Invasive bamboo management in the southeastern U.S.

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Alternative crops

- Biomass stock species (biofuels, paper pulp)
- Share key traits with invasive species
  - High establishment, tolerate low resource environment, rapid biomass accumulation
- Aggressively marketed as farmers strive to diversify

2

In Florida

- Citrus canker
  - Multiple introductions
  - Bacterial infection
  - Early fruit drop

- Citrus greening
  - Bacterial infection
  - Vectored by Asian psyllid
  - Tree decline & fruit drop
  - $4.5bil loss over 5yrs

(Hodges & Spreen, 2012)

3

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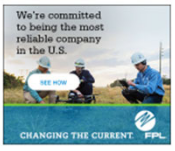
BUSINESS

Organic bamboo introduced as new crop at Mixon Fruit Farms

BY JAMES A. JONES JR.
jajones1@bradenton.com
October 29, 2017 08:30 AM
Updated October 29, 2017 08:30 AM

BRADENTON — Pressures exerted on the Florida citrus crop by the relentless forces of nature – greening, canker and weather –

Florida citrus growers to try new cash crop: bamboo



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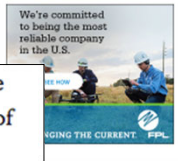

FROSTPROOF — Byron and Cynthia Matteson said they don't plan to give up on their longtime commitment to citrus, but they agreed they need another cash crop to survive the uncertainties of growing Florida's signature crop.

So they are planting bamboo on 35 acres of their farm near Frostproof, south of Lake Wales in Polk County.

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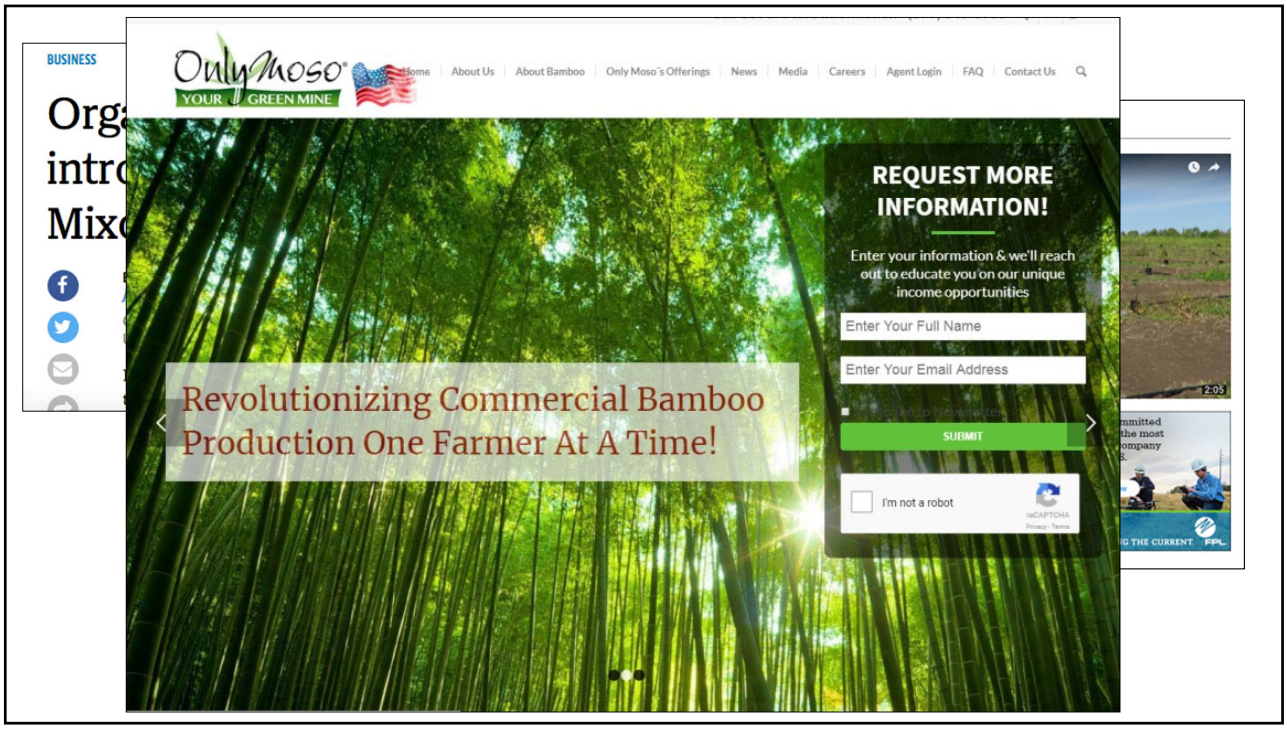

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In Alabama, the focus is on the 'Black Belt' region where economic opportunity is depressed.

Ideal for bamboo production

- Rich soil, mild climate, amount of annual rainfall, and available crop land found in the region

8

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Ideal for bamboo production

- Rich soil, mild climate, amount of annual rainfall, and available crop land found in the region

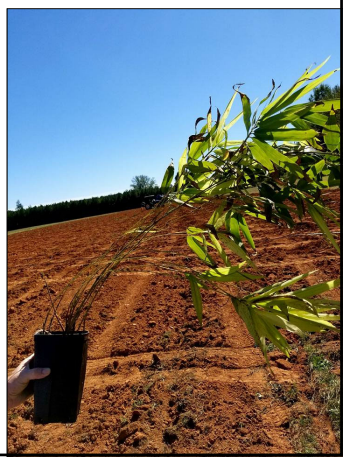
Promises

- "rejuvenates" degraded lands
- Prevents erosion
- Increased carbon sequestration

9

In the Southeast

- Companies are promoting bamboo as a cash crop throughout the region



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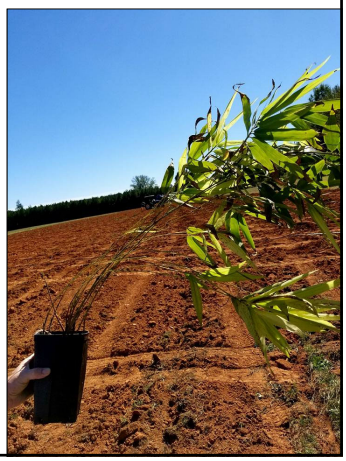
In the southeast

- Companies are promoting bamboo as a cash crop throughout the region
  - Arkansas, North Carolina, South Carolina, Georgia, Texas, Louisiana, Virginia, West Virginia, Tennessee, and Mississippi





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SOUTHERN REGIONAL EXTENSION FORESTRY

FOREST HEALTH

Growing Bamboo for Commerical Purposes in the Southeastern U.S.: FAQs

AUTHORED BY: DAVID COYLE, NANCY LOWENSTEIN, DEAH LIEURANCE, RYAN BEAN, YANSHU LI, STEPHEN ENLOE, AND PUSKAR KHANAL

Introduction

HOW DOES BAMBOO GROW?

However, there is
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increase in carbo
photosynthesis. (

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Outline

- **Bamboo basics: origin, growth, and invasion risks**
- Control methods
- Growing bamboo for commercial purposes?

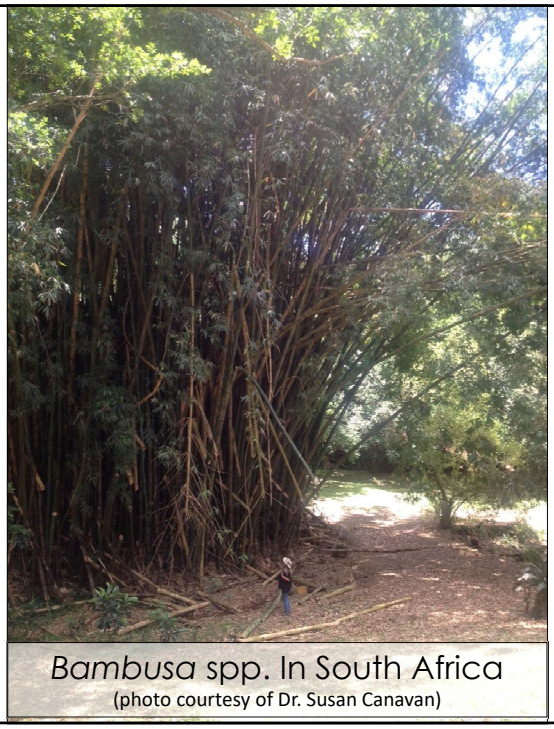
14

Bamboo

- Perennial grass
- 1000 to 1400 species
- Most are native to Asia, Africa, and South America

15

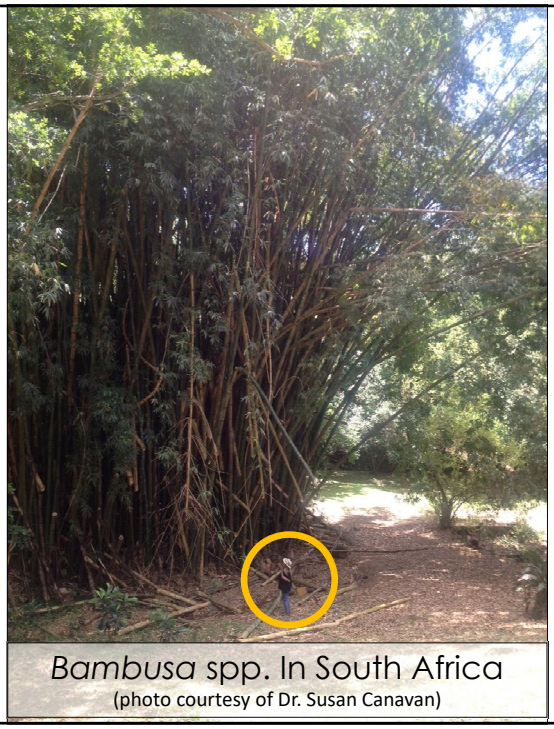
Dwarf bamboo



Bambusa spp. In South Africa
(photo courtesy of Dr. Susan Canavan)

16

Dwarf bamboo



Bambusa spp. In South Africa
(photo courtesy of Dr. Susan Canavan)

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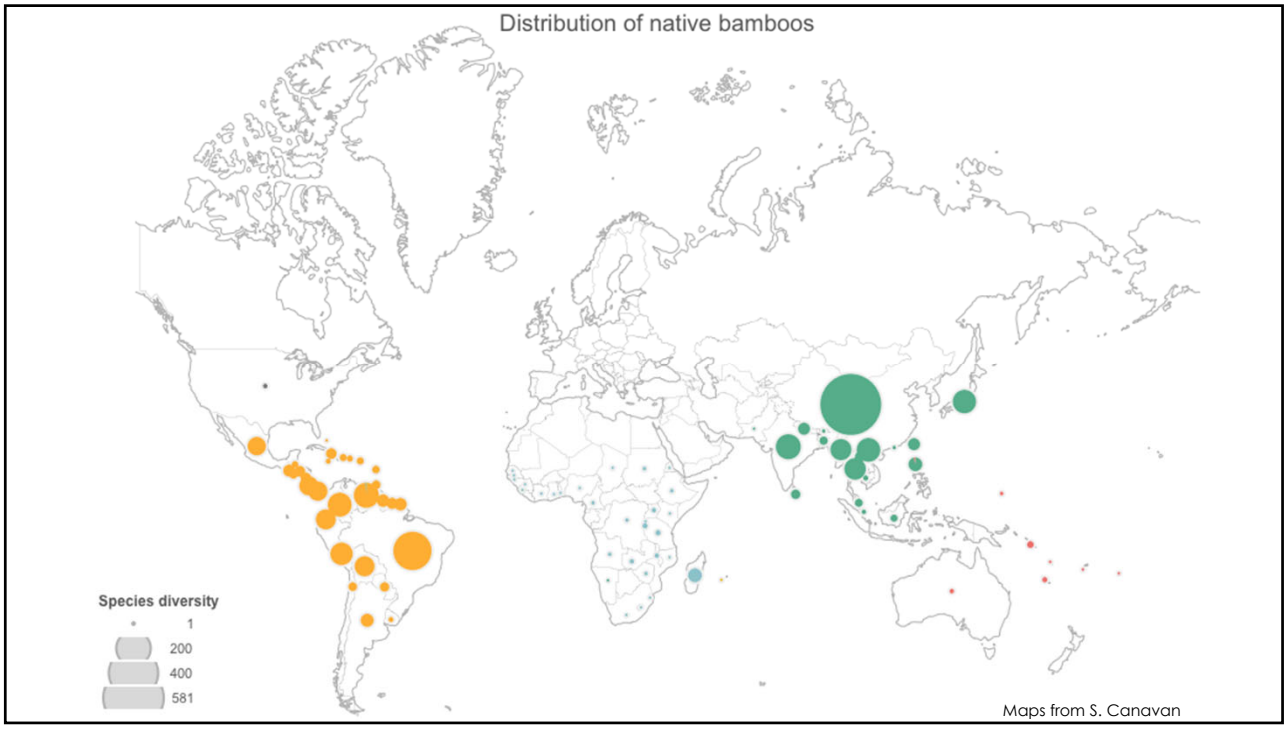

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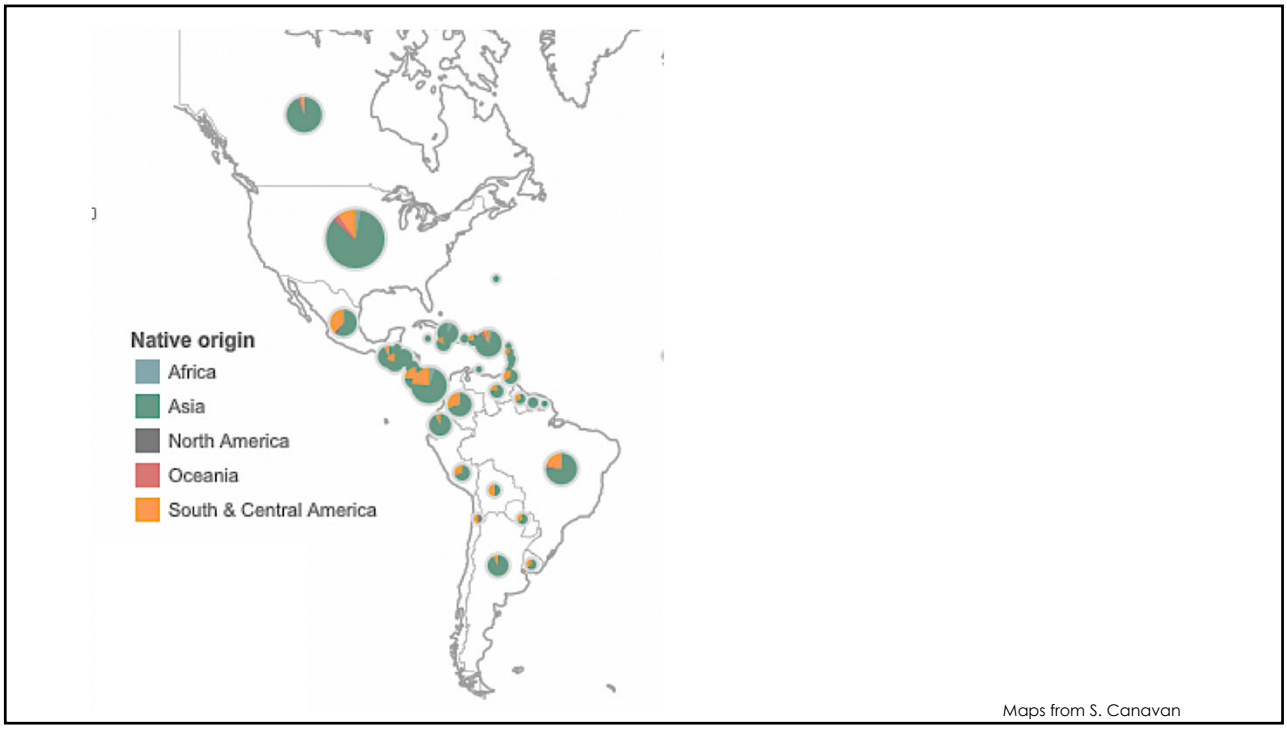
Native origin
Africa
Asia
North America
Oceania
South & Central America
Maps from S. Canavan

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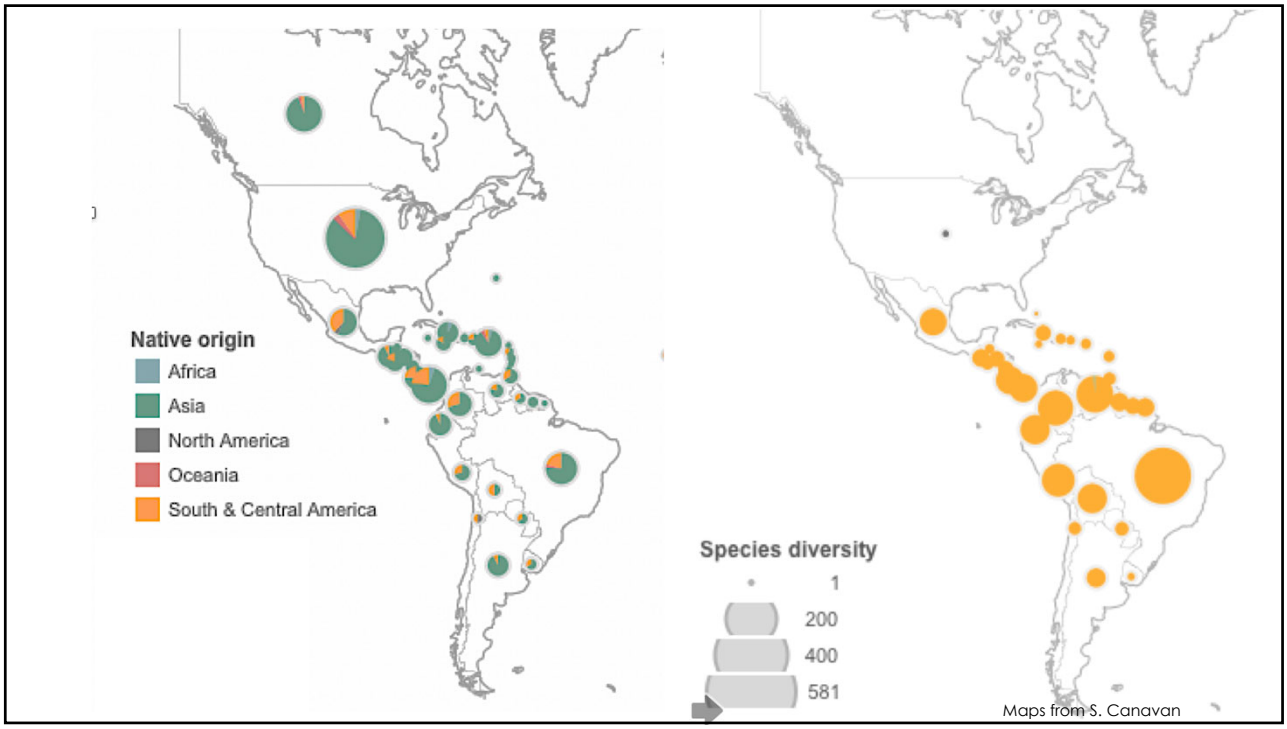
Native origin
Africa
Asia
North America
Oceania
South & Central America
Species diversity
1
200
400
581
Maps from S. Canavan

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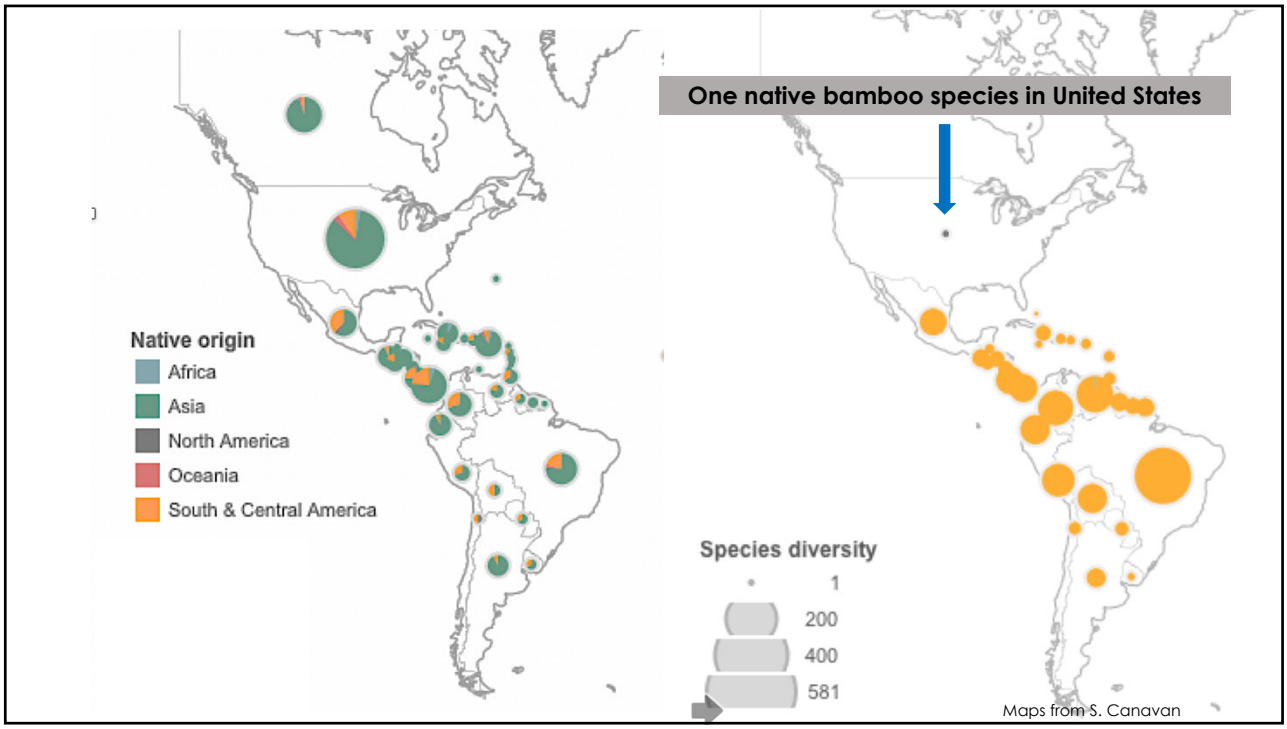

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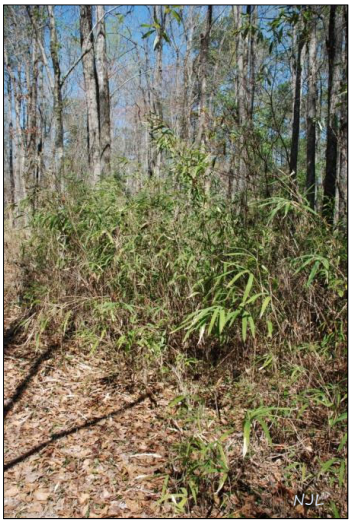
Our native bamboo *Arundinaria* spp.

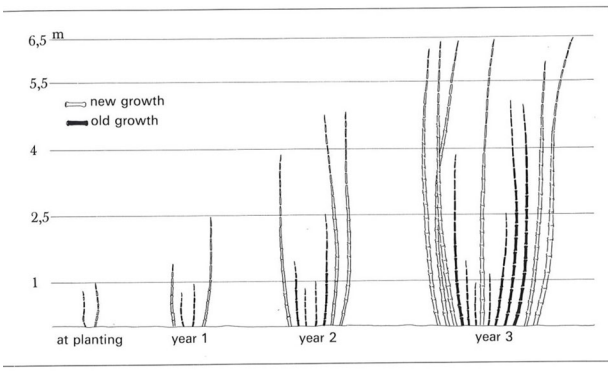


switch cane, giant cane, river cane (Photos courtesy of Nancy Loewenstein)

22

Bamboo growth

- New culms emerge from the ground and elongate very quickly

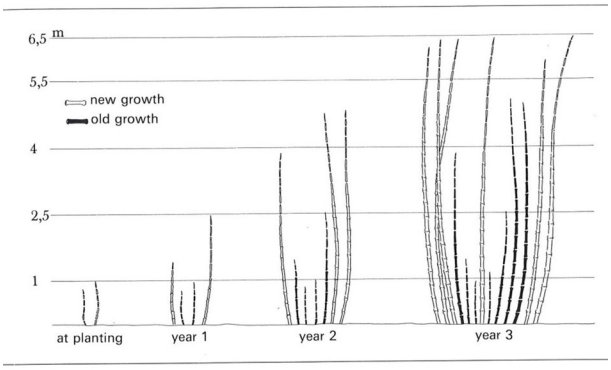


Recht and Wetterwald 1992

23

Bamboo growth

- New culms emerge from the ground and elongate very quickly
- Redistribution of stored carbohydrates from the previous growing season (not from current photosynthesis)



Recht and Wetterwald 1992

24

Bamboo growth

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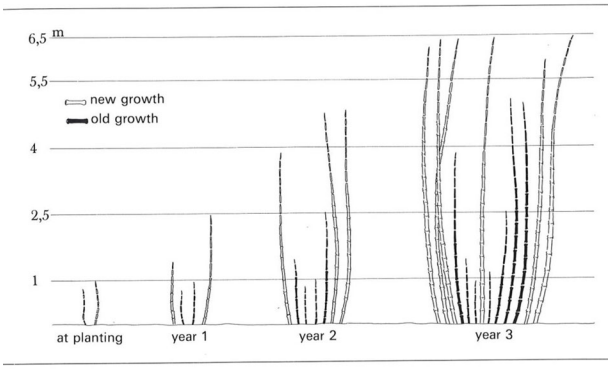

Recht and Wetterwald 1992

25

Bamboo growth

- New culms emerge from the ground and elongate very quickly
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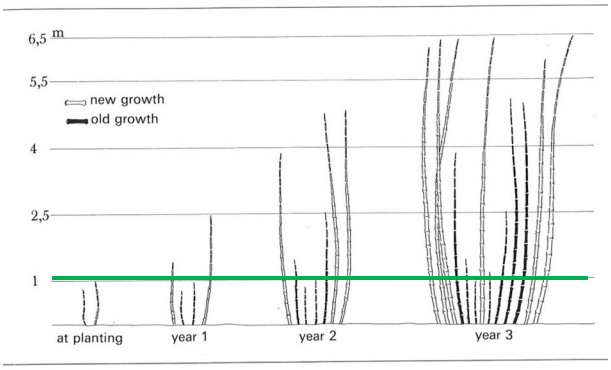
- Each year's new culm will increase in height and diameter



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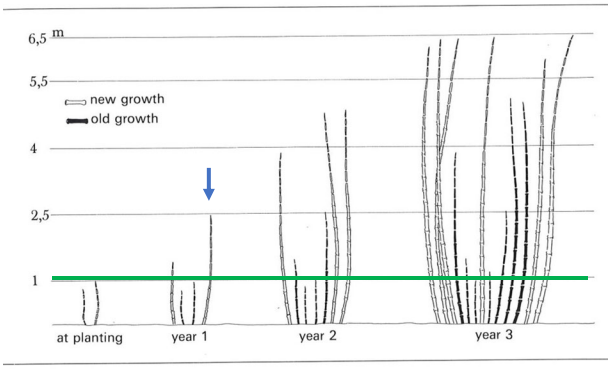

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27

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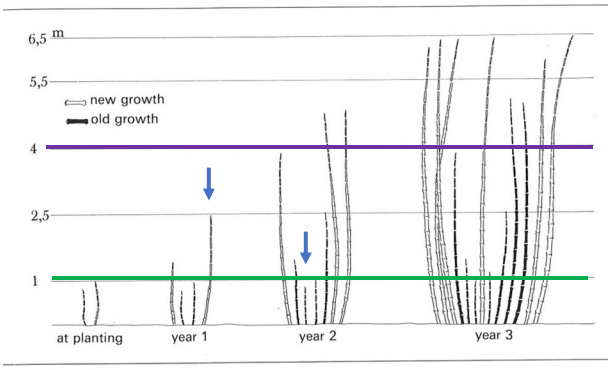

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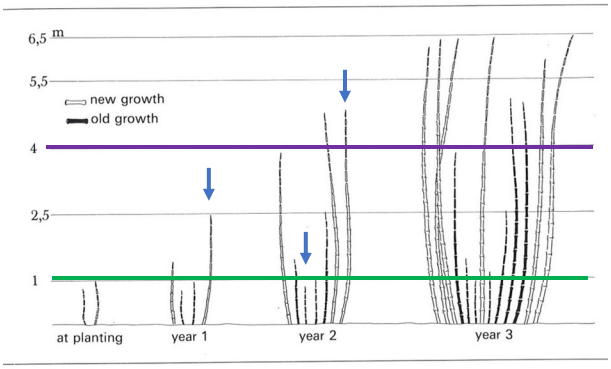

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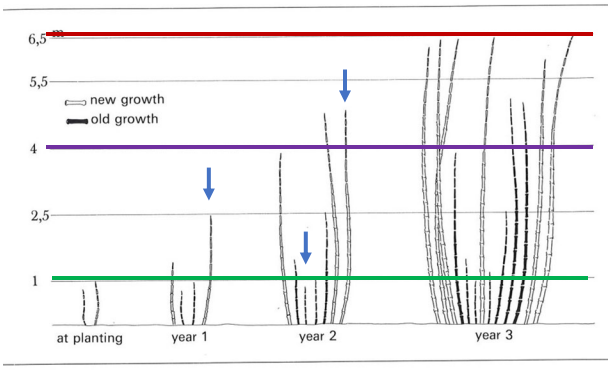

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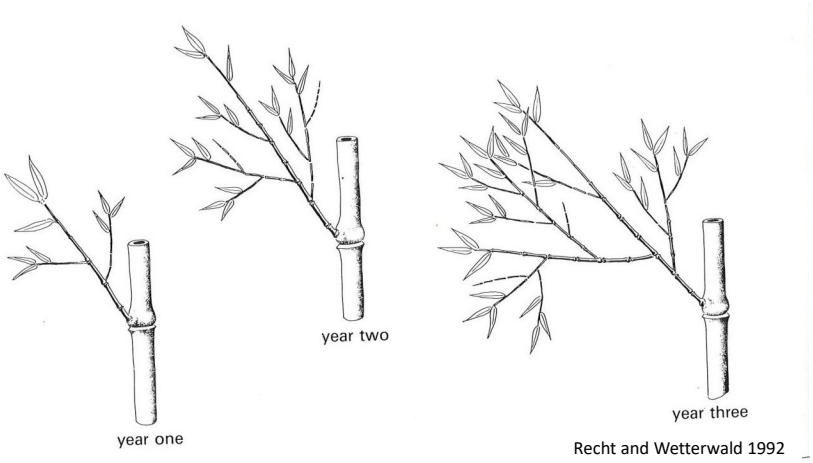
Bamboo growth



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Culms do add new leaves every year

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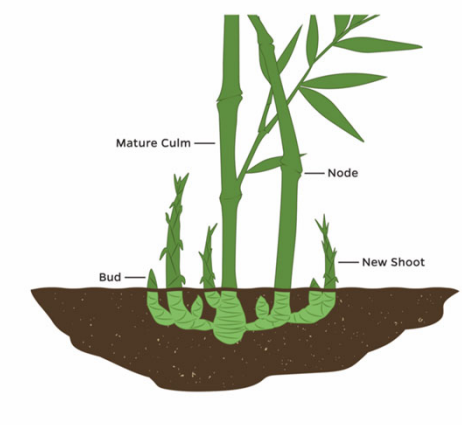
Clumping bamboo



Clumping (pachymorph) bamboo

- grow radially producing very little horizontal growth
- spread rather slowly, forming dense clumps
- subtropical/tropical regions: Asia, Africa and South America
- not very cold tolerant

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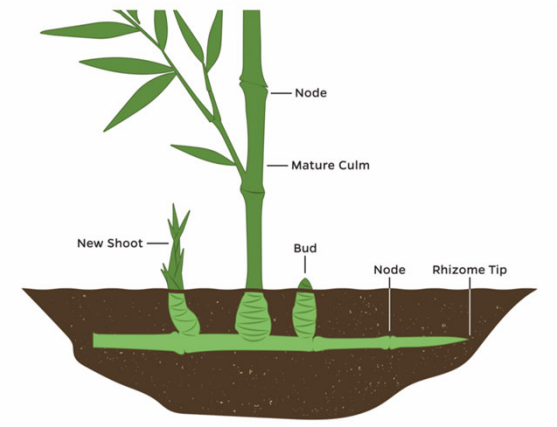
Running bamboo



Running (leptomorph) bamboo

- more horizontal growth
- send up multiple culms along the rhizome
- greater spatial spread
- tolerant of cold
- generally better suited for temperate climates

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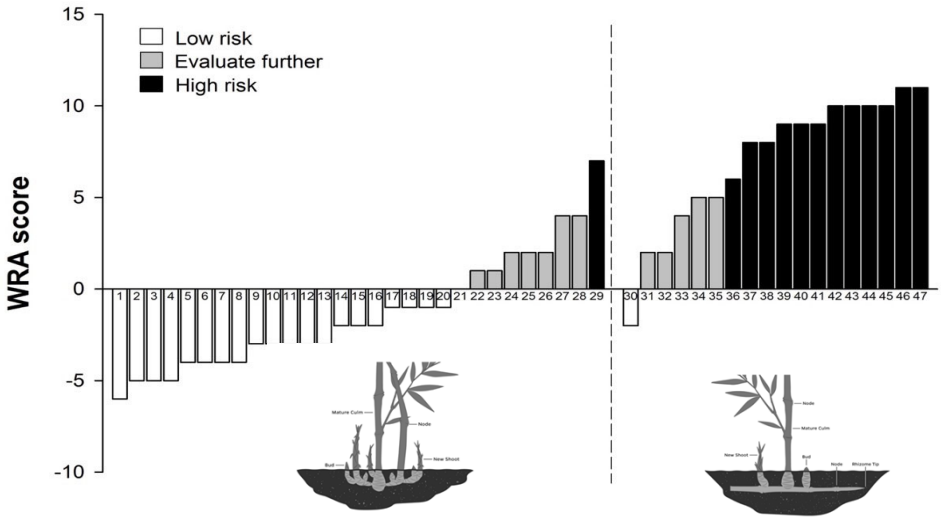
Is bamboo invasive?



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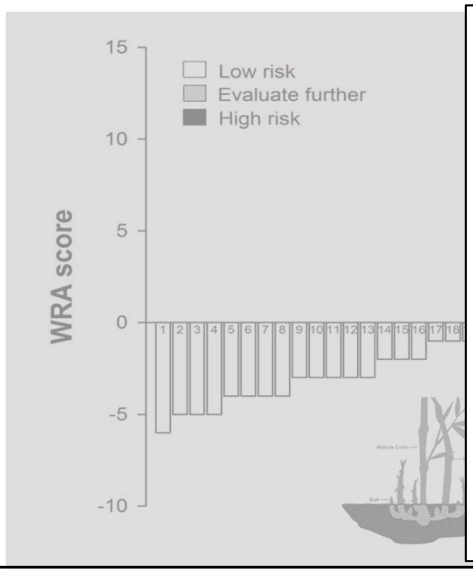

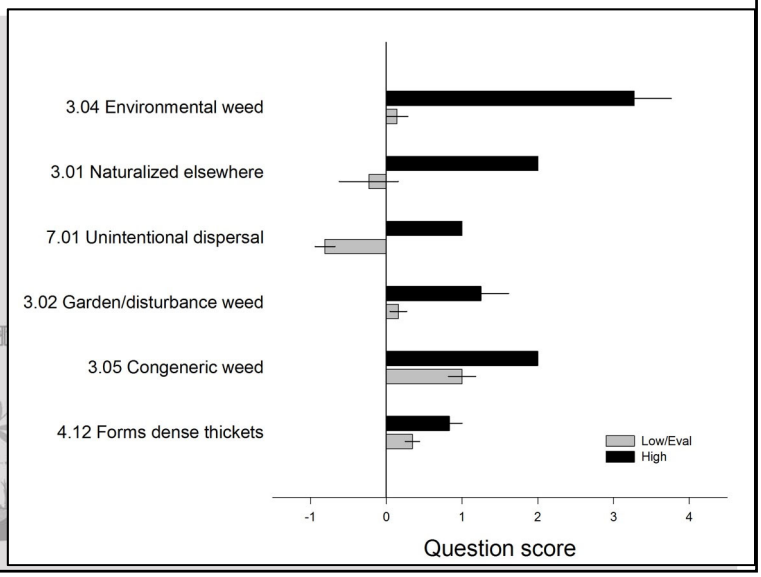

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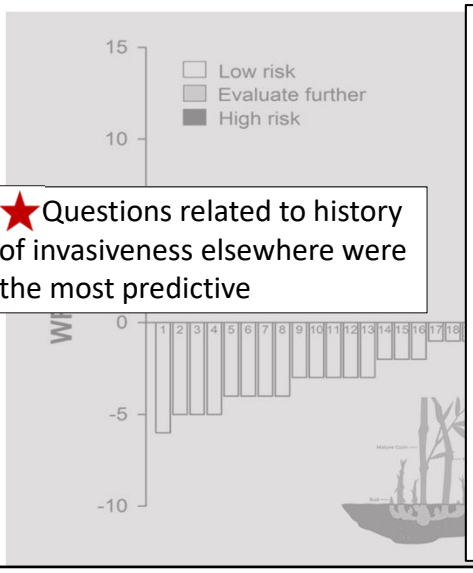
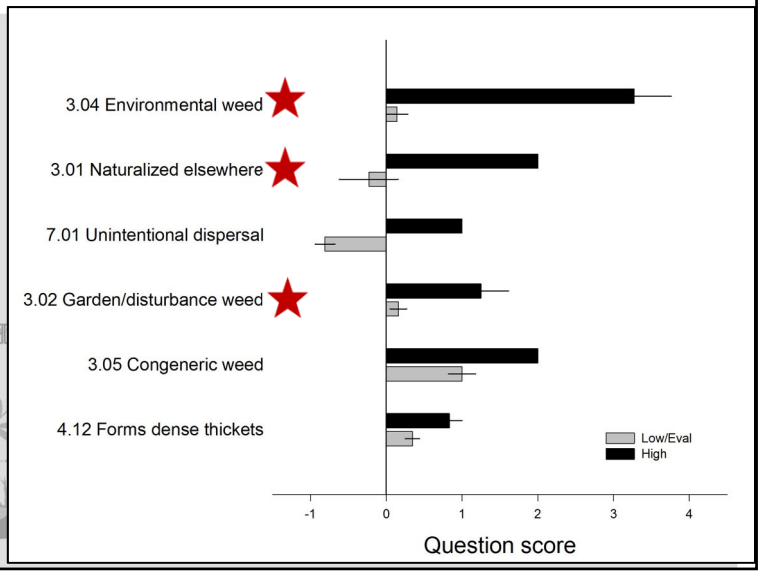


★Questions related to history of invasiveness elsewhere were the most predictive



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Bamboo encroaching into wooded areas

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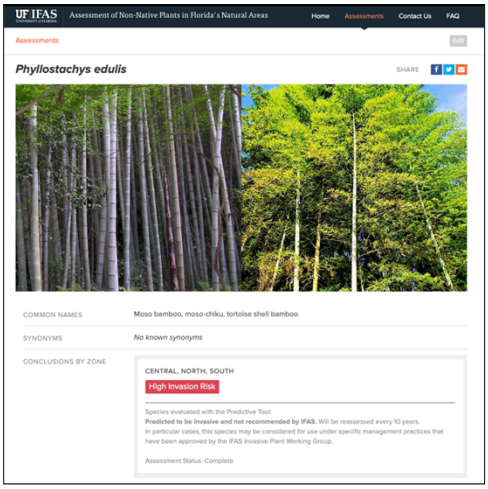
What species are being promoted?

- Southeastern region (runners)
  - *Phyllostachys edulis*
  - *Phyllostachys rubromarginata*

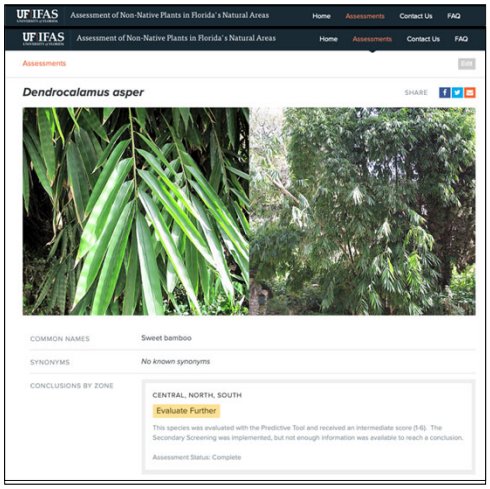


40

What species are being promoted?

- Southeastern region (runners)
  - *Phyllostachys edulis*
  - *Phyllostachys rubromarginata*

- Florida specific
  - *Dendrocalamus asper*



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Outline

- Bamboo basics: origin, growth, and invasion risks
- **Control methods**
- Growing bamboo for commercial purposes?

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Table 1. Summary of approaches and techniques to control species of running bamboo. There are few published studies for many of these techniques.

Approach	Technique	Comments
Prevention	Increasing awareness/ Education[a]	Recognize that many individuals are still unaware of the problems bamboo can cause. Proactive education can help prevent "learning by mistake."
	Do not plant - use suitable alternatives[b]	Avoid using running bamboos for privacy screens, living fences or other risky ornamental plantings. Native replacements include giant cane (*Arundinaria gigantea*), or other dense hedges such as eastern red cedar (*Juniperus virginana*). Other shorter but robust native grasses include switchgrass (*Panicum virgatum*) and Eastern gamagrass (*Tripsacum dactyloides*).
	Trenching[c-f]	When bamboo is present nearby, trenching can eliminate rhizome encroachment across property lines. Trenches should be dug to a depth below the rhizome depth of the species. New rhizomes will grow to the trench wall, initiate vertical growth and produce a new shoot at the trench interface - these will require occasional removal. Several trenching/barrier installation guides are available online from commercial bamboo nursery operations. However, there has been little trenching/barrier research published to verify these.
	Rhizome barriers[c-f]	In addition to trenching, polyethylene plastic barriers are effective in preventing rhizome spread if properly installed. Critical issues are plastic thickness and angle and depth of installation. Several trenching/barrier installation guides are available online from commercial bamboo nursery operations. However, there has been little trenching/barrier research published to verify these.
Physical control	Rhizome excavation	Heavy equipment such as a backhoe or root rake can remove much of the rhizome system if complete soil disturbance is feasible. Any rhizome pieces left in the soil can resprout and follow-up removal will be required.
	Hand pulling/ weed wrench	Not feasible for running bamboo in most situations. Woody stems cannot be hand pulled and weed wrenches will crush stems or break them off near the soil surface, leaving intact rhizomes.
	Burning[11]	Not well studied but unlikely to control bamboo as a standalone technique. Anecdotal observations indicate rapid regeneration of new shoots from rhizomes. Accumulation of fine fuels and dead stems may allow fire to carry through dense stands. When burned, stems make loud popping noises due to hollow stems.
	Cutting/mowing	In theory, repeated cutting or mowing should gradually exhaust energy reserves in the rhizomes. The frequency to accomplish this has not been studied but is likely several years.
	New sprout elimination	A suppressive technique to reduce patch expansion. New shoots are extremely high in water content and can be easily broken off/mowed/crushed in the spring during the shooting period. This technique will not reduce the existing stand but can reduce spread. Timing is critical and must be done before shoots begin to harden off. This technique has not been well studied.
Biological control	Grazing[12]	All classes of livestock will graze the leaves, but hardened stems will not be eaten. Repeated, intensive grazing of new shoots probably won't suppress bamboo growth and spread over time. Historically, native bamboo (*Arundinaria* spp.) likely declined across the southeast as woodland grazing by livestock increased. However, grazing prescriptions for invasive bamboos have not been well studied.
	Classical biocontrol	There are no insects or diseases that have been utilized for classical biological control. Historically, invasive grasses have had very few successful biocontrol programs.
Chemical Control	Foliar[3,7,18]	Glyphosate: 5% v/v as a backpack or high-volume handgun treatment (using a 41% ai formulation or higher). Broadcast treatments of 120 oz/A will result in suppression and follow-up treatments will be needed. Foliar glyphosate treatments are most effective as a follow-up to cutting, when shoots have regrown to 3-4 feet in height. Multiple treatments over a few years will be required. Homeowners should avoid any RTU (Ready to use formulations of glyphosate) as they are too low in concentration to provide control. This is a non-selective treatment that will injure or kill other plants that are sprayed during bamboo treatment. Imazapyr: 2% v/v (using a 27% ai formulation) or 1% (using the 54% ai formulation common in forestry) as a backpack or high-volume handgun treatment. Broadcast treatments of 64 or 32 oz/A for the 27 and 54% ai formulations respectively. Imazapyr is the most effective
	Basal bark	Anecdotal reports of control when using triclopyr ester at 20% v/v applied to the lower 18 inches of each woody stem. This is a spot treatment only as high stem densities would result in reaching the maximum label use rate per acre on even small patches. Not confirmed in any published research. Imazapyr formulations compatible with basal oils are effective. However, this approach has not been well tested.
	Cut stem (Cut stump)	Not well tested for running bamboo.
	Woody stem injection	This treatment, which was developed for hollow stemmed species such as giant reed (*Arundo donax*) and Japanese knotweed, has not been tested on running bamboo.
	Granular	Granular formulations of imazapyr have been observed to control running bamboo. However, uniform treatment of large stands is difficult with ground equipment.

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Prevention

- Increase awareness/educate the public
- Avoid planting running bamboo, use caution and manage clumping bamboo
- Barriers/trenching

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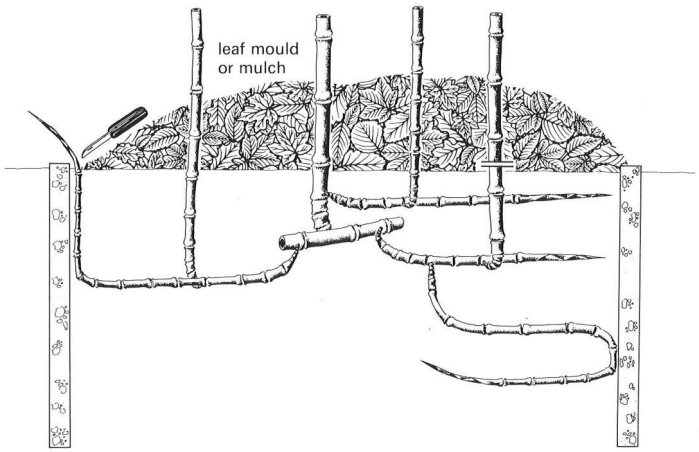
Bamboo barriers



Recht and Wetterwald 1992

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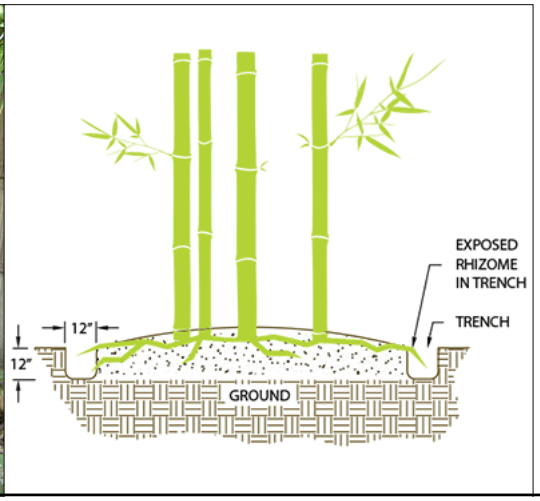
Trenching

Labor intensive and expensive, not suitable for large areas



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Physical control

- Rhizome excavation (root rake/back hoe)
  - rhizomes are fairly shallow
  - have to get it all though
- Hand pulling/weed wrench
  - Labor intensive
- Cutting/mowing (e.g. 20 ft mowed buffer)
  - takes a long time to exhaust reserves
- Manual removal of young culms

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Chemical control

- Cut and treat stumps or regrowth
  - glyphosate and imazapyr at high rates
  - labor intensive
- Foliar
  - 5-10% glyphosate
  - 1% imazapyr
  - tank mix of the two
- Basal bark
  - 20% triclopyr ester applied at lower 18in
  - Spot treatment, high density application results in max label use rate per acre
- Granular
  - Imazapyr controls running bamboo
  - Hard to achieve uniform treatment on larger scale

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Foliar herbicide treatments

- Cut bamboo down
- Let it regrow to 3-4 feet
- Spray foliage
- Treat in Sept or Oct

49

Foliar herbicide treatments

- Cut bamboo down
- Let it regrow to 3-4 feet
- Spray foliage
- Treat in Sept or Oct

"When using glyphosate, may need to mow and spray as many as four times."
– Ferrell, Czarnota and Langeland

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Outline

- Bamboo basics: origin, growth, and invasion risks
- Control methods
- **Growing bamboo for commercial purposes?**

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Growing bamboo for commercial purposes?

Crop Comparison Chart

CROPs	PROFIT x ACRE x YEAR in US $	MACHINERIES INVESTMENTs	APPLICATIONS in MARKETs	RISK FACTORS weather + others	SOWING years	LABOR INTENSIVE	PESTICIDEs
CORN	50 to 200	hundred thousands	2	few	every year	HIGH	YES
SWEET POTATO	1200-1500	hundred thousands	few	few	every year	HIGH	YES
TOBACCO	1500-2000	hundred thousands	few	high	every year	very high	YES
BLUEBERRIES	2500-4000	thousands	few	VERY HIGH	every 7-8	very high	YES
PINE TREES	ridiculous	thousands	few	pine tree bug	every 15-25	not much	YES
COTTON	ridiculous	hundred thousands	few	high	every year	very high	YES
WHEAT	ridiculous	hundred thousands	2 or 3	high	every year	very high	YES
PEANUTS	1000-1500	hundred thousands	2 or 3	VERY HIGH	every year	very high	YES
CITRUS	1500-2500	thousands	2	greening disease	once	HIGH	YES
RICE	800-900	thousands	4 or 5	few	5 Years	not much	YES
SUGAR CANE	1600-2000	hundred thousands	more than 5	HIGH	every 1.5 year	HIGH	YES
SOY-BEANS	400-500	hundred thousands	more than 5	HIGH	every year	very high	YES
WATERMELON	0-200	thousands	more than 5	High	90 days	very high	yes
ALFALFA	600-700	thousands	2 or 3	high	every year	very high	YES
HAY	30-40	thousands	6 or more	high	every year	HIGH	YES
BAMBOO	15-25.000	none	1500	none	once lifetime	no	no

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Growing bamboo for commercial purposes?

WATERMELON	0-200	thousands	more than 5	High	90 days	Very high	Yes
ALFALFA HAY							YES YES
BAMBOO	15-25,000	none	1500	none	once lifetime	no	no

$15-25,000 per acre per year!!!

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Questions about production

- Establishment BMPs and costs?
  - Site prep, plants, irrigation, fertilization, herbivory control

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Questions about production

- Establishment BMPs and costs?
  - Site prep, plants, irrigation, fertilization, herbivory control
- Labor costs?
  - Planting, containment, marking culms, harvest

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- Establishment BMPs and costs?
  - Site prep, plants, irrigation, fertilization, herbivory control
- Labor costs?
  - Planting, containment, marking culms, harvest
- Yield expectations?

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Questions about production

- Establishment BMPs and costs?
  - Site prep, plants, irrigation, fertilization, herbivory control
- Labor costs?
  - Planting, containment, marking culms, harvest
- Yield expectations?
  - Harvesting strategies and techniques?

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- Establishment BMPs and costs?
  - Site prep, plants, irrigation, fertilization, herbivory control
- Labor costs?
  - Planting, containment, marking culms, harvest
- Yield expectations?
  - Harvesting strategies and techniques?
  - Compared to pine or other options?

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Questions about production

- Establishment BMPs and costs?
  - Site prep, plants, irrigation, fertilization, herbivory control
- Labor costs?
  - Planting, containment, marking culms, harvest
- Yield expectations?
  - Harvesting strategies and techniques?
  - Compared to pine or other options?
- Markets?
  - Raw materials? Which products?
  - CO_2 (carbon sequestration likely similar to pine)
  - Transportation?

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Questions about production

- Establishment BMPs and costs?
  - Site prep, plants, irrigation, fertilization, herbivory control
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  - Compared to pine or other options?
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  - CO_2 (carbon sequestration likely similar to pine)
  - Transportation?
- Support systems?

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Questions about production

- Establishment BMPs and costs?
  - Site prep, plants, irrigation, fertilization, herbivory control
- Labor costs?
  - Planting, containment, marking culms, harvest
- Yield expectations?
  - Harvesting strategies and techniques?
  - Compared to pine or other options?
- Markets?
  - Raw materials? Which products?
  - CO_2 (carbon sequestration likely similar to pine)
  - Transportation?
- Support systems?
  - Extension and peer expertise lacking

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Questions about production

- Establishment BMPs and costs?
  - Site prep, plants, irrigation, fertilization, herbivory control
- Labor costs?
  - Planting, containment, marking culms, harvest
- Yield expectations?
  - Harvesting strategies and techniques?
  - Compared to pine or other options?
- Markets?
  - Raw materials? Which products?
  - CO_2 (carbon sequestration likely similar to pine)
  - Transportation?
- Support systems?
  - Extension and peer expertise lacking
  - Navigating the contracts

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Other risks? Ecological & health concerns

- Very little grows under bamboo
  - Dense shade and leaf litter
  - Minimal wildlife habitat
- Histoplasmosis
  - fungal lung disease associated with birds roosting in bamboo stands (or elsewhere)
- Plantings that aren't properly contained or are abandoned will spread

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Summary

- Majority of bamboo planted in SE for commercial purposes are running species
- Once established, bamboo is very difficult to control
- Little information regarding the economic costs and benefits of growing bamboo commercially
- Best management practices have not been developed
- Established markets for raw materials have not been established in the U.S.
- No extension and peer-support systems

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Additional sources

UF IFAS Extension UNIVERSITY of FLORIDA

SS-AGR-75

Bamboo Control[1]

Jason Ferrell, Mark Czarnota, and Ken Langeland[2]

http://edis.ifas.ufl.edu/pdffiles/ag/ag26600.pdf

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Journal for Nature Conservation

Volume 43, June 2018, Pages 39-45

Running bamboo species pose a greater invasion risk than clumping bamboo species in the continental United States

Deah Lieurance [a], Aimee Cooper [a], Austin L. Young [a], Doria R. Gordon [b, c], S. Luke Flory [d]

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Identifying Native Bamboos

Margaret C. Cirtain, Department of Biological Sciences, University of South Carolina,

The bamboos native to the southeastern United States are *Arundinaria* species (grass family, Poaceae); *A. gigantea* (river or giant cane), *A. tecta* (switch cane), and *A. appalachiana* (hill cane). They are unique globally as the only temperate native bamboos in this hemisphere. Rarely found in urban areas, they are most often located in rural areas with infrequent to no disturbance, for example along stream banks and field and fence edges. They are also often understory plants in forested landscapes, such as in Congaree National Park (**Figure 1**).

Figure 2. River cane found along a stream bank, Coldwater River in northern Mississippi.

https://scnps.org//wp-content/uploads/2012/04/Winter_2010.pdf

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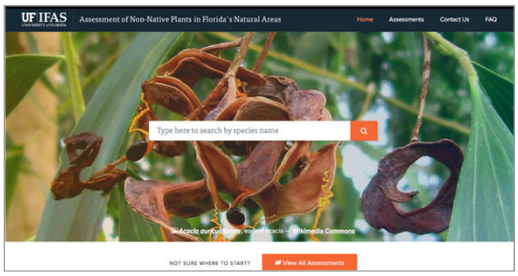

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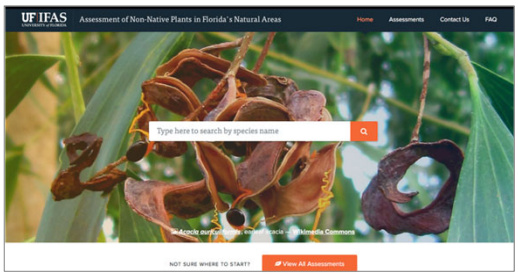

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