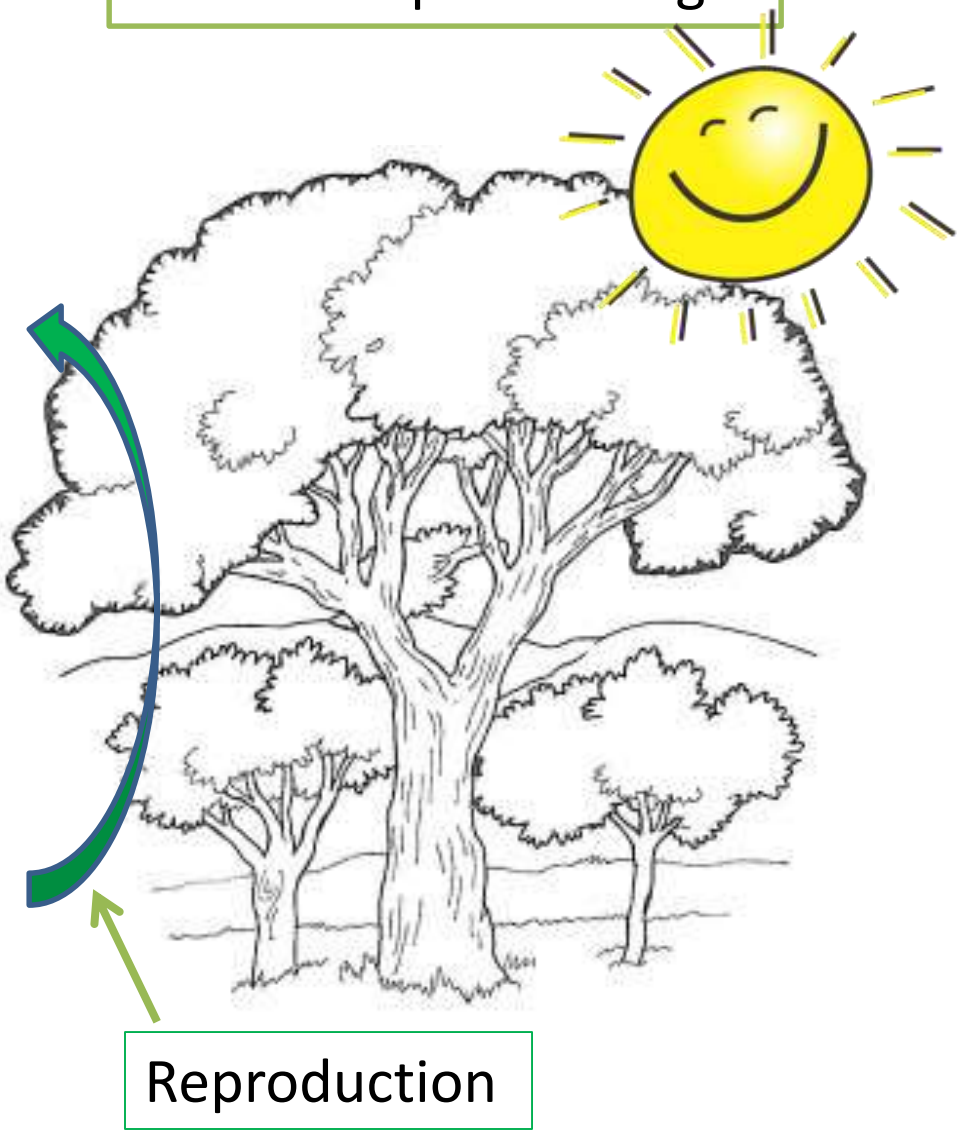
Inputs a set of plot data: estimate site quality

Introduces new saplings to stand

Kills some trees from stand

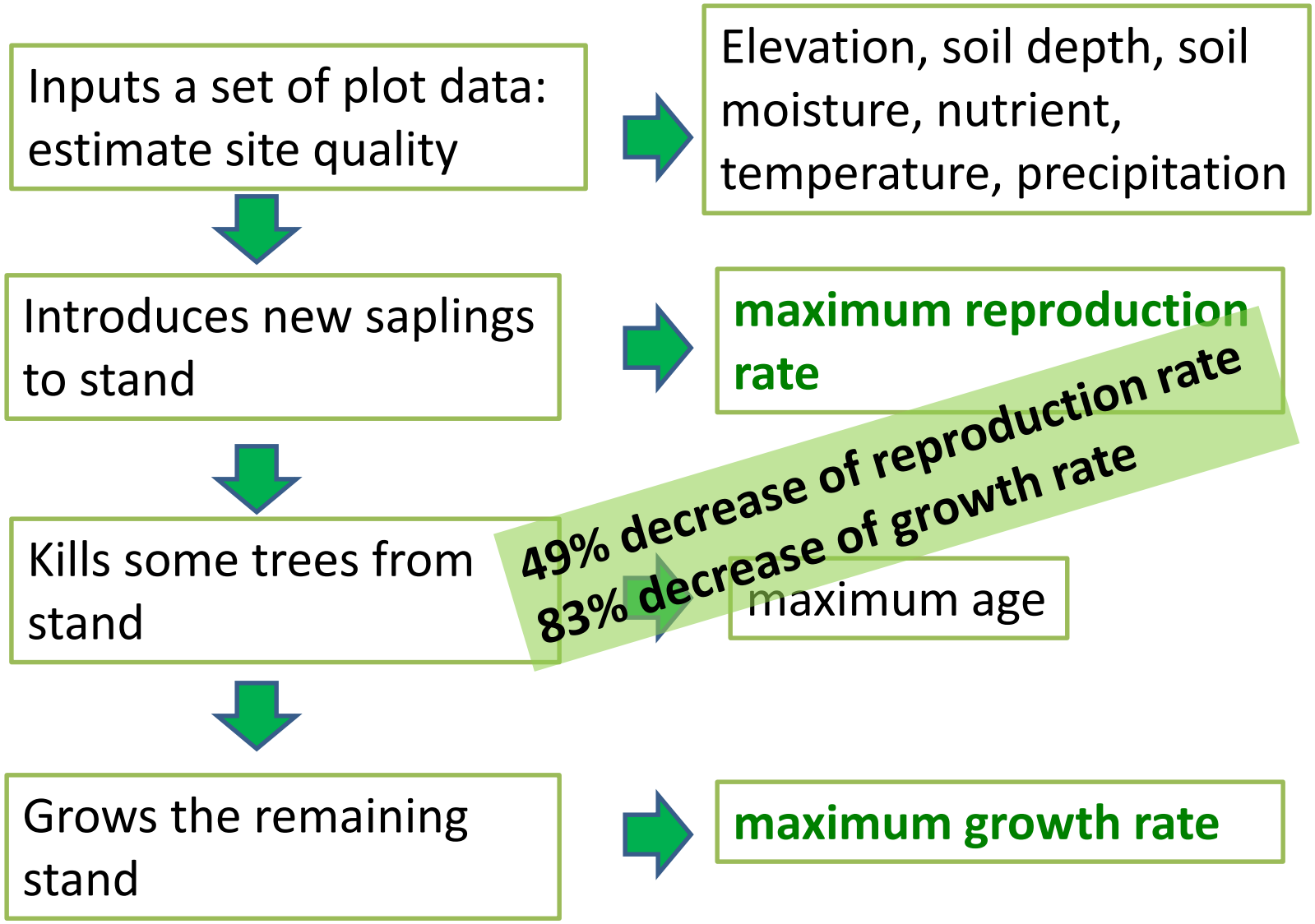
Grows the remaining stand

Direct competition: light



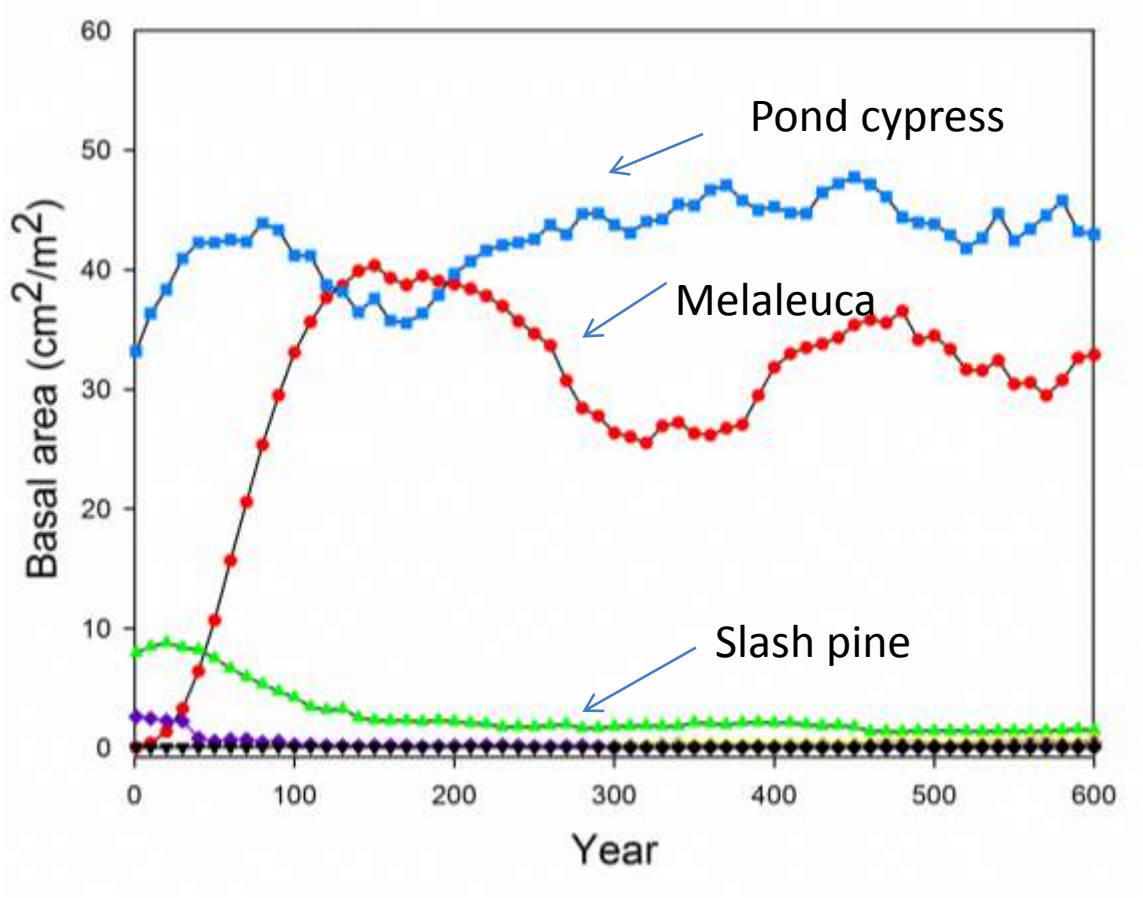
Reproduction

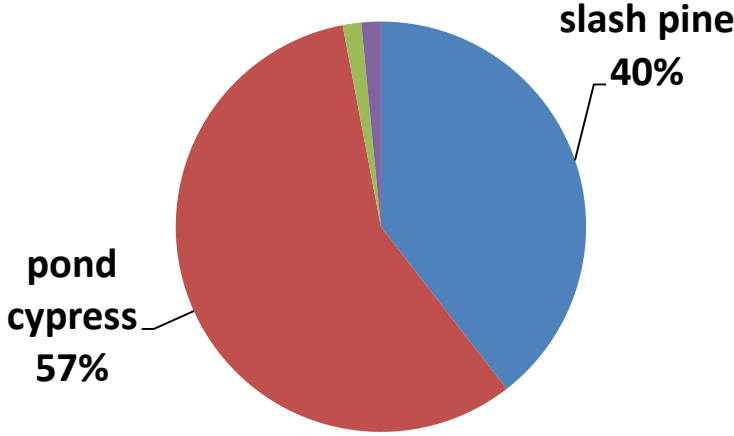
Zhang et al. in press Landscape Ecology



Zhang et al. in press Landscape Ecology

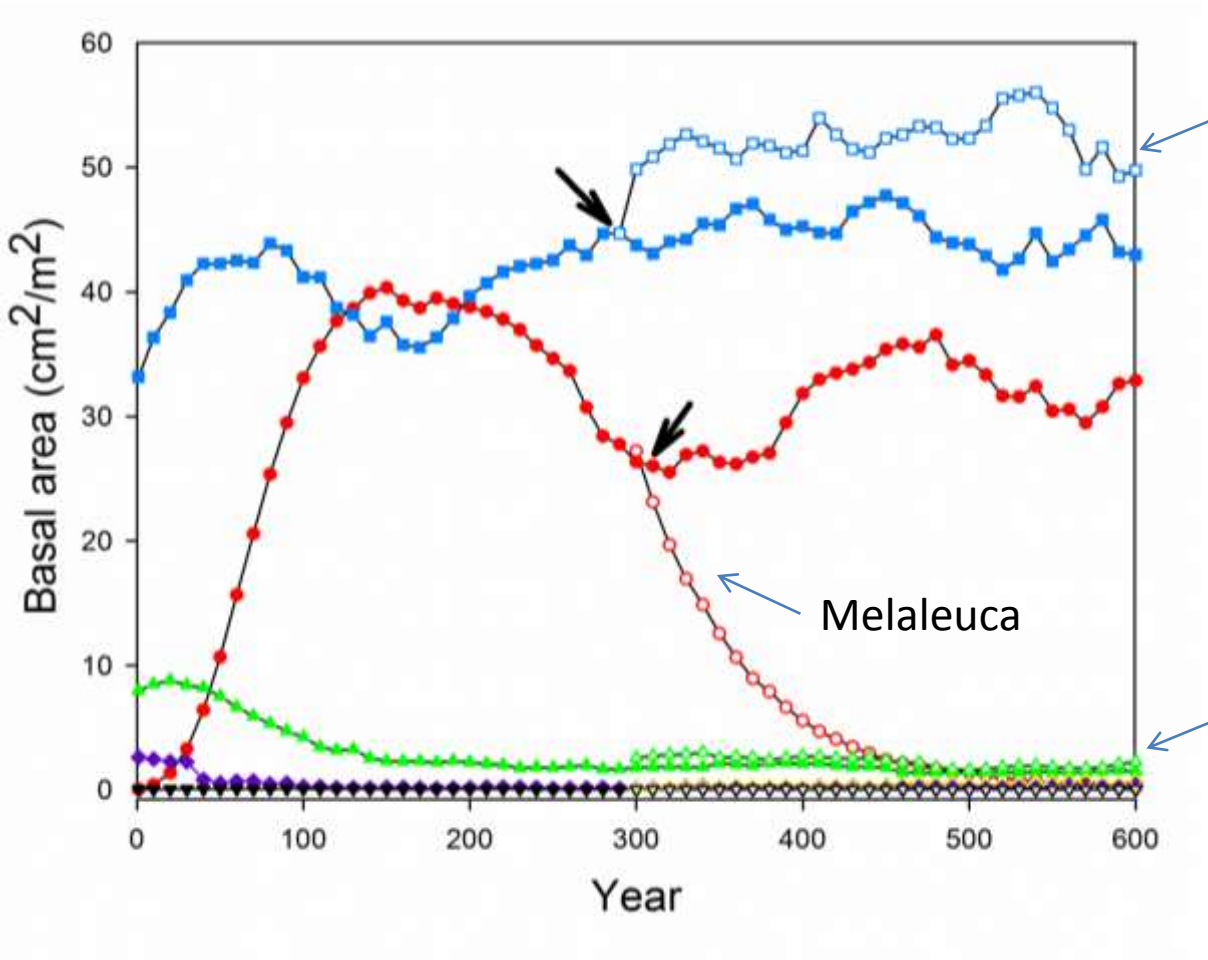
The basal area of native species with melaleuca in *Cypress swamps* without bio-control





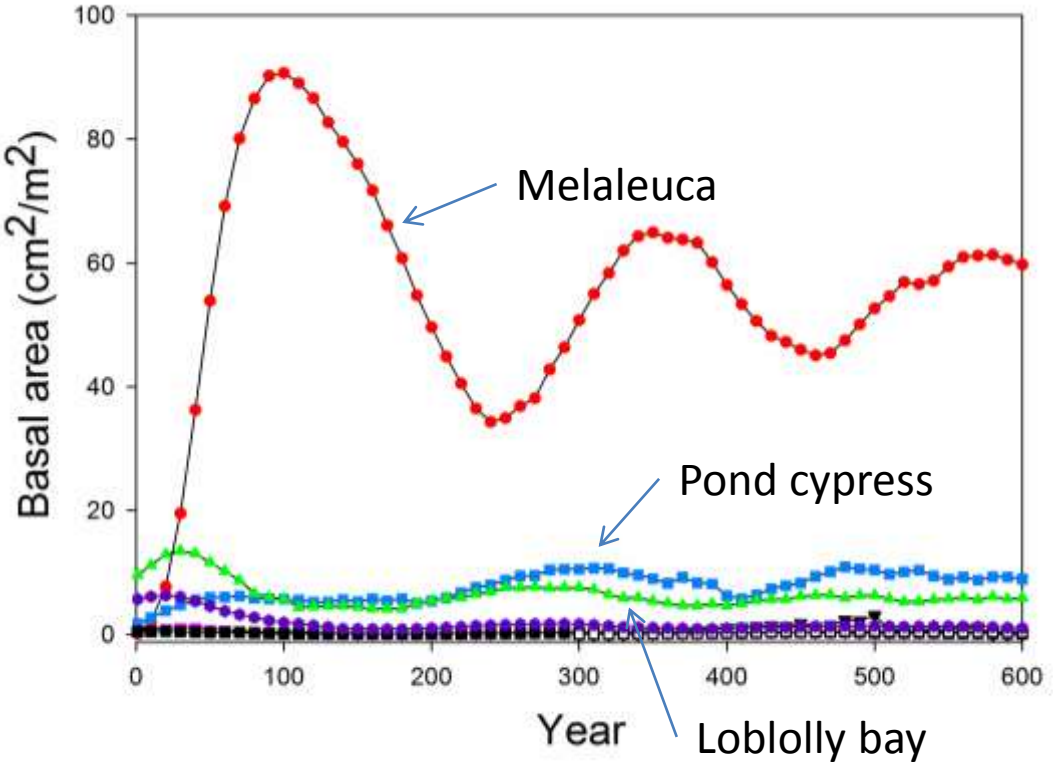
Zhang et al. in press Landscape Ecology

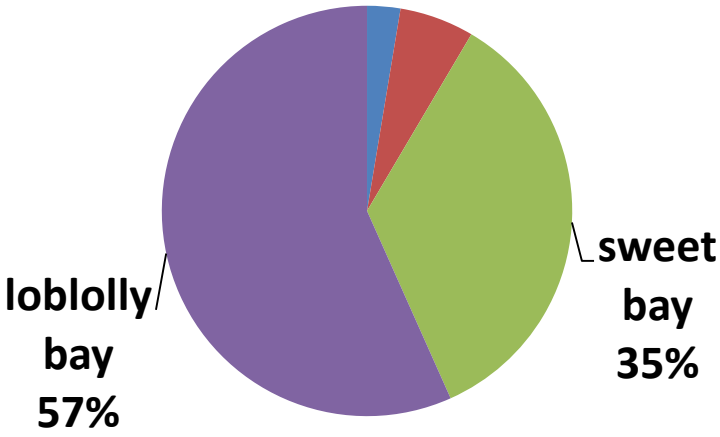
The basal area of native species with melaleuca in *Cypress swamps* without and with bio-control



Zhang et al. in press Landscape Ecology

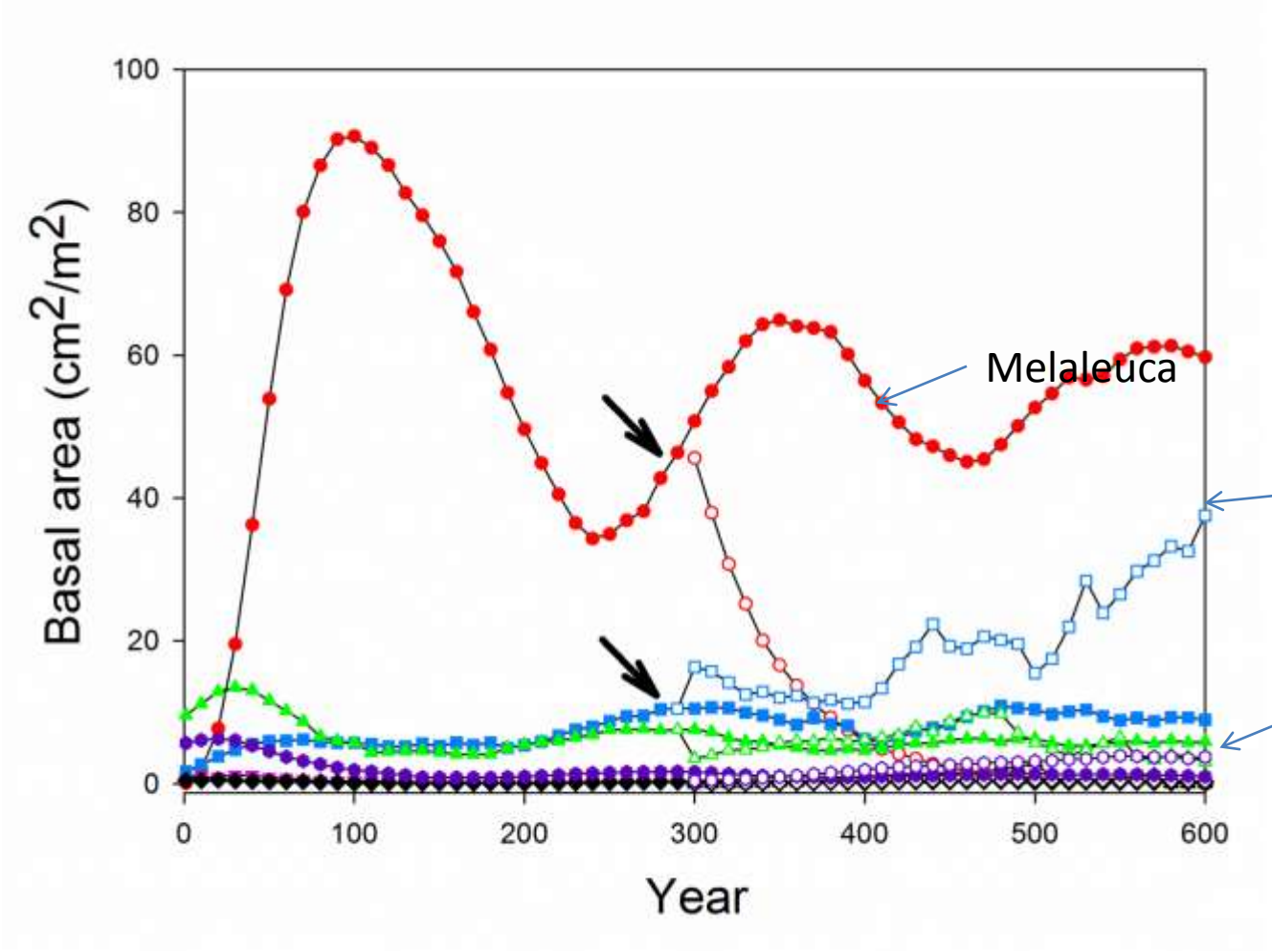
The basal area of native species with melaleuca in *Bay swamps* without bio-control





Zhang et al. in press Landscape Ecology

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

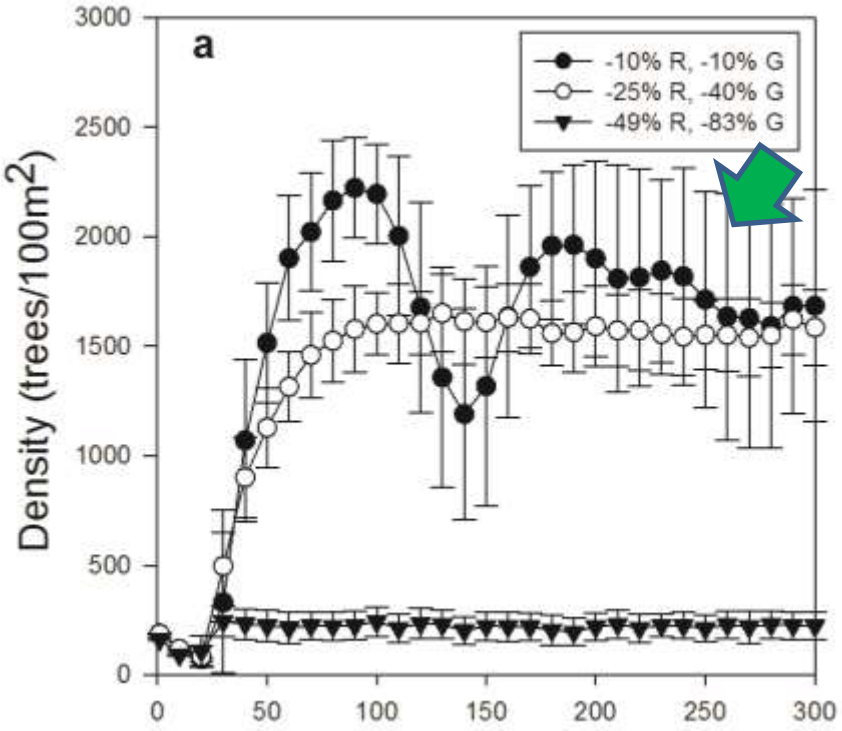


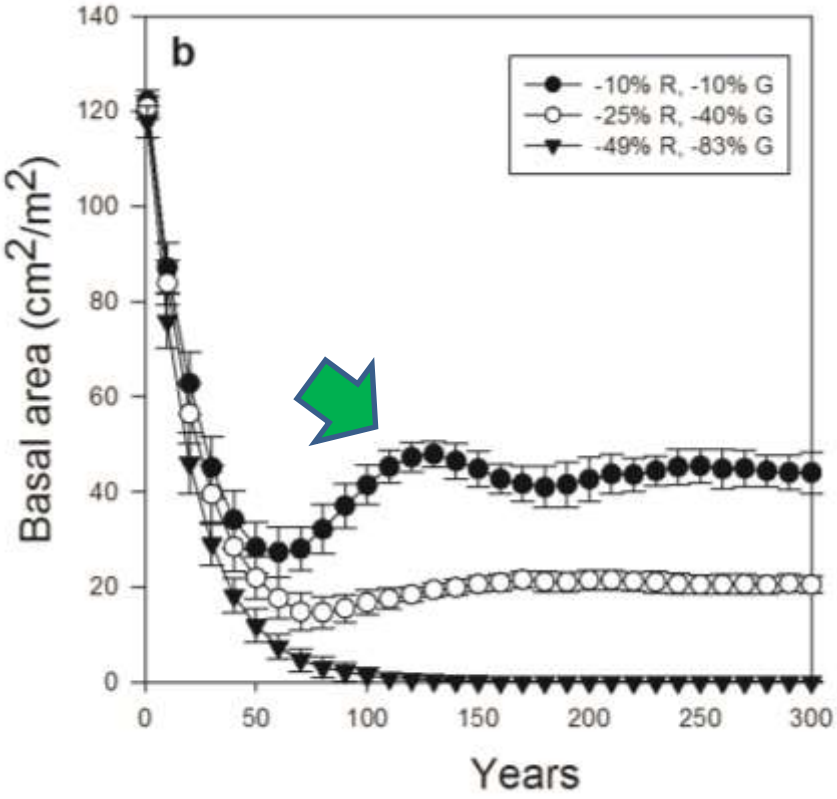
Zhang et al. in press Landscape Ecology

But this is not always the case..

Sensitivity analysis

Non-efficiency bio-control agent





Zhang et al. in press Landscape Ecology

Conclusions

- Bio-control decreased the invasion of melaleuca.
- With bio-control, native species can recover back to the habitat.
- Re-allocating more carbon to foliage helped compensate for the losses to bio-control, therefore, it is important to have a strong and efficiency bio-control agent.
- (This work is being extended by working with others to the whole south Florida region using USGS dispersal models).

Funding Resources

USGS's Greater Everglades Priority Ecosystem Science funding.

USGS
science for a changing world