Invasive Exotic Species and Control Workshop

Presented by the

Six Rivers Cooperative Invasive Species Management Area (CISMA) and
Florida Forest Stewardship Program

September 28, 2017; 9:00 am to 3:00 pm CT
UF/IFAS Okaloosa County Extension Office
3098 Airport Rd, Crestview, FL 32539-7124

Today's workshop will help you identify and control some of the most troublesome invasive exotic plants like **cogongrass**, **Japanese climbing fern**, **privets** and others. We'll also address exotic insects that are causing or will cause big headaches for forestry and natural resource professionals. This is also a great opportunity to earn **DOACS pesticide applicator CEUs and SAF Forestry CFEs**, and connect with partnership and assistance opportunities!

Agenda:

9:00 am	**Sign-in, meet & greet**
9:15	**Welcome & Introduction**, Sheila Dunning, UF/IFAS Okaloosa County Extension and Chris Demers, UF/IFAS School of Forest Resources and Conservation (SFRC)
9:25	**Herbicide Label, Required PPE, Application Techniques**, Dr. Pat Minogue, SFRC
10:15	**Break**
10:30	**Herbicide Resistance, Modes of Action, Rotation**, Dr. Pat Minogue, SFRC
11:20	**Terrestrial and Aquatic Invasive Exotic Plants and Control Update**, Dr. Stephen Enloe, UF/IFAS Center for Aquatic and Invasive Plants
12:10 pm	**Lunch**
1:00	**Invasive Species Identification and Look-alikes**, Gregg Walker, Florida Natural Areas Inventory
1:50	**Established and New Invasive Exotic Insects**, Jeff Eickwort, Florida Forest Service
2:40	**Working with Six Rivers CISMA**, Kristal Walsh, Florida Fish and Wildlife Conservation Commission
3:00	**Evaluation, CEUs, CFEs, adjourn**

Continuing Education Credits: Approved for 5.0 FDACS Pesticide Applicator CEUs (3.0 private applicator, natural areas weed mgmt., forest pest control, ROW; 2.0 CORE 487/482); and 4.0 Cat. 1 SAF CFEs.

Funding for this workshop is provided by the USDA Forest Service through the Florida Department of Agriculture and Consumer Services Florida Forest Service and the Florida Sustainable Forestry Initiative Implementation Committee.

Table of Contents

We appreciate the support of our
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-listed on the back cover-

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Questions about this or other Forest Stewardship Program activities can be directed to :
Chris Demers, (352) 846-2375, cdemers@ufl.edu
For more information and events see the Florida Forest Stewardship Program web site:
http://www.sfrc.ufl.edu/forest_stewardship

Got Invasives?

Invasive exotic plant problem? Find a program to help by using FloridaInvasives.org.

The Florida Invasive Species Partnership has collected, evaluated and categorized assistance programs into a single resource, making it easier to find the financial and/or technical assistance available to Florida landowners to prevent or control invasive exotic species problems. FloridaInvasives.org has an online resource of management assistance programs to help in your fight against problematic plant species. This resource takes the guesswork out of finding the agencies or organizations offering assistance and will direct you to available programs. The Landowner's Incentives Database will also provide the requirements for each program, to help you decide if they are a good match for your needs.

Why was FloridaInvasives.org developed?

Invasive species have been identified as being costly ecologically and economically statewide in Florida. The Florida Invasive Species Partnership (FISP) is a collaboration of public and private entities in Florida, formed to link efforts at preventing and controlling invasive exotic plants across agency and property boundaries. FISP has developed an on-line tool of available financial and technical assistance sources to make it easier for landowners and land managers to find them.

How does FloridaInvasives.org help you?

FISP has created a searchable database, the Florida landowner incentives database, accessible at FloridaInvasives.org that allows you to find an assistance program for your needs. Search by your county, target species or other pertinent information into the online tool, and you will retrieve a current list of available programs. Floridainvasives.org will help provide focus to your search so that you can get the right person at the right program.

FloridaInvasives.org:

- Builds community awareness,
- Leverages limited resources through cooperation and
- May reduce individual land management costs.

This resource will be regularly updated with the most current program information to provide you the most up-to-date opportunities.

Go to FloridaInvasives.org to find out more.

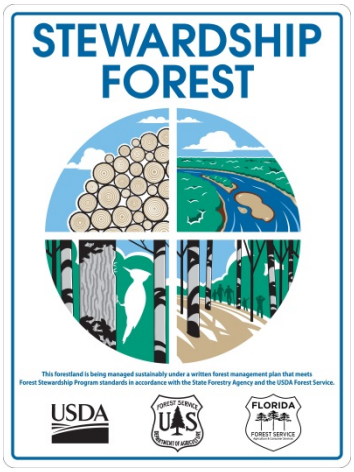
Species Shown from top to bottom:
Mexican Petunia, Boston Fern, Mimosa, Cogongrass, Camphor

FISP
Florida Invasive Species Partnership

Think Locally, Act Neighborly

invasive species know no boundaries!

Florida's Forest Stewardship Program



Forest Stewardship is active management of forest land to keep it in a productive and healthy condition for present and future generations, and to increase the economic, environmental and social benefits of these lands. Forest Stewards are landowners who manage their forest lands on a long-term basis by following a multiple resource management plan.

The Forest Stewardship Program addresses the improvement and maintenance of timber, wildlife, soil and water, recreation, aesthetics, as well as forage resources.

Eligibility

Private forest landowners with at least 20 acres of forest land and a desire to manage their ownerships according to Stewardship principles can participate in the Forest Stewardship Program. Also, adjacent landowners, with similar management objectives, may combine their holdings to meet this acreage limitation.

Benefits to Landowners

- A customized management plan that is based on the landowner's objectives. The plan will include forest stand characteristics, property maps, management recommendations, and a five-year time line for future planning. This plan also serves as documentation of active management on the property that may help reduce tax liability.
- An opportunity for public recognition as a certified "Forest Steward".
- Educational workshops, tours and the quarterly Florida Land Steward newsletter developed and distributed by the University of Florida, IFAS Cooperative Extension Service and other partners.

How to Enroll

Contact your local Florida Forest Service County Forester and tell them that you would like to have a Forest Stewardship Plan prepared for your property. More information and application online at: **http://FreshFromFlorida.com/ForestStewardship**

Tree Farm Program

The American Tree Farm System® is a program of the American Forest Foundation and was founded in 1941 to promote the sustainable management of forests through education and outreach to family forest landowners. Nearly 26 million acres of privately owned forestland and 80,000 family forest landowners in 46 states are enrolled in this program and committed to excellence in forest stewardship. About half of all Tree Farms are located in the South.

Eligibility

Private forest landowners with at least 10 acres of forest land and have a desire to manage their ownerships according to sustainable forestry guidelines can participate in Tree Farm.

Benefits to Landowners

Tree Farmers are good stewards of their forestland committed to protecting watersheds and wildlife habitat and conserving soil. They manage their forestland for various reasons, including timber production, wildlife, recreation, aesthetics, and education/outreach. Tree Farmers receive many benefits:

- Representation on local, state, and federal issues affecting forestland owners.
- Exposure to a network of forestry professionals and landowners committed to sustainable forestry.
- Invitations to workshops, tours and the quarterly Florida Land Steward newsletter produced by University of Florida IFAS and other partners.
- Certification that meets international standards of sustainable forest management.
- Participation in local, state, regional, and national Outstanding Tree Farmer of the Year awards and recognition.

Getting into the Program

Contact your local Florida Forest Service County Forester and tell them that you would like to join the Tree Farm program. More information here:

https://www.treefarmsystem.org/florida

Herbicide Safety and Application Techniques

Pat Minogue, Ph.D., R.F.
Associate Professor of Silviculture
School of Forest Resources and Conservation

SFRC
UF|IFAS
UNIVERSITY of FLORIDA

"I WANT A SPRAY THAT KILLS EVERYTHING BUT ISN'T DANGEROUS"

Pesticide Toxicity

Toxicity - measure of the potential to injure, kill, or cause an adverse effect for a particular organism

- **Acute - short term studies with the active ingredient AND product formulation required by US EPA for pesticide registration**
- **Chronic – studies of long term exposure, 12 & 24 month feeding studies with the active ingredient**

Exposure - contact with chemical

Hazard = Toxicity + Exposure

US EPA Acute Toxicity Studies:

- Acute oral
- Acute dermal
- Acute inhalation
- Primary eye irritation
- Primary skin irritation
- Dermal sensitization

- LD_{50} Lethal dose to 50% of test species, mg/kg
- Used to determine "Signal Word" and "Personal Protective Equipment" (PPE)

Chronic Mammalian Toxicity

- Long term feeding studies, 12 and 24 month

- Carcinogenicity- Potential to cause cancer
- Potential for adverse effects on reproduction
- Teratogenicity- Potential to cause birth defects
- Mutagenicity- Potential to cause genetic changes

- Wildlife/Insect Toxicity- quail, duck, rainbow trout, bluegill, honey bee, *Daphnia* (water flea)

Toxicity and Persistence

PPM (parts per million):
1 inch in 16 miles
1 minute in two years
1 oz in 62,500 lbs
1 tbs in 3,906 gal
1 cent in $10,000
PPB (parts per billion):
1000 times less than ppm - 1 tablespoon in 3,906,000 gal

Half-life: Time for 1/2 of initial amount to be degraded

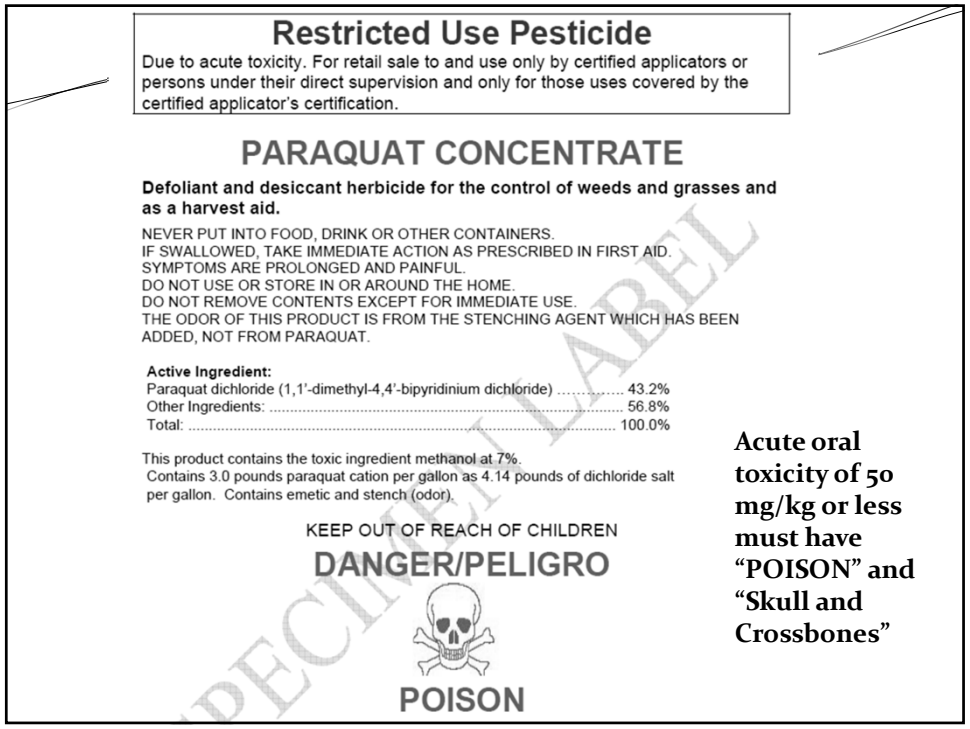
Parts per Million (ppm)

1 mg / kg = 1 ppm
1 liter of water = 1 kg
1 mg / liter = 1 ppm
1% = 10,000 ppm

Signal Word & Toxicity Categories

Acute Study	Category I DANGER	Category II WARNING	Category III CAUTION	Category IV (CAUTION)
Acute Oral	50 mg/kg	50-500 mg/kg	500-5,000 mg/kg	>5,000 mg/kg
Acute Dermal	200 mg/kg	200-2,000 mg/kg	2,000 – 5,000 mg/kg	>5,000 mg/kg
Acute Inhalation	0.05 mg/L	0.05-0.5 mg/L	0.5-2 mg/L	>2 mg/L
Primary Eye Irritation	Corrosive or corneal involvement more than 21 days	Corneal involvement or irritation clearing in 8-21 days	Corneal involvement or irritation clearing in 7 days or less	Minimal effects clearing in less than 24 hours
Primary Skin Sensitization	Corrosive	Severe irritation at 72 hours	Moderate irritation at 72 hours	Mild or slight irritation at 72 hours

The most severe toxicity type determines the category.



Acute oral toxicity of 50 mg/kg or less must have "POISON" and "Skull and Crossbones"

Specimen Label

Dow AgroSciences

Forestry Garlon® XRT

Specialty Herbicide

®Trademark of Dow AgroSciences LLC

For the control of woody plants and annual and perennial broadleaf weeds in forests and in the establishment and maintenance of wildlife openings. Use on these sites may include application to grazed areas.

Active Ingredient:

triclopyr: 3,5,6-trichloro-2-pyridinyloxyacetic acid, butoxyethyl ester	83.9%
Other Ingredients	16.1%
Total	100.0%

Acid equivalent: triclopyr – 60.3% - 6.3 lb/gal

EPA Reg. No. 62719-553

Keep Out of Reach of Children

WARNING AVISO

Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle. (If you do not understand the label, find someone to explain it to you in detail.)

Precautionary Statements

Hazards to Humans and Domestic Animals

Causes Substantial But Temporary Eye Injury • Harmful If Swallowed • Prolonged Or Frequently Repeated Skin Contact May Cause Allergic Reactions In Some Individuals

Do not get in eyes or on clothing. Avoid contact with skin. Wear protective eyewear. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, or using tobacco. Remove and wash contaminated clothing before reuse.

Personal Protective Equipment (PPE)

Applicators and other handlers who handle this pesticide must wear:

- Long-sleeved shirt and long pants
- Shoes plus socks
- Chemical-resistant gloves such as nitrile or butyl
- Protective eyewear

Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables exist, use detergent and hot water. Keep and wash PPE separately from other laundry.

Engineering Controls

When handlers use closed systems, enclosed cabs, or aircraft in a manner that meets the requirements listed in the WPS (40 CFR 170.240(d)(4-6), the handler PPE requirements may be reduced or modified as specified in the WPS.

User Safety Recommendations

Users should:

- Wash hands before eating, drinking, chewing gum, using tobacco, or using the toilet.
- Remove clothing/PPE immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.
- Remove PPE immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

First Aid

If in eyes: Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.

If swallowed: Call a poison control center or doctor immediately for treatment advice. Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a poison control center or doctor. Do not give anything by mouth to an unconscious person.

If on skin or clothing: Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call a poison control center or doctor for treatment advice.

Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact 1-800-992-5994 for emergency medical treatment information.

Environmental Hazards

This pesticide is toxic to fish. Do not apply directly to water, or to areas where surface water is present, or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwater or rinsate.

This chemical has properties and characteristics associated with chemicals detected in groundwater. The use of this chemical in areas where soils are permeable, particularly where the water table is shallow, may result in groundwater contamination.

MATERIAL SAFETY DATA SHEET

Dow AgroSciences

Emergency Phone: 800-992-5994
Dow AgroSciences LLC
Indianapolis, IN 46268

Effective Date: 13-Feb-07
Product Code: 106732

FORESTRY GARLON* XRT HERBICIDE

1. PRODUCT AND COMPANY IDENTIFICATION:

PRODUCT: Forestry Garlon* XRT Herbicide

COMPANY IDENTIFICATION:
Dow AgroSciences LLC
9330 Zionsville Road
Indianapolis, IN 46268-1189

2. HAZARDOUS IDENTIFICATIONS:

EMERGENCY OVERVIEW

Amber liquid with a mild odor. May cause eye and skin irritation. Toxic to aquatic organisms and birds.

EMERGENCY PHONE NUMBER: 800-992-5994

3. COMPOSITION/INFORMATION ON INGREDIENTS:

COMPONENT	CAS NUMBER	W/W%
Triclopyr-butyl	064700-56-7	83.9
Balance		16.1

4. FIRST AID:

EYE: Hold eyes open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, and then continue rinsing eyes. Call a poison control center or doctor for treatment advice.

SKIN: Take off contaminated clothing. Wash skin with soap and plenty of water for 15-20 minutes. Call a poison control center or doctor for treatment advice. Wash clothing before reuse. Shoes and other leather items which cannot be decontaminated should be disposed of properly.

INGESTION: Call a poison control center or doctor immediately for treatment advice. Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by the poison control center or doctor. Never give anything by mouth to an unconscious person.

INHALATION: Move person to fresh air. If person is not breathing, call an emergency responder or ambulance, and then give artificial respiration; if by mouth to mouth use rescuer protection (pocket mask etc). Call a poison control center or doctor for treatment advice.

NOTE TO PHYSICIAN: No specific antidote. Treatment of exposure should be directed at the control of symptoms and the clinical condition of the patient. Have the MSDS, and if available, the product container or label with you when calling a poison control center or doctor, or going for treatment.

5. FIRE FIGHTING MEASURES:

FLASH POINT: >200°F (>93.3°C)
METHOD USED: Not applicable

FLAMMABLE LIMITS
LFL: Not determined
UFL: Not determined

EXTINGUISHING MEDIA: Foam, CO_2, or Dry chemical

FIRE AND EXPLOSION HAZARDS: Foam fire extinguishing system is preferred because uncontrolled water can spread possible contamination. Toxic irritating gases may be formed under fire conditions.

FIRE-FIGHTING EQUIPMENT: Use positive-pressure, self-contained breathing apparatus and full protective equipment.

6. ACCIDENTAL RELEASE MEASURES:

ACTION TO TAKE FOR SPILLS: Absorb small spills with materials such as sand, sawdust, Zorball, or dirt. Wash exposed body areas thoroughly after handling. Report large spills to Dow AgroSciences at 800-992-5994.

7. HANDLING AND STORAGE:

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE: Keep out of reach of children. Do not swallow. Avoid contact with eyes, skin, and clothing. Avoid breathing vapors and spray mist. Handle concentrate in ventilated area. Wash thoroughly with soap and water after handling and before eating, chewing gum, using tobacco, using the toilet or smoking. Keep away from food, feedstuffs, and water supplies. Store in original container in a well-ventilated area.

Diluted solutions are less toxic

- Undiluted Accord XRT II is 100 times more toxic than a 1% solution of Accord XRT II in water.
- Always take greatest precaution when handling undiluted products or concentrated solids.

Primary Routes of Exposure

- Oral
- Dermal
- Inhalation

Wash spray clothes separately!

Silvicultural Herbicide BMPs

- Follow Silviculture BMPs: (FL Forest Service)
  - Choose equipment that directs the chemical only to the target area.
  - Do not conduct aerial application, mist blowing, or operational application of pesticides within the Primary Zone (within 35 ft lakes, sinkholes to 200 ft Class I drinking water sources) of the Special Management Zone (SMZ)
  - Do not leave pesticide containers on site.
  - Do not rinse spray equipment or discharge rinse water in water bodies, wetlands, or within the SMZ.

Environmental Safety!!!

- Read "Environmental Hazards" and follow "Environmental Precautions" on product label.
- **Know your herbicide characteristics**, in particular:
  - Water solubility- potential to leach or move in surface flow
  - Soil sorption, mobility, half-life
  - Volatility

Application Methods

- **Hand-held Techniques**
  - Backpack Foliar
  - Basal Stem
  - Hack & Squirt
  - Cut Stump
  - Soil Spot and Soil Basal
- **Ground Sprayer Machinery**
- **Aerial Application**

Backpack Foliar Sprays

- Best for **targeted** applications on low brush, **less than 4 feet tall**
- **Less than 1,500 rootstocks per acre**
- **Use low volumes**, **10-20** gallons spray per acre (GPA)
- **Common Herbicides:**
  - Arsenal® AC, Chopper®
  - Garlon® 4, Garlon® 3A
  - Accord® XRT

Proper Personal Protective Equipment

Basal Stem Treatment

- Spray bark of **small diameter stems**, **< 4"d**
- May be applied in **dormant season**
- Apply from **ground to 12-15** inches high
- Use with **"basal oil"** or oil emulsion carrier
- **Common Herbicides**
  - Garlon® 4 Ultra
    - No residual effect
  - Chopper® Gen II
    - Residual soil activity

Hack & Squirt (Cut Stem)

- Used on **taller vegetation**, greater than **4" diameter**
- Make cuts at a **downward angle** around the tree
- See labels regarding solution concentration, spacing between "hacks".
- Generally apply 1 ml/hack, about the same as 1 pull on a squirt bottle.
- **Common Herbicides:**
  - **Arsenal® AC**
  - **Garlon® 3A**
  - **Weedar® 64 (2,4-D)**

Cut Stump

- Best for a **few targeted** trees
- Spray just the **cambium**
- Best on **freshly cut** stumps
- Treat all the stumps!
- **Common Herbicides**
  - **Chopper®, Stalker®**
  - **Garlon® 4 Ultra (ester), Garlon® 3A (amine)**
  - **Pathfinder® II (RTU)**
  - **Accord® XRT II**

Soil Basal and Spot Treatments

Spring applications

- Undiluted ***Velpar® L***
- Exact delivery handgun application to the **base of woody vegetation**
- For ***trees*** use 2-4 ml product **per inch** of stem diameter at breast height.
- For **brush** apply 2-4 ml product **per 3 feet** canopy width.

Ground Sprayer Design

Boom-less sprayers

- **Cluster nozzles**
- **Boom-Busters**
- **Flooding fan nozzles**

Jim Miller ©

Boom Jet®

Ground Sprayer Design

Straight-stream manifold

Radiarc®
- controlled droplet size

Tractor Mounted Band Sprayer

- **Selective herbicides** over the top of planted trees
  - Oust® XP
  - Arsenal® AC
  - Velpar® L
  - Escort® XP
- A 4 to 6 foot wide band is common for herbaceous weed control on planted rows.
- Bands use **less herbicide** and have less environmental impact than broadcast treatment.

Aerial Herbicide Spraying

Rotor-wing aircraft

- Appropriate for **large areas** (40+ Acres), or difficult access.
- Herbicide plus burning has largely replaced mechanical forest site preparation.
- Selective herbicides can be applied **through the canopy mid-rotation**.
- Broadcast Velpar® or Oust® applications may **promote native grasses**.

Solids: Iso-Lair Bucket

Factors Affecting Drift Potential

- **Application parameters**, especially **droplet size** and spraying technique (nozzle selection, booms, aircraft, etc.)
- **Weather effects**, especially **wind speed and direction**, height of **inversion layer**
- **Tank mix effects**, product formulations, surfactants, emulsifiers, drift control agents

Small Droplets Give Good Coverage on the Leaf Surface

Droplet Diameter (Microns)	Droplets on Leaf (Per Sq. Inch)
50	92,250
100	11,750
200	1,425
400	180
800	22

Akesson and Yates, 1987, WSSA

Small Droplets Drift!!!!

Droplet Diameter (Microns)	Wind 1 mph	5 mph	10 mph
10	1.5 miles	7.5 miles	14.5 miles
100	75 feet	375 feet	750 feet
300	8 feet	42 feet	83 feet
600	2 feet	11 feet	21 feet
800	1 foot	6 feet	12 feet

Hansen, 1965; see Akesson and Yates, 1987, WSSA

Evaporation Rate & Droplet Size

20 ft, 1 mph Wind, 25C, 55%RH

Droplet Diameter (Microns)	Droplet Disappears (Fall Distance)
200	--
150	15 ft
120	7 ft
100	3.5 ft
80	2 ft

Akesson and Yates, 1987, WSSA

Application Parameters Effecting Droplet Size Spectrum

- **Orifice size** and type of nozzle
- Nozzle discharge angle
- **Pressure** at the nozzle
- **Application height**
- Droplet shear, turbulence, airspeed
- Evaporative losses while airborne

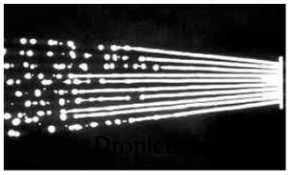
Aerial Spray Equipment

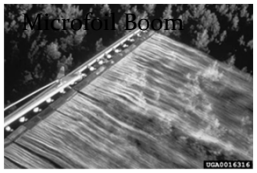
CONVENTIONAL
- Simplex(R) Boom
- Warnell(R) Boom
- Teejet(R) Disc-Core Nozzles
- Raindrop(R) Nozzles

CONTROLLED DROPLET BOOMS
- Microfoil(R) Boom
- Thru-Valve(R) Boom
- Microfoil(R) Nozzles
- TVB(R) Nozzles
- Accu-Flo(R) Nozzles

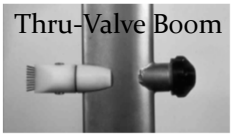
Advances in Aerial Application Technology

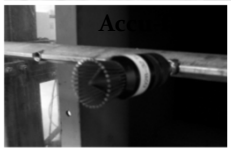
Controlled droplet size = reduced drift





Thru-Valve Boom





GPS: Global Positioning Systems

- Documents **path of the aircraft**
- **Delineates** treatment area
- Very useful to **determine airspeed** ensure correct calibration of spray volume and herbicide rates per acre.
- Can be **integrated with injection systems** to control delivery rate.

Sources of Additional Information

- **Southern Regional Extension Forestry: http://www.sref.info/**

Extension Forestry
Southern Regional

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UF UNIVERSITY of FLORIDA
IFAS
North Florida Research and Education Center

How Herbicides Work:

Absorption, Translocation, Mode of Action, and Behavior in the Environment

Patrick J. Minogue, Ph.D., R.F.
Associate Professor of Silviculture
University of Florida, NFREC, Quincy

Know your Herbicides to Ensure Safe and Effective Use

- Chemical and Physical Properties
- Herbicidal Properties
- Behavior in Soil
- Behavior in Plants
- Toxicology
- Eco-toxicology and Environmental Fate

Chemical and Physical Properties

- **Molecular Weight** – Plant uptake, Mobility
- **Vapor Pressure** – Volatility
- **Stability** – Persistence, Reactivity
- **Water Solubility** – Mobility, Leaching, Rain fastness
- **pKa** (ions) – Soil Sorption, Mobility
- **K_{ow}** (Octonol:Water Partition Coefficient) – affinity to **lipids (oil)** vs. **water**

Herbicidal Properties - Terminology

- Pre-emergence, Post-emergence, Both
- Foliar Active, Soil Active, Both
- Residual (Persistence) – "Half-life"
- Contact vs. Trans-locating Herbicides
- Selective Weed Control

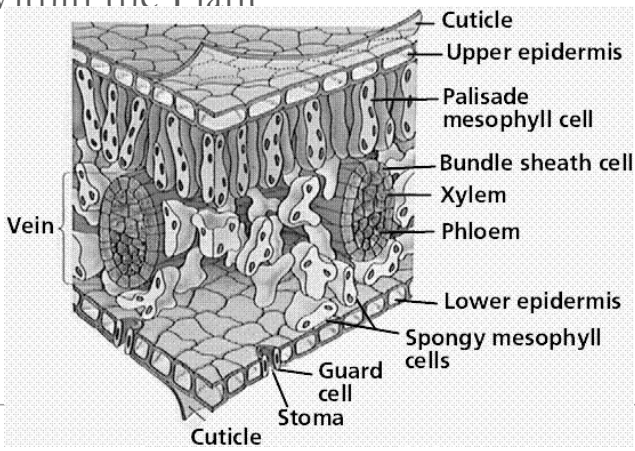
Behavior in Soil

- Sorption (adsorption, absorption)
- Transformation
  - Photo Degradation
  - Biological Degradation (Microbial)
  - Chemical Degradation
- Persistence
- Mobility

Behavior in Plants - Consider:

- Site of Absorption Into Plant
- Translocation Within the Plant
- Site of Physiological Action
- Symptoms, Fast vs. Slow

Herbicide Absorption & Translocation Within the Plant



Herbicides are Grouped into "Families" with Common MOA

Common Modes of Action for Natural Resource Management:

- Growth Regulators
- Photosynthetic Inhibitors
- Amino Acid Synthesis Inhibitors
- Protoporphyrinogen Oxidase Inhibitors (PPO)
- Inhibition of Cellulose Biosynthesis

Herbicides inhibit physiological processes, mediated by plant enzymes

- *When plants are under stress from drought or injury herbicides don't work as well.*
- *Allow 6 to 8 weeks after herbicide application before site prep burning or use of machinery to permit the herbicide to translocate throughout the plant – particularly to roots.*

Growth Regulators

Family	Common Name	Trade Name
Benzoic Acid	Dicamba	Banvel®
Phenoxyacetic Acid	2,4-D, 2,4-DP	Weedone® *many others*
Pyridine-Carboxylic Acids (Picolinic Acid)	Triclopyr Clopyralid Aminopyralid	Garlon® Transline® Milestone®

Growth Regulators: Absorption

- **Dicamba**: Readily penetrates leaves, roots, and stems.
- **2,4-D, 2,4-DP**: Plant roots absorb the polar amine forms whereas the more lipophilic ester forms penetrate the foliage rapidly.
- **Triclopyr**: Primarily absorbed by foliage; root uptake does occur, primarily for the water soluble amine
- **Clopyralid**: Readily absorbed by roots and foliage

Growth Regulators: Translocation

- All translocate via the xylem and phloem, but most movement is in the phloem and within the cell-to cell continuum bound by membranes – the symplasm
- Following root absorption translocation is primarily in the xylem
- All accumulate in growing points
- Differences in translocation between species account for differential susceptibility.

Growth Regulators: MOA

- Not completely understood, **similar to exogenous auxin (IAA)**. The specific site of action has not been identified. Many processes affected.
- Primarily effects cell wall plasticity and nucleic acid metabolism.
- Cell wall is acidified through stimulation of the ATPase driven proton pump, increasing cell wall elongation through action of loosening enzymes.
- Low concentrations stimulate RNA polymerase, resulting in increases in RNA and DNA, stimulating protein synthesis.

Growth Regulators: Symptoms

- Epinastic bending and twisting of stems and petioles, stem swelling at nodes, stem elongation, and leaf cupping and curling (auxin like).
- Chlorosis of growing points, growth inhibition, wilting, and necrosis.
- Death of susceptible plants occurs within 3-5 weeks. In woody plants **rapid necrosis of foliage may reduce effectiveness** of translocating herbicides.

Photosynthesis Inhibitors

Family	Common Name	Trade Name
Triazine	Atrazine	Aatrex®
		Others
	Hexazinone	Velpar®

Triazines: Absorption and Translocation

- Absorbed through roots with soil applications and translocated upward through xylem
- Absorbed through leaves following foliar applications but poorly translocated to other plant parts
- For atrazine, essentially no basipetal (downward) movement from leaves.

- *Why we need solid hexazinone formulations!*

Triazines: MOA and Symptoms

- Photosynthesis inhibitor: Inhibits electron transport in photosystem II (“z”-scheme)
- Symptoms begin with interveinal chlorosis and yellowing of leaf margins and progress to chlorosis and necrosis.
- Older leaves show more symptoms than new growth

Inhibitors of Amino Acid Synthesis

Family	**Common Name**	**Trade Name**
Organo-phosphorus	Glyphosate	Accord® Roundup® *Many Others*
Imidazolinone	Imazapyr Imazapic	Arsenal® Plateau®
Sulfonylureas	Sulfometuron methyl Metsulfuron methyl	Oust® *Escort*®

Glyphosate: Absorption and Translocation

- Absorption is through the foliage. It is strongly absorbed by soil, and root uptake occurs only to a very limited extent in sandy soils with high rates and saturated conditions.
- Primarily translocated in the phloem and within the symplasm, most research results show little to no movement in the xylem.
- Glyphosate accumulates in underground tissues, immature leaves, and meristems.

Glyphosate: Mode of Action

- Inhibits the formation of aromatic amino acids (tryptophan, tyrosine, and phenylalanine) in the shikimate acid pathway.
- The site of action is the enzyme enolpyruvyl shikimate-3-phosphate (EPSP).
- ***Having a very specific site of action facilitates development of herbicide resistance.***

Glyphosate: Symptoms

- Symptoms appear relatively slowly (4-7 days).
- Growth is inhibited soon after application followed by foliar chlorosis and necrosis, appearing first in in immature leaves and growing points.
- Foliage sometimes turns reddish-purple in certain species.
- Re-growth of woody species often displays multiple shoots, small contorted leaves.

Imidazolinones: Absorption and Translocation

- Absorbed through roots and foliage
- **Imazapyr**: Rapid translocation throughout the plant through the xylem and phloem. Accumulates in symplasm through ion-trapping mechanism.
- **Imazapic**: Moves in xylem and phloem, but primarily in phloem and symplasm. Much less polar than imazapyr.

Imidazolinones: MOA, Symptoms

- Inhibits branched chain amino acid synthesis (valine, leucine, and isoleucine)
- Site of action is acetolactate synthase (aka acetohydroxyacid synthase)
- Growth is inhibited after a few hours but symptoms are very slow to develop; 1-3 weeks in herbaceous plants to several months in woody plants.
- Symptoms first occur in growing points as chlorosis then progressing to necrosis.
- **Imazapyr**: Certain plants develop a black color in foliage, purple colored sap in trees.

Imazapyr injury in pines

Sulfonylureas: Absorption and Translocation

- Readily absorbed by leaves following post treatments and by roots from treated soil.
- Move primarily in the xylem and to a limited extent by mass flow in the phloem.
- Accumulate in meristematic regions of the plant.

Sulfonylureas: MOA & Symptoms

- Inhibit branched chain amino acid synthesis (valine, leucine, and isoleucine)
- Site of action is acetolactate synthase (aka acetohydroxyacid synthase)
- Growth is inhibited after a few hours but symptoms are very slow to develop; 2-3 weeks in herbaceous plants to several months in woody plants.
- Symptoms gradually appear as chlorosis in growing points then progress to chlorosis and necrosis of the foliage.

Other Modes of Action

Family	Common Name	Trade Name
Cellulose Biosynthesis	Indaziflam	Esplanade®
PPO Inhibitors	Saflufenacil	Detail®

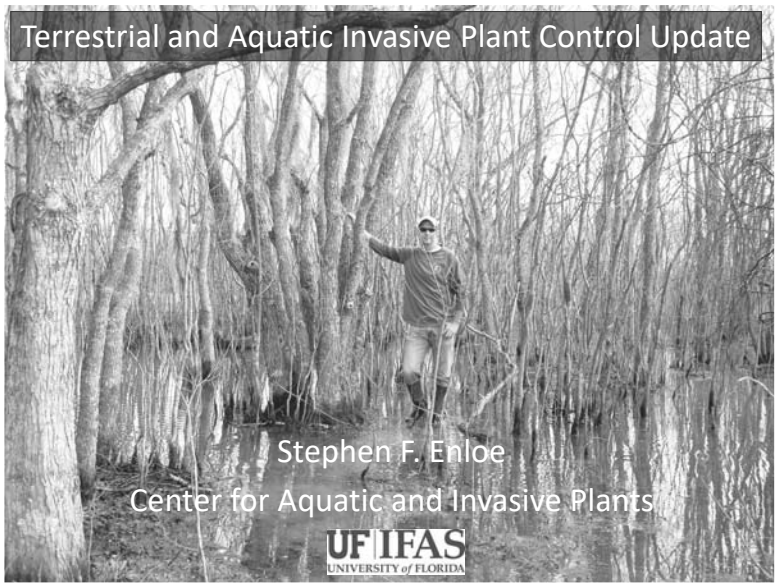
Source of Information

- Herbicide Handbook. 2014. D.L. Shaner, Ed.. Tenth Edition, Weed Science Society of America, 810 E. 10th Street, Lawrence, KS 66044-8897. (ISBN 978-0-615-98937-2)
- Osiecka, A. and P. Minogue. 2017. Forest herbicide characteristics. University of Florida Cooperative Extension Service Circular FOR 283. 9 pp. http://edis.ifas.ufl.edu/fr345
- Osiecka, A. and P. Minogue. 2017. Developing herbicide prescriptions for forest vegetation management. University of Florida Cooperative Extension Service Circular FOR 273. 8 pp. http://edis.ifas.ufl.edu/fr335

New Forest Vegetation Management Website

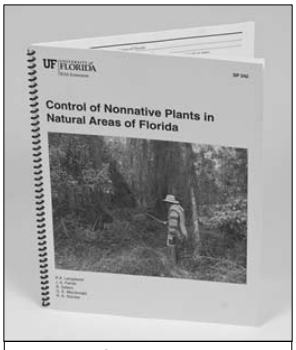
Extension Forestry
Southern Regional

- Forestry Herbicides
- Wildlife Management
- Prescribed Burning
- Sources of Assistance for Forest landowners



New publications on the way!!!
Expected October 2017

Efficacy of Herbicide Active Ingredients Against Aquatic Weeds (SS-AGR-044)



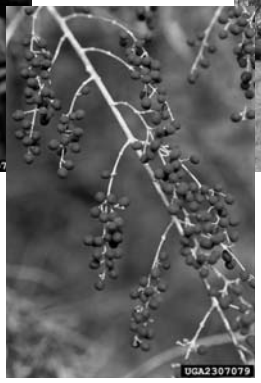
Control of Nonnative plants in Florida Natural Areas (SP242)

Upland Research Updates

- Chinese privet
- Chinese tallow

Aquatic Research Updates

- Torpedograss



Chinese privet
Ligustrum sinense

Basal bark treatment

Triclopyr ester
20% v/v on a product basis
20% herbicide, 80% oil carrier

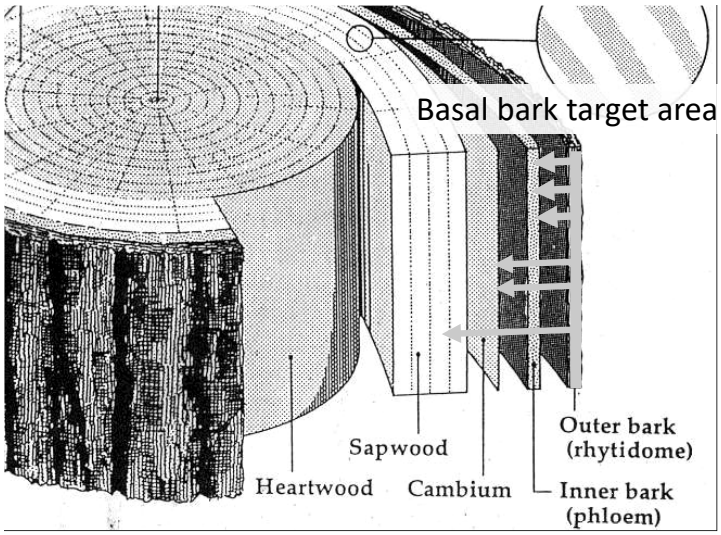
Triclopyr ester
Ready to use (RTU)
(100% v/v)

SPECIMEN LABEL

DIESEL FUEL

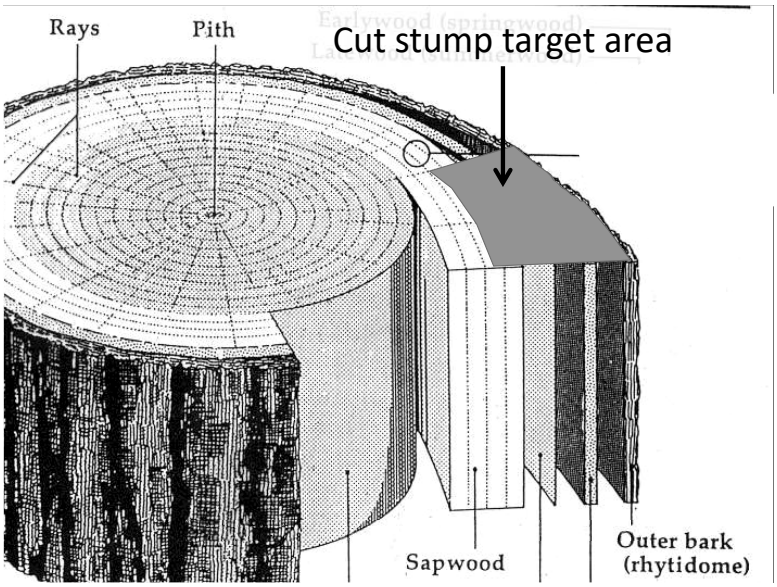

http://projecttallow.weebly.com/

Treat the lower 12-18 inches of every stem

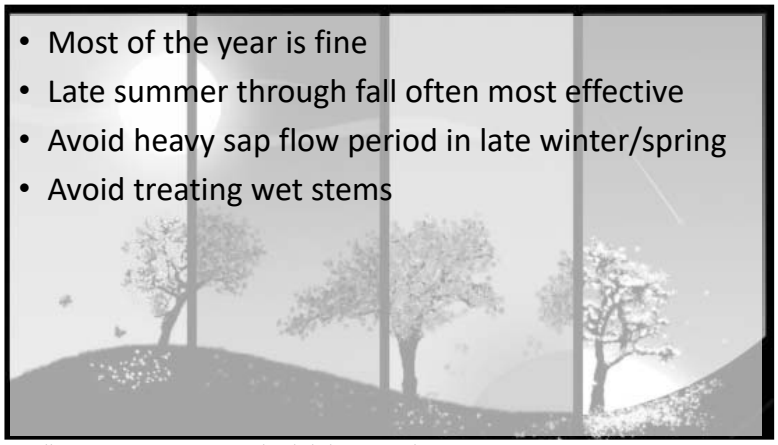


Triclopyr amine
50% v/v on a product basis
50% herbicide, 50% water

Glyphosate
50% v/v on a product basis
50% herbicide, 50% water



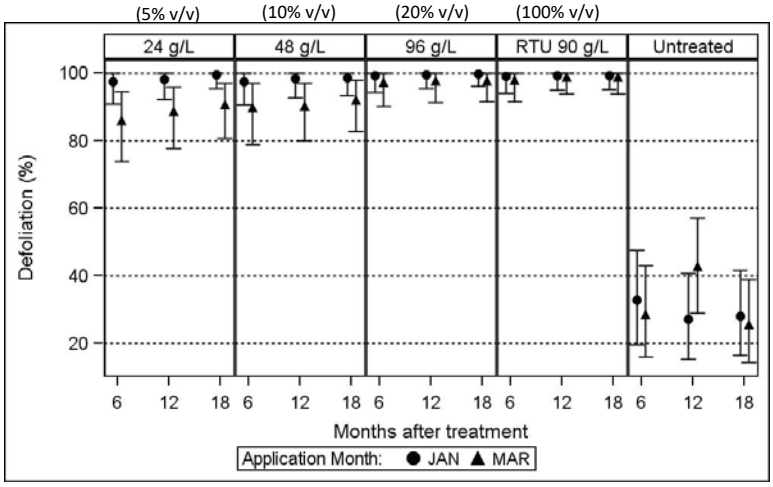
When can I do cut stump and basal bark treatment?



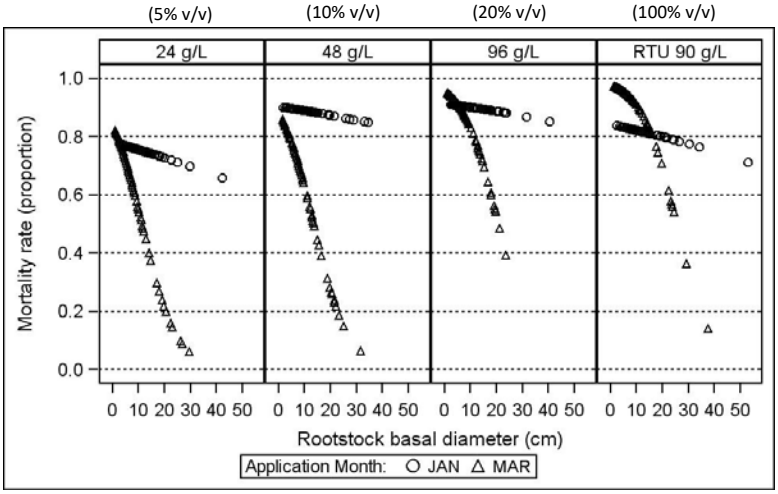
https://possiblythemostgrumpy.wordpress.com/2015/08/27/10-the-seasons/

How does Garlon 4 at 20, 10, and 5% v/v compare to Pathfinder II in winter or spring application timings?

Chinese privet % defoliation

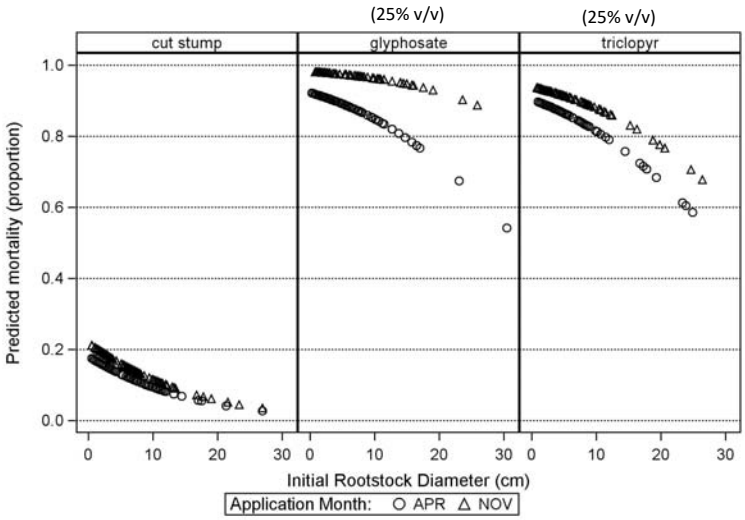


Chinese privet mortality



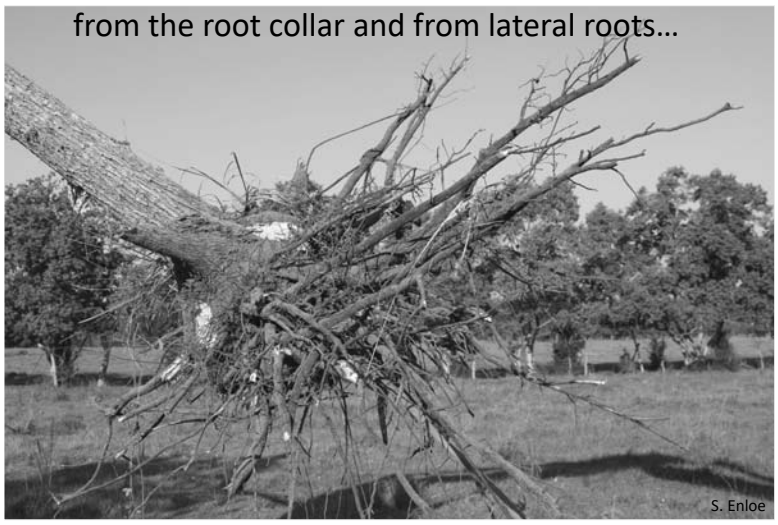
How does Garlon 3A at 25% v/v compare with Accord Concentrate at 25% v/v in fall or spring application timings?

Chinese privet mortality



Chinese privet summary

- Season matters
  - Cut stump: glyphosate or triclopyr amine (25% v/v) in fall
    - Lower control in spring, especially as diameter increases
  - Basal bark: triclopyr ester (10-20% v/v) in winter
    - Lower control in spring as diameter increases
  - Foliar: glyphosate (3% v/v) in late fall, early winter
    - Triclopyr amine not consistent

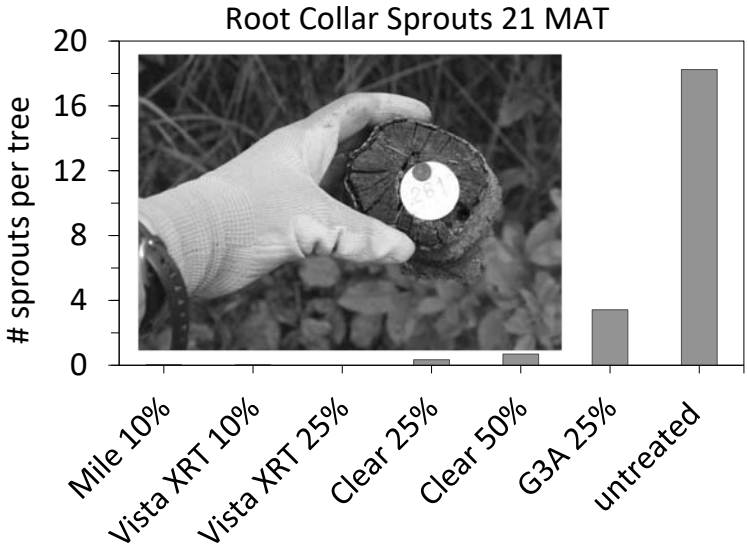


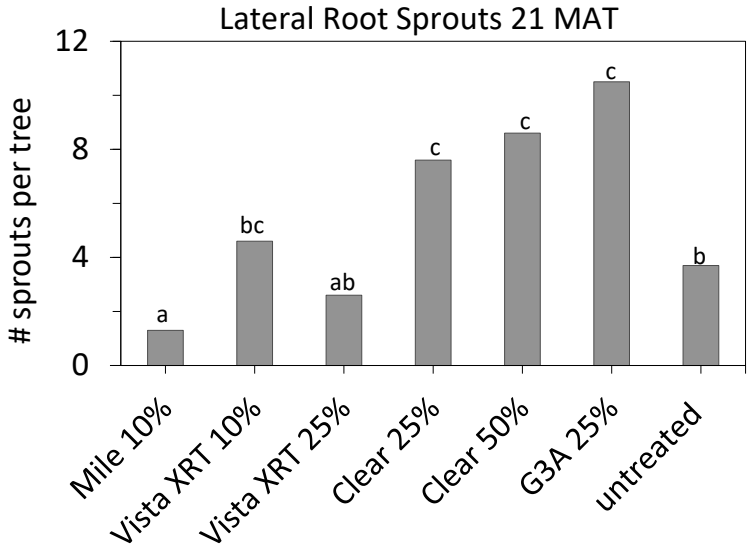
Cut Stump Treatments

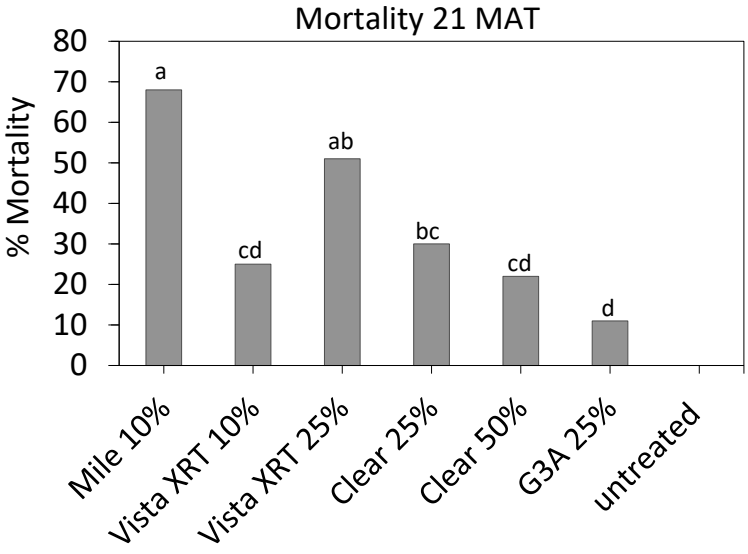
Applied December 2011

- Garlon 3A (25% v/v)
- Clearcast (25%, 50% v/v)
- Milestone (10% v/v)
- Vista XRT (10%, 25% v/v)
- Untreated

1.5 – 6 inch diameter RCD
Mean = 4 inches





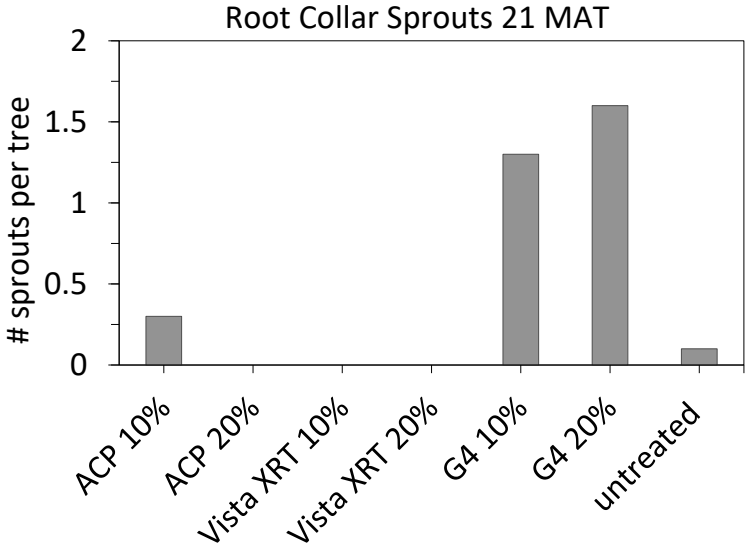


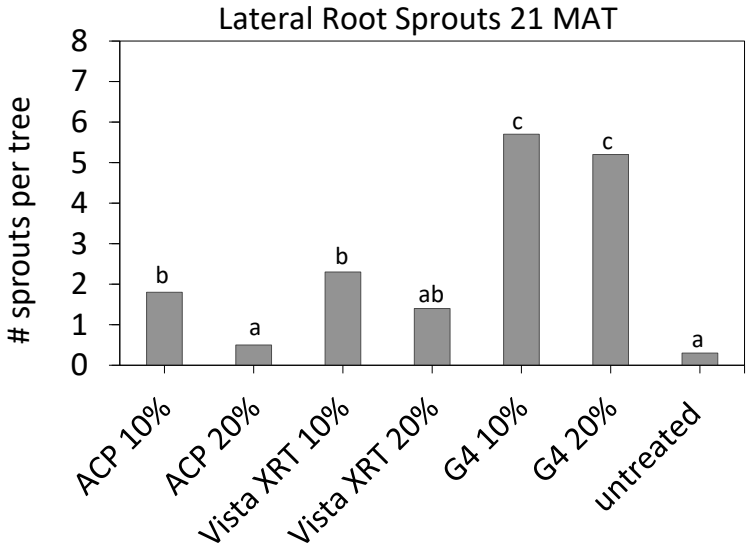
Basal bark treatments

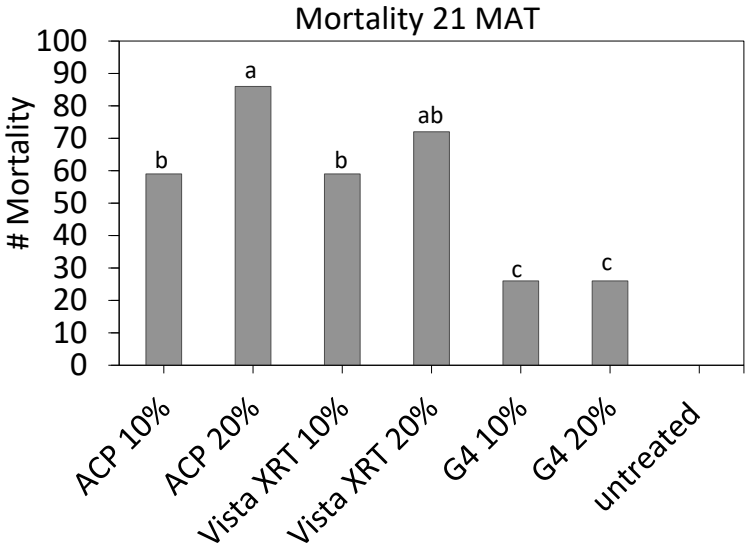
Applied December 2011 with Bark Oil Blue

- Garlon 4
  - 10% v/v
  - 20% v/v
- Vista XRT
  - 10% v/v
  - 20% v/v
- Method 240SL
  -Aminocyclopyrachlor (ACP)
  - 10% v/v
  - 20% v/v
- Untreated

1.4 – 6.6 inch RCD
Mean = 4 inches





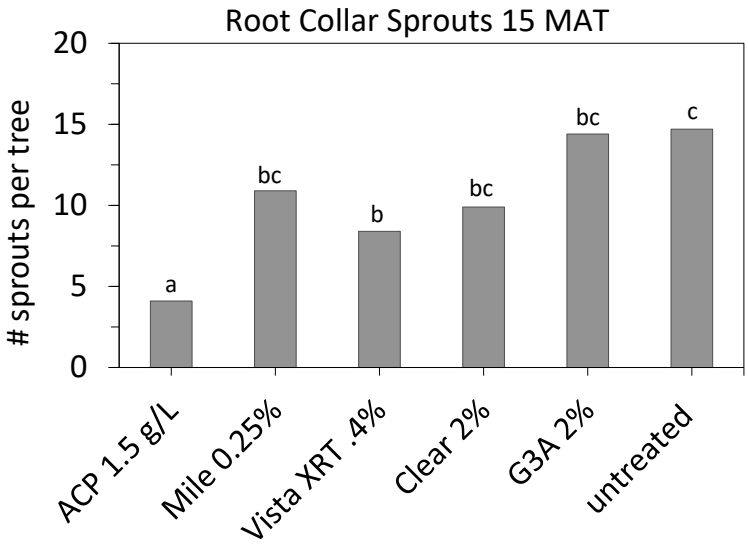


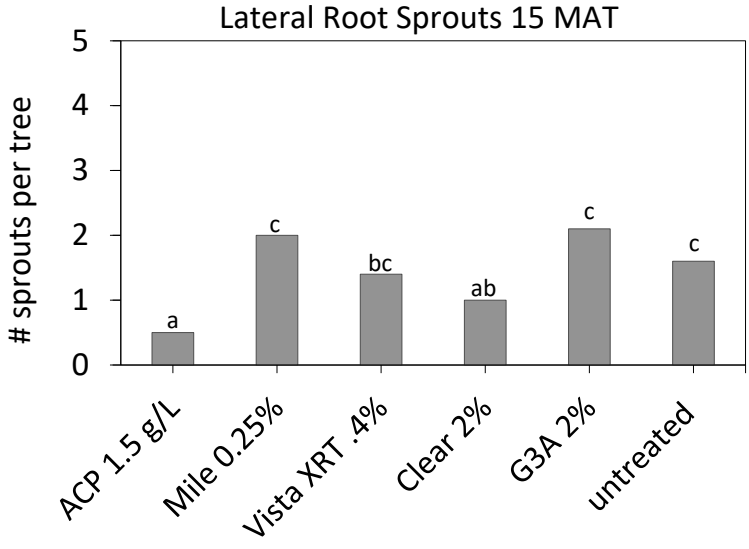
Foliar treatments

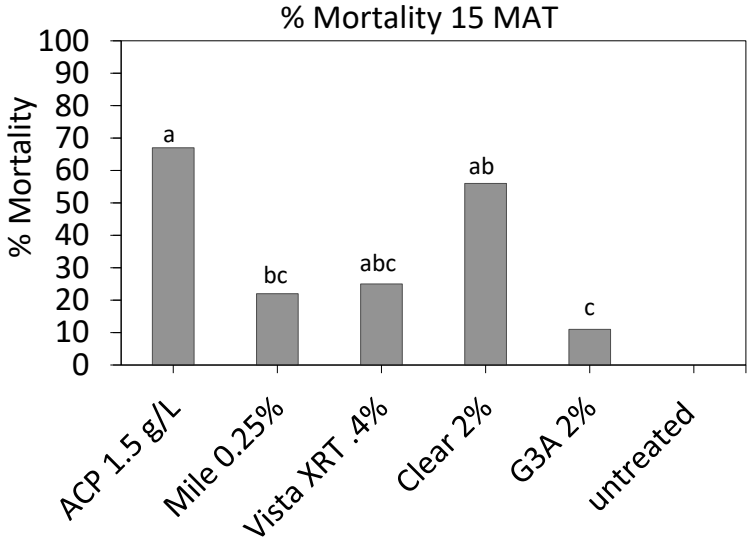
Applied June 2012 …after ~50 inches of regrowth

- Garlon 3A
  - 2% v/v
- Clearcast
  - 2% v/v
- Milestone
  - 0.25% v/v
- Vista XRT
  - 0.4% v/v
- Aminocyclopyrachlor
  - 1.5 g/L
- Untreated

1.3 – 6 inch RCD
Mean = 3.6 inches



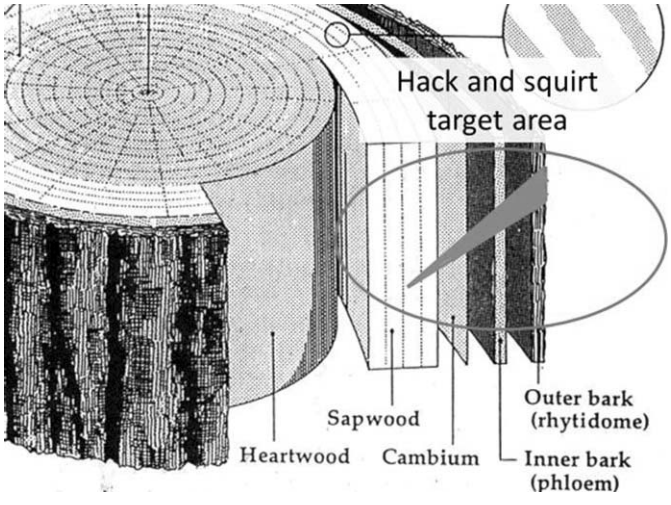




Chinese tallow summary

- Cut stump:
  - Aminopyralid (Milestone @ 10% v/v) good control
  - Triclopyr amine (Garlon 3A @ 25% v/v) DID NOT WORK
    - 50% v/v will do better
  - Imazamox (Clearcast was not as good as expected)
  - Fluroxypyr (Vista had decent activity at higher rate)
- Basal bark:
  - Triclopyr ester (Garlon 4 @ 20% v/v) struggled to control lateral root sprouts
  - Aminocyclopyrachlor (Method @ 20%) excellent control
  - Fluroxypyr (Vista at 20% v/v) very good control
- Foliar: Cutting and then foliar treating regrowth makes for increasingly difficult control
  - Method and Clearcast provided the best control in this situation

Extreme overkill!



What do the Milestone and Method Labels Current Say about hack and squirt?

- Milestone: 10%v/v with continuous or overlapping hacks
- Method: 100% v/v , 1 hack/2 inches DBH (soon)

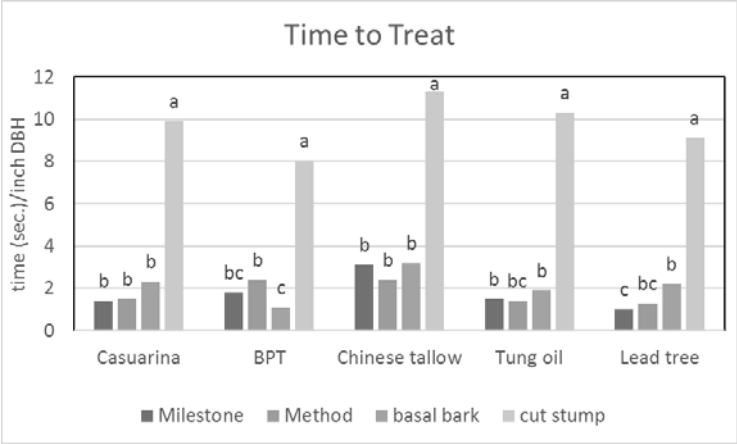
Treatments

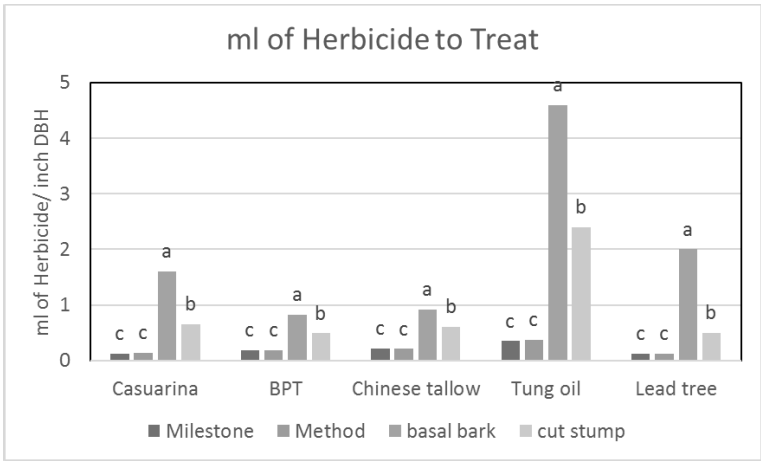
Method	Treatment	Active Ingredient	Rate
Hack and Squirt	Milestone	Aminopyralid	100%
Hack and Squirt	Method 240 SL	Aminocyclopyrachlor	100%
Basal Bark	Garlon 4 Ultra	Triclopyr	20% v/v
Cut stump	Garlon 3A	Triclopyr	50% v/v
Untreated	Untreated	No herbicide	0%

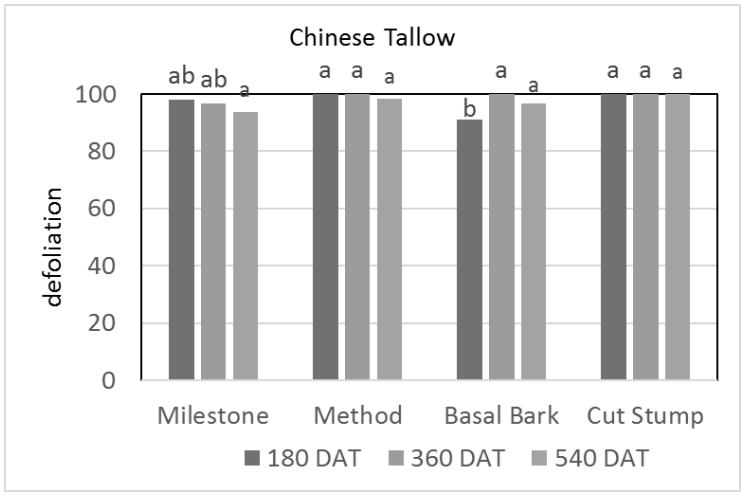
Reduced Hack and Squirt

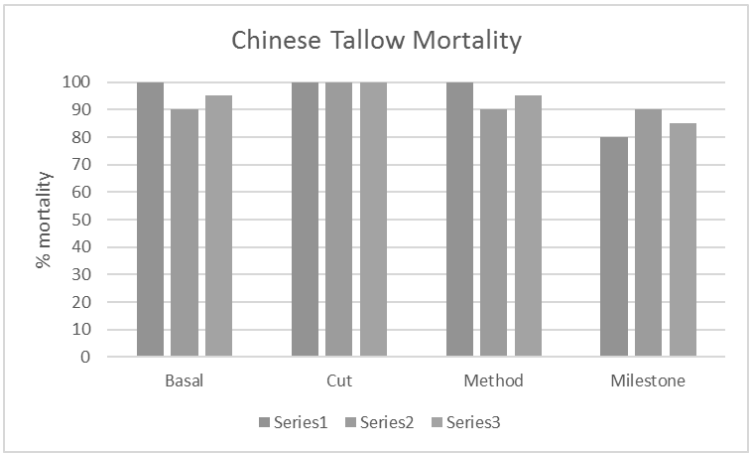
Species Comparison

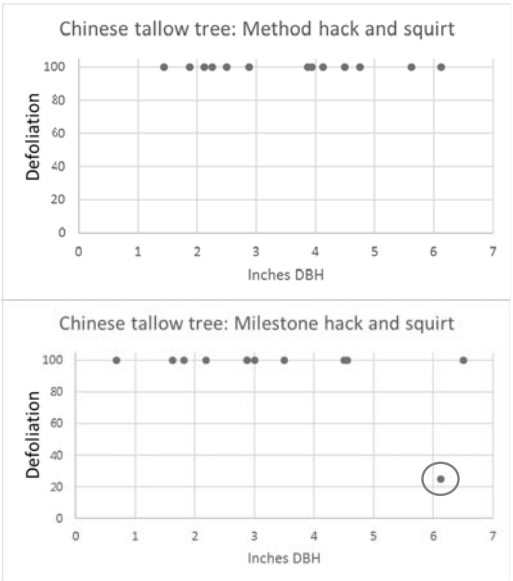
Species	Averag DBH (in)	DBH Range	Averag Stem #	Stem # Range
Casuarina	4.4	1.5 – 10.75	1	1
Chinese Tallow	5	0.7 – 13.3	1.9	1 – 9
Bishopwood	5.89	1 – 29.75	1.54	1 – 7
Brazilian Peppertree	13.06	2.25 – 43.25	4.28	1 – 16
Melaleuca	5.97	1.5 – 14.5	1.1	1 – 3
Lead Tree	4.95	1.25 – 14.25	1.13	1 – 2
Surinam Cherry	5.29	2 – 18.5	1.75	1 – 5
Tung Oil	5.24	1 – 17.25	1.18	1 - 4

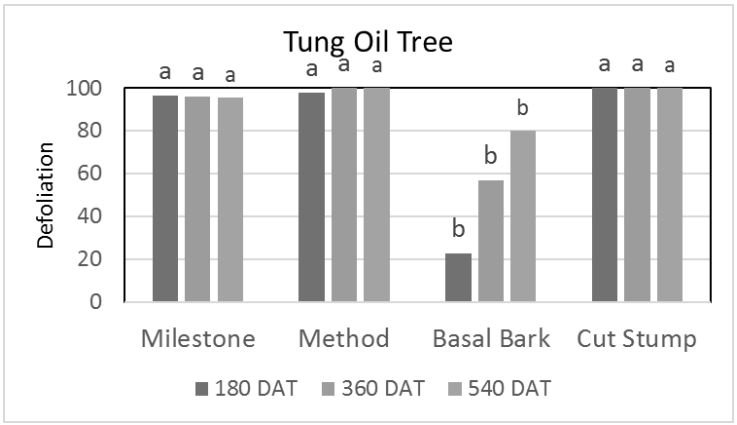





Chinese Tallow
defoliation
100
80
60
40
20
0
ab ab a
a a a
b a a
a a a
Milestone
Method
Basal Bark
Cut Stump
180 DAT
360 DAT
540 DAT


Chinese Tallow Mortality
% mortality
100
90
80
70
60
50
40
30
20
10
0
Basal
Cut
Method
Milestone
Series1
Series2
Series3


Chinese tallow tree: Method hack and squirt
Defoliation
100
80
60
40
20
0
0
1
2
3
4
5
6
7
Inches DBH
Chinese tallow tree: Milestone hack and squirt
Defoliation
Inches DBH


Tung Oil Tree
Defoliation
100
80
60
40
20
0
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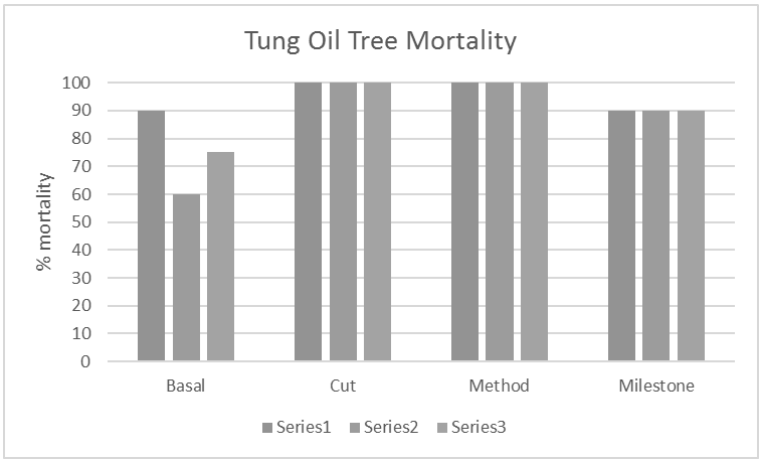
a a a
b
b
b
a a a
Milestone
Method
Basal Bark
Cut Stump
180 DAT
360 DAT
540 DAT


Tung Oil Tree Mortality
% mortality
100
90
80
70
60
50
40
30
20
10
0
Basal
Cut
Method
Milestone
Series1
Series2
Series3

Hack and Squirt Summary

- Both Milestone and Method are very promising as new tools for increasing efficiency of hack and squirt
- We have killed 6-7 inch DBH tallow with a single hack injected with 0.5 ml of either herbicide at 100% v/v
- Currently waiting on EPA on Method label, working for a 24(c) for Milestone

Wrap up and Questions?

sfenloe@ufl.edu

UF IFAS
UNIVERSITY of FLORIDA

Do graminicides have a future in aquatic invasive grass management in Florida?

Stephen Enloe and Michael Netherland
UF Center for Aquatic and Invasive Plants

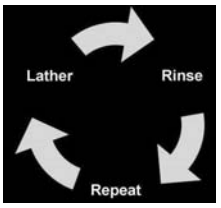
UF IFAS UNIVERSITY of FLORIDA

ERDC INNOVATIVE SOLUTIONS for a safer, better world

Troublesome aquatic invasive grasses in FL

- Torpedograss
- Paragrass
- West Indian marsh grass
- Tropical American water grass
- Limpograss

Glyphosate
Imazapyr



ACCase inhibitors 1(A) (graminicides)

Aryloxyphenoxypropionates
"FOPS"

- **Fluazifop**
  - Fusilade
- Diclopfop
  - Hoelon
- Quizalofop
  - Assure2
- Fenoxaprop
  - Fusion
- Haloxyfop
  - Verdict

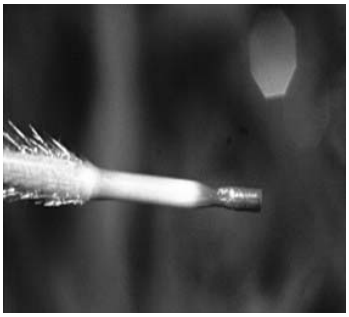
cyclohexanediones
"DIMS"

- **Sethoxydim**
  - Poast, Vantage, TIGR
- Clethodim
  - Select, Arrow

phenylpyrazolins
"DENS"

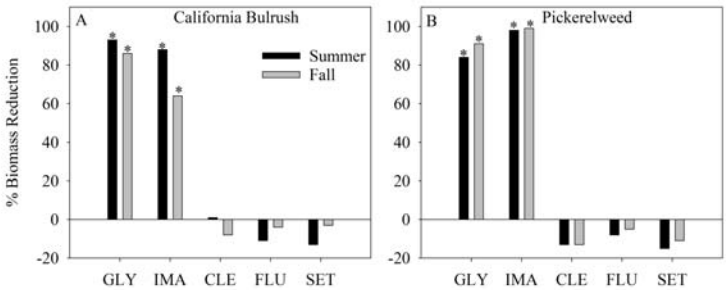
- Pinoxaden
  - Axial

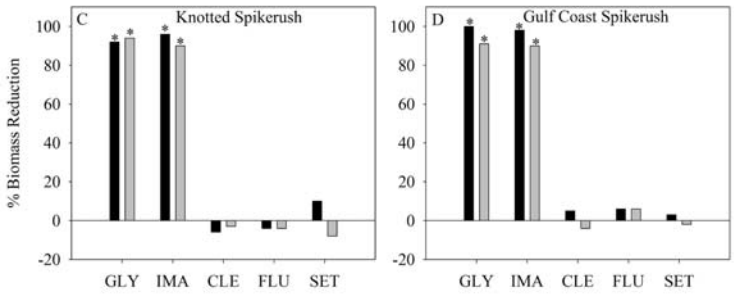
ACCase inhibitor Symptoms

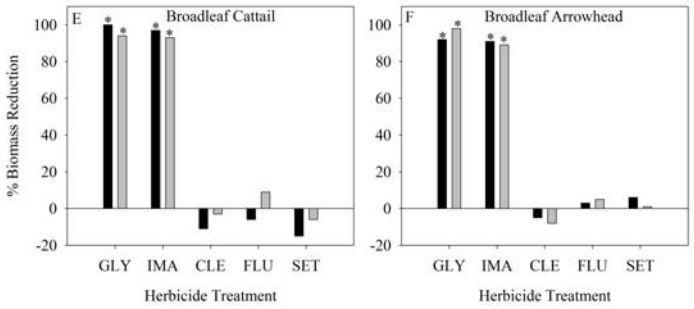


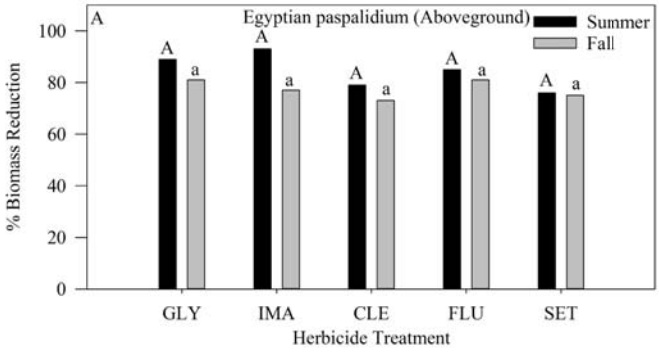
Herbicides tested in mesocosm studies for emergent selectivity

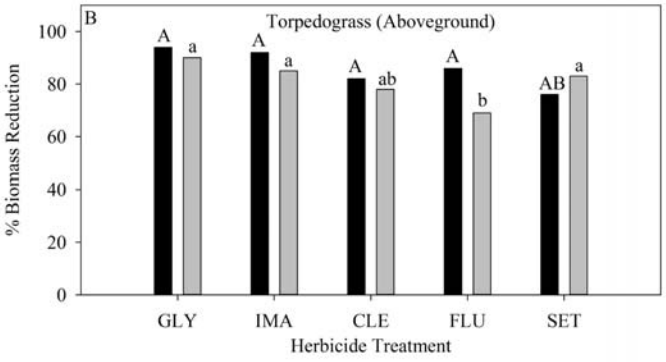
- Sethoxydim
- Clethodim
- Fluazifop-p-butyl
- Glyphosate
- Imazapyr





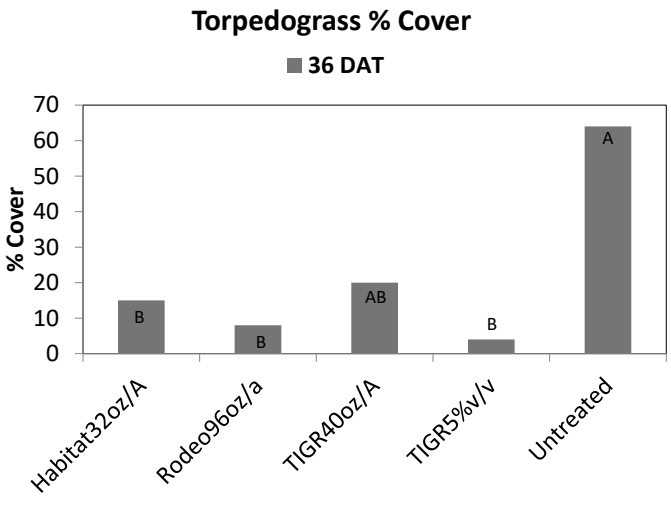


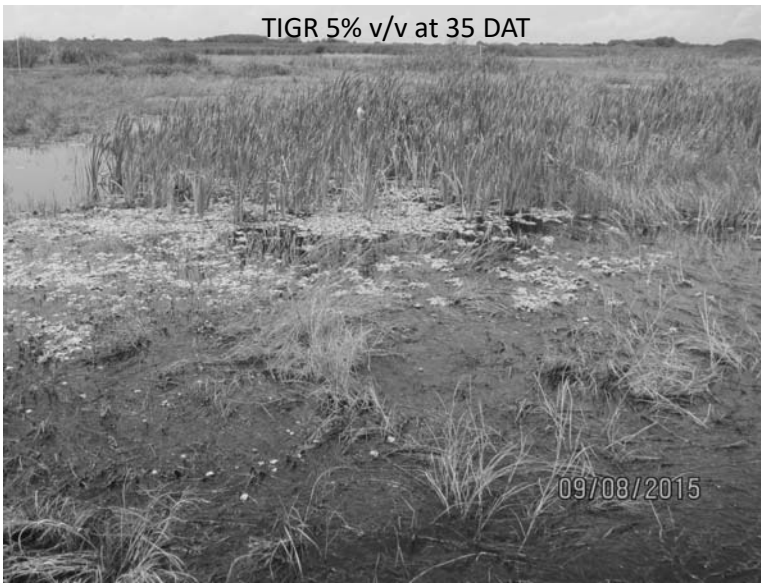


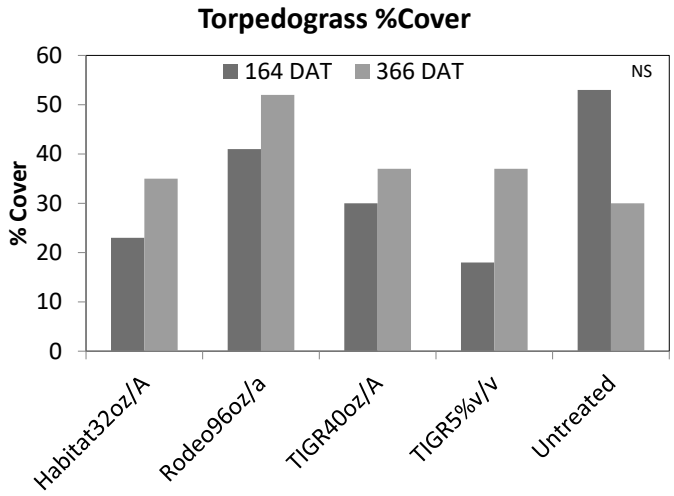


Lakeside Ranch STA, Okeechobee, FL

- 0.5 Acre plots, 18 inch water depth
- Airboat application at 50 GPA
- Applied August 4-5, 2015







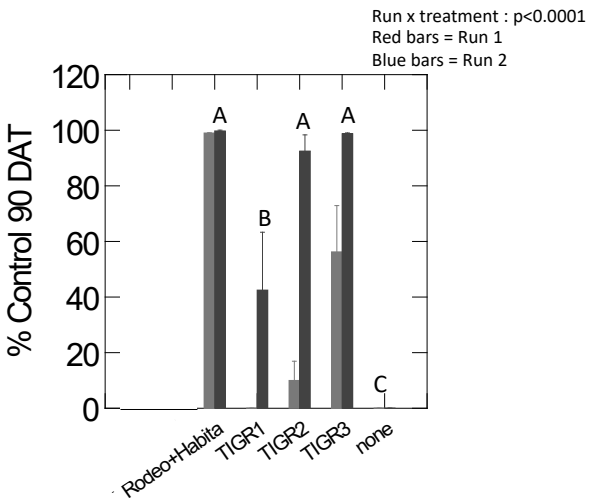
Billy Don Grant (BDG) parcel Bonita Springs, FL

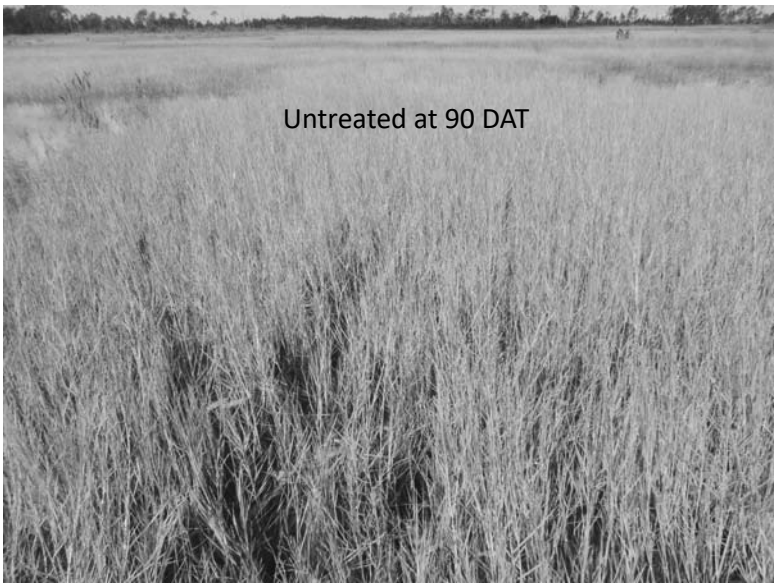
Daina Stoutenberg, North Star Construction

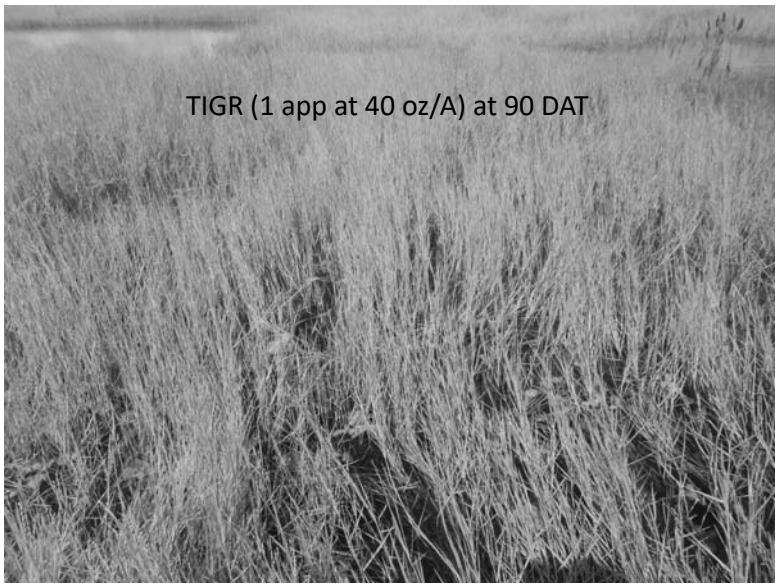
	Run 1 app dates		4/27	5/12	5/27
	Run 2 app dates		5/27	6/9	6/24
TRT#	AI	Product	Application Rate (fl oz/A)		
1	Sethoxydim	TIGR	40	.	.
2	Sethoxydim	TIGR	40	40	.
3	Sethoxydim	TIGR	40	40	40
4	Glyphosate + Imazapyr	Rodeo + Habitat	96 +32	.	.
5	Untreated	none	.	.	.

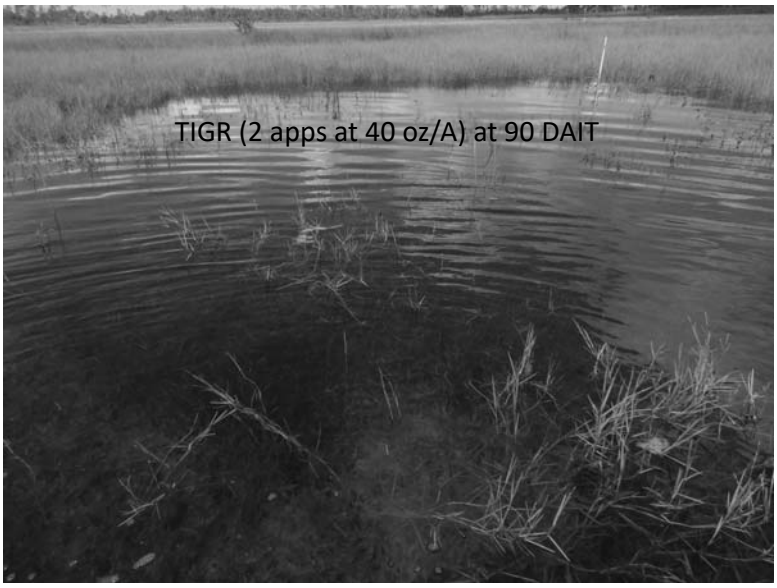
MSO (32 oz/A) added to each treatment

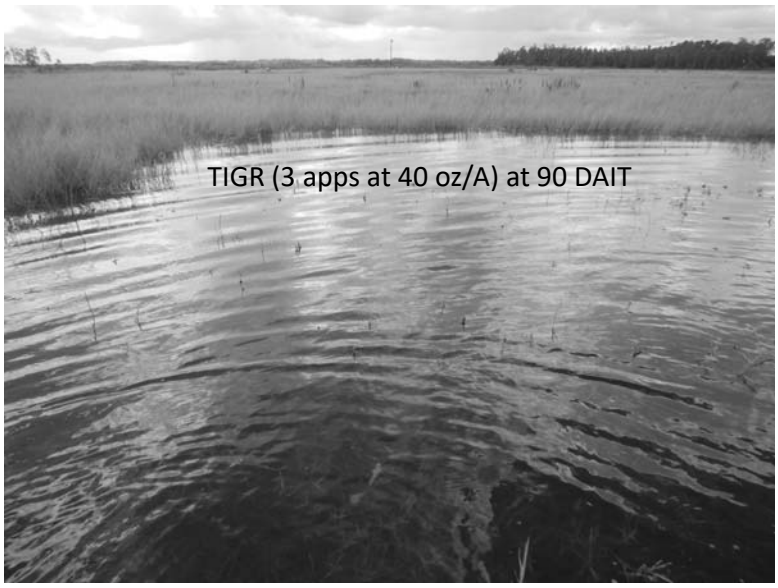
April 29, 2016

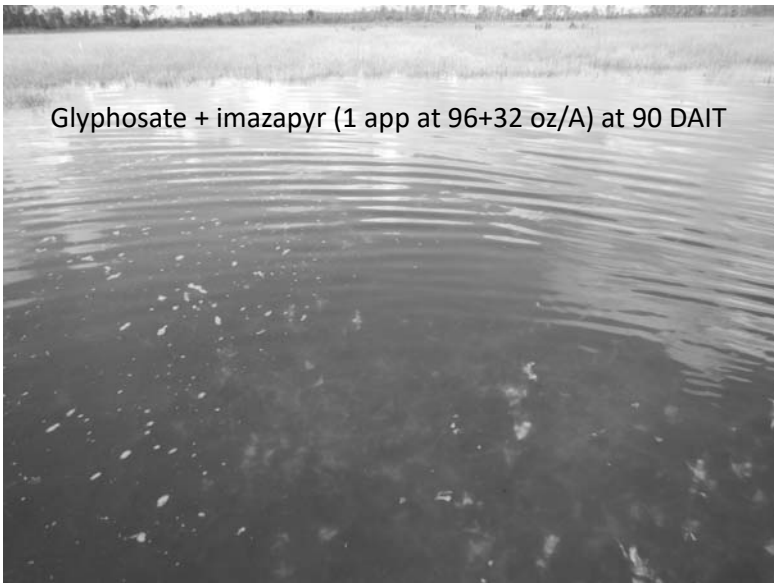

Run x treatment : p<0.0001
Red bars = Run 1
Blue bars = Run 2
% Control 90 DAT
120
100
80
60
40
20
0
A
B
A
A
C
Rodeo+Habita
TIGR1
TIGR2
TIGR3
none


Untreated at 90 DAT

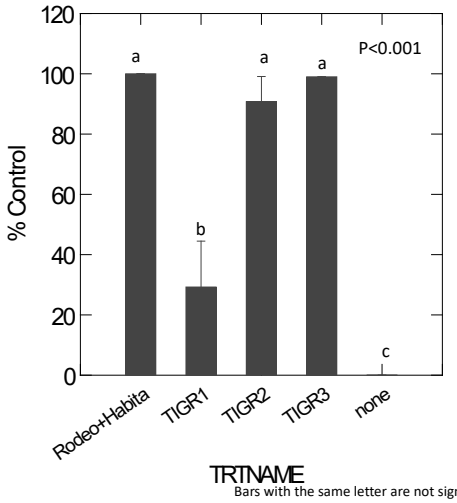

TIGR (1 app at 40 oz/A) at 90 DAT


TIGR (2 apps at 40 oz/A) at 90 DAIT


TIGR (3 apps at 40 oz/A) at 90 DAIT

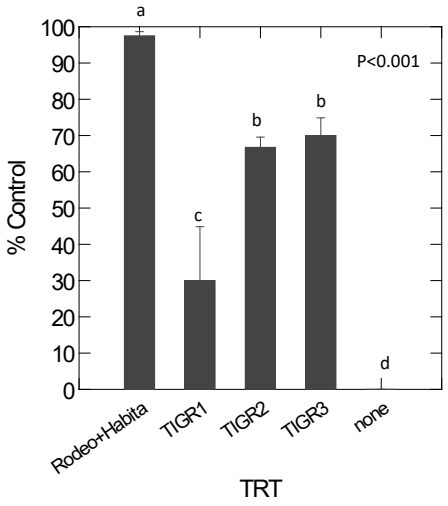

Glyphosate + imazapyr (1 app at 96+32 oz/A) at 90 DAIT

180 DAIT

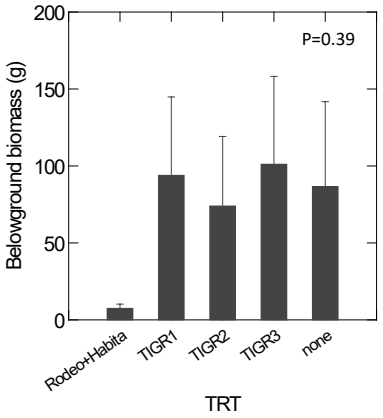


Bars with the same letter are not significantly different at p=0.05

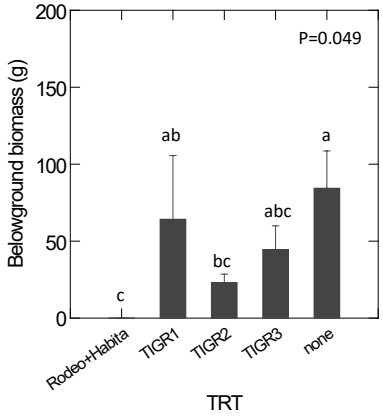
360 DAIT



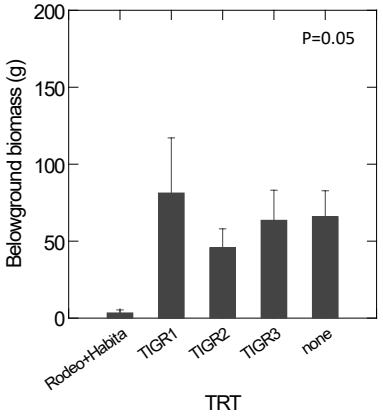
Belowground biomass 90 DAIT



Belowground biomass 180 DAIT



Belowground biomass 360 DAIT



Summary

- Sethoxydim mid-spring sequential timings not as effective as late-spring sequential timings
- Single applications of sethoxydim resulted in insufficient control
- Repeated applications much more promising
- Rhizome impact with sethoxydim is not as pronounced as glyphosate + imazapyr, but there appears to be some negative impact

Many thanks to US Army Engineering Research & Development Center and South Florida Water Management District for funding this project

Contract # W912HZ-16-2-0002

Key features in determining the weeds from the natives

Gregg Walker
Invasive Plant Biologist
September 28, 2017

FLORIDA Natural Areas INVENTORY

Introduction

- *Land managers and contractors*
- *Active exotics removal in Florida and at same time high number of native/rare species that are very similar to exotics*
- *Avoiding non-target damage to our natives is KEY*
- *This presentation is a series of species comparisons to help us avoid non-target damage*

Information Sources:
- *Florida Natural Areas*
- *ISB Atlas of Florida Plants*
- *UF/IFAS Center for Invasive Plants*

EXOTIC	NATIVE

Don't let "mistaken identity" happen in your invasives control projects !!!

TREES AND SHRUBS

CHINESE TALLOW *Triadica sebifera*	CORALBEAN *Erythrina herbacea*

CHINESE TALLOW *Triadica sebifera*	CORALBEAN *Erythrina herbacea*

- Tree, unarmed
- Simple leaf
- Small yellow flowers
- Milky sap
- Capsule with white seeds

- Small shrub, armed
- Compound leaf
- Red tubular flower
- No milky sap
- Legume (bean pod) with red seeds

CORAL ARDISIA
Ardisia crenata

WILD COFFEE
Psychotria nervosa

CORAL ARDISIA
Ardisia crenata

- Alternate leaves
- Revolute, crenate leaf margin
- Leaf veins not prominent

WILD COFFEE
Psychotria nervosa

- Opposite leaves
- Slightly revolute, entire to wavy leaf margin
- Leaf veins prominent

CHINESE PRIVET
Ligustrum sinense

GODFREY'S SWAMPPRIVET
Forestiera godfreyi

CHINESE PRIVET
Ligustrum sinense

- Terminal flower clusters
- Evergreen leaves
- Leaf margins entire

- Short petiole
- Underside of leaves with hairs along the midvein

GODFREY'S SWAMPPRIVET
Forestiera godfreyi

- Axillary flower clusters
- Deciduous leaves
- Leaf margins toothed above the middle
- Longer petiole
- Underside of leaves uniformly hairy

CHINESE PRIVET
Ligustrum sinense

WALTER'S VIBURNUM
Viburnum obovatum

CHINESE PRIVET
Ligustrum sinense

- Four petals/flower
- Leaf margin entire
- No short shoots
- Young stems hairy

WALTER'S VIBURNUM
Viburnum obovatum

- Five petals/flower
- Leaf margin entire or serrate
- Short shoots
- Young stems and leaves with rusty scales

HEAVENLY BAMBOO
Nandina domestica

DEVIL'S WALKINGSTICK
Aralia spinosa

HEAVENLY BAMBOO
Nandina domestica

DEVIL'S WALKINGSTICK
Aralia spinosa

HEAVENLY BAMBOO
Nandina domestica

- Leaflet margin entire
- Stem and leaves unarmed
- Red berry

DEVIL'S WALKINGSTICK
Aralia spinosa

- Leaflet margin serrate
- Stem and leaves armed with prickles
- Purple/black drupe

DEVIL'S WALKINGSTICK
Aralia spinosa

HEAVENLY BAMBOO
Nandina domestica

SILVERTHORN
Elaeagnus pungens

GUM BULLY
Sideroxylon lanuginosum

SILVERTHORN
Elaeagnus pungens

- Twigs and underside of leaf with silvery and rusty scales
- Fruit a large berry covered with scales
- No milky sap

GUM BULLY
Sideroxylon lanuginosum

- Twigs and underside of leaf with soft hairs
- Fruit a black berry
- Milky sap

CAMPHOR TREE
Cinnamomum camphora

SWAMP BAY
Persea palustris

CAMPHOR TREE
Cinnamomum camphora

- Crushed leaves have a strong camphor smell
- Glaucous leaf underside
- Three veins at leaf base
- Fruit with a cupule

SWAMP BAY
Persea palustris

- Crushed leaves have a bay leaf smell
- Pubescent leaf underside
- One vein at leaf base
- Fruit lacking a cupule

WHITE MULBERRY
Morus alba

RED MULBERRY
Morus rubra

WHITE MULBERRY
Morus alba

- Upper surface of leaf glabrous
- Lower surface of leaf with glabrous or with hairs on veins
- Leaf apices abruptly acuminate

RED MULBERRY
Morus rubra

- Upper surface of leaf scabrous (with short hairs)
- Lower surface of leaf uniformly covered with soft hairs
- Leaf apices conspicuously acuminate

WHITE MULBERRY
Morus alba

RED MULBERRY
Morus rubra

PAPER MULBERRY
Broussonetia papyrifera

RED MULBERRY
Morus rubra

PAPER MULBERRY
Broussonetia papyrifera

- Clonal
- Small twigs pubescent
- Petioles often longer, up to the length of the leaf

RED MULBERRY
Morus rubra

- Solitary
- Small twigs glabrous or with only a few hairs
- Petioles 2 to 2.5 cm long

FERNS

SWORD FERN
Nephrolepis cordifolia

WILD BOSTON FERN
Nephrolepis exaltata

SWORD FERN
Nephrolepis cordifolia

- Roots often with tubers
- Scales on rachis two colors
- Pinnae (leaflets) blunt-tipped

WILD BOSTON FERN
Nephrolepis exaltata

- Roots lacking tubers
- Scales on rachis one color
- Pinnae more pointed at apex

SWORD FERN
Nephrolepis cordifolia

WILD BOSTON FERN
Nephrolepis exaltata

GRASSES

COGON GRASS
Imperata cylindrica

BROOMSEDGE BLUESTEM
Andropogon virginicus

COGON GRASS
Imperata cylindrica

- Rhizomatous
- Midvein of leaf white and often offset
- Leaves originate near base

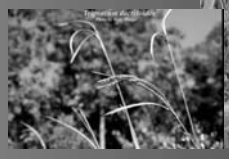
BROOMSEDGE BLUESTEM
Andropogon virginicus

- Clumping
- Midvein of leaf usually centered
- Leaves originate near base or on stem

COGON GRASS
Imperata cylindrica

BROOMSEDGE BLUESTEM
Andropogon virginicus

COGON GRASS
Imperata cylindrica



FAKAHATCHEEGRASS
Tripsacum dactyloides

COGON GRASS
Imperata cylindrica

- Rhizomatous
- Midvein of leaf white and often offset
- Leaves originate from base

FAKAHATCHEEGRASS
Tripsacum dactyloides

- Rhizomatous, sod-forming
- Prominent midvein usually centered
- Leaves can originate from stem

TORPEDO GRASS
Panicum repens

MAIDENCANE
Panicum hemitomon

TORPEDO GRASS
Panicum repens

- Plants shorter (20-90 cm tall), leaves narrower
- Rhizomes sharp-pointed
- Inflorescence broader
- Blueish appearance

MAIDENCANE
Panicum hemitomon

- Plants taller (50-200 cm tall), leaves broader
- Rhizomes not sharp
- Inflorescence narrow (to 1 cm wide)
- Green appearance

WEST INDIAN MARSH GRASS
Hymenachne amplexicaulis

MAIDENCANE
Panicum hemitomon

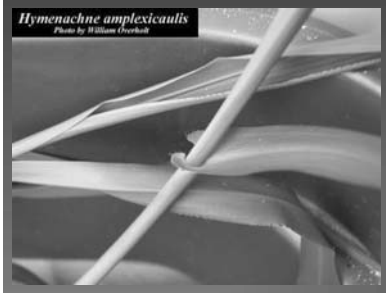
WEST INDIAN MARSH GRASS
Hymenachne amplexicaulis

- Internodes with solid white pith
- Base of leaf blade clasping
- Ligules 1-2.5 mm long

MAIDENCANE
Panicum hemitomon

- Internodes without solid white pith
- Base of leaf cordate
- Ligules <1 mm long

WEST INDIAN MARSH GRASS
Hymenachne amplexicaulis



MAIDENCANE
Panicum hemitomon

WEST INDIAN MARSH GRASS
Hymenachne amplexicaulis

AMERICAN CUPSCALE
Sacciolepis striata

WEST INDIAN MARSH GRASS
Hymenachne amplexicaulis

- Internodes with solid white pith
- Base of leaf blade clasping
- Ligules 1-2.5 mm long

AMERICAN CUPSCALE
Sacciolepis striata

- Internodes without solid white pith
- Base of leaf cordate
- Ligules <1 mm long

GOLDEN BAMBOO
Phyllostachys aurea

SWITCHCANE
Arundinaria gigantea

GOLDEN BAMBOO
Phyllostachys aurea

- Stem flattened or grooved on one side just above the node
- Swollen band just below node

SWITCHCANE
Arundinaria gigantea

- Stem round
- Node may be swollen, but lacking a swollen band just below the node

VINES

CHINESE WISTERIA
Wisteria sinensis

AMERICAN WISTERIA
Wisteria frutescens

CHINESE WISTERIA
Wisteria sinensis

- Leaves longer (to 40 cm); 7-13 leaflets
- Flowers just before or as leaves are emerging
- Inflorescence longer (up to 40 cm long)

AMERICAN WISTERIA
Wisteria frutescens

- Leaves shorter (to 30 cm); 9-15 leaflets
- Flowers after leaves have appeared
- Inflorescence shorter (up to 25 cm long)

CHINESE WISTERIA
Wisteria sinensis

AMERICAN WISTERIA
Wisteria frutescens

AIR-POTATO
Dioscorea bulbifera

FLORIDA YAM
Dioscorea floridana

AIR-POTATO
Dioscorea bulbifera

- Stems have aerial tubers
- Leaves larger
- Secondary veins often prominent

FLORIDA YAM
Dioscorea floridana

- Stems lacking tubers
- Leaves smaller
- Secondary veins less prominent

JAPANESE HONEYSUCKLE
Lonicera japonica

TRUMPET HONEYSUCKLE
Lonicera sempervirens

JAPANESE HONEYSUCKLE
Lonicera japonica

- Leaves pubescent or glabrous, but not glaucous
- Leaf apex acute to slightly acuminate
- Flowers white to creamy yellow

TRUMPET HONEYSUCKLE
Lonicera sempervirens

- Leaves with a glaucous underside
- Leaf apex rounded
- Flowers red

JAPANESE HONEYSUCKLE
Lonicera japonica

TRUMPET HONEYSUCKLE
Lonicera sempervirens

BEACH VITEX
Vitex rotundifolia

- Opposite leaves
- Woody growth
- Panicles of smaller blue flowers

RAILROAD VINE
Ipomoea pes-caprae ssp. *brasiliensis*

- Alternate leaves
- Herbaceous
- Solitary, “morning glory” flowers

BEACH VITEX
Vitex rotundifolia

RAILROAD VINE
Ipomoea pes-caprae ssp. *brasiliensis*

BEACH VITEX
Vitex rotundifolia

RAILROAD VINE
Ipomoea pes-caprae ssp. *brasiliensis*

THANK YOU!!

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FLORIDA Natural Areas INVENTORY

Exotic Tree-Killing Insects: Current and Future

Jeff Eickwort, Entomologist & Supervisor
Forest Health Section
Florida Forest Service

Quick Overview– Laurel Wilt Disease

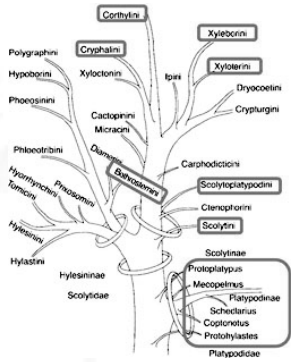
- Lethal disease of redbay, avocado, and several other tree species in the family Lauraceae
- Caused by an exotic fungus (*Raffaelea lauricola*)
- Carried by the redbay ambrosia beetle (*Xyleborus glabratus*)
- Kills host trees within 2-3 weeks, spreads through stand over 2-3 years.

The History

- 2002 – Previously undetected ambrosia beetle species caught in Early Detection Rapid Response (EDRR) traps near Port Wentworth, Georgia
  - Identified as an Asian species, *Xyleborus glabratus* Eichhoff.
  - Assigned a "low risk" rating (ambrosia beetles = not usually a problem).

Backing up - What is an ambrosia beetle?

- In weevil family (Curculionidae), closely related to bark beetles
- Very diverse, ~3,000 species in Scolytinae and Platypodinae
- Defined more by behavior than taxonomy
- **Fungus farmers!**

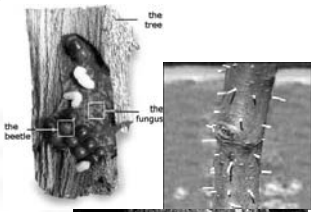


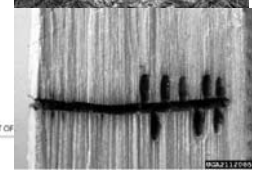
Ambrosia beetles, cont'd.

By definition:

- Don't eat the tree.
- Carry fungi with them, often in specialized structures (mycangia).
- Burrow into the wood of the tree, create tunnels ("galleries").
- Inoculate tree with fungus, which infects the wood.
- Eat fungus that grows on the walls of the galleries.

Not usually killers of healthy trees.





The redbay ambrosia beetle (*Xyleborus glabratus*)

A.E. Mayfield

Haplodiploid mating scheme = "Extreme inbreeders"

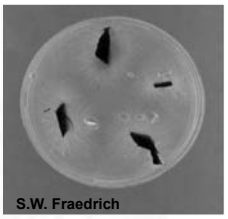
- **Females fly & infest new trees**
- **Lay eggs**
- **Unfertilized eggs with ½ the chromosomes (haploid) = males (flightless).**
- **Fertilized eggs = females**
- **Females mate with males, emerge to infest new trees**

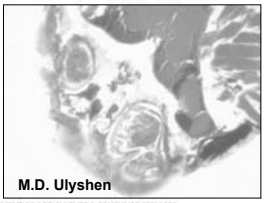
Very easy to start new populations!

Laurel Wilt pathogen (*Raffaelea lauricola*)

- Previously undescribed species
- Transmitted to host during attack of female RAB on stems, branches
  - Spores carried in mandibular mycangia
- Causes tree to disrupt vascular system, halt movement of water & nutrients.

S.W. Fraedrich et al. 2008. Plant Disease 92:215-224





Primary host:

Redbay (*Persea borbonia*)

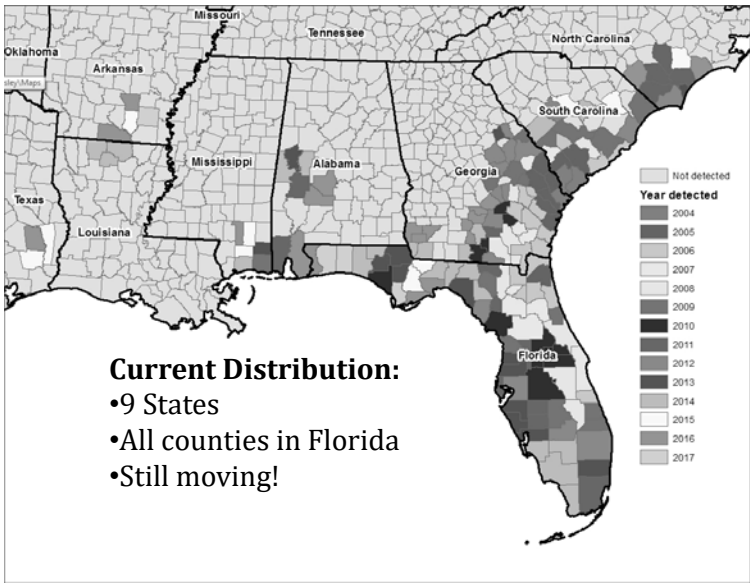
"*sensu lato*"

Family: Lauraceae

- Aromatic, broadleaved, evergreen of SE coastal plain
- Other closely-related "bay" species or varieties (swamp bay, silk bay)
- Wide habitat variety
- Cultural value: culinary, cabinetry, woodturning
- Fruits utilized by variety of wildlife
- *Persea* bays are only host of Palamedes swallowtail butterfly larvae

Known and potential hosts: Florida trees in the Lauraceae

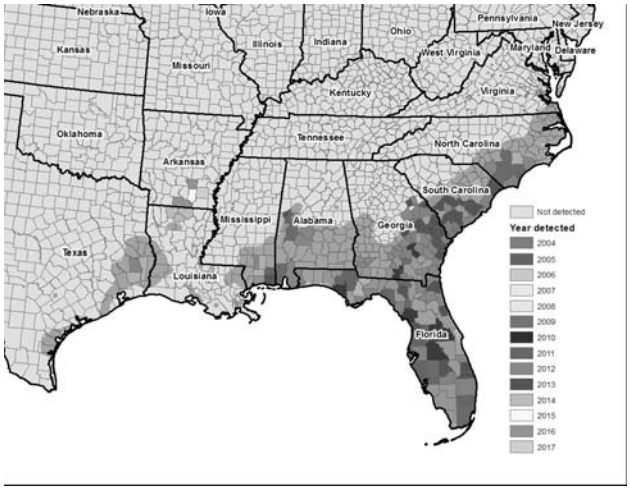
- Redbay
  - *Persea borbonia*
- Swamp bay
  - *Persea palustris*
- Silk bay
  - *Persea humilis*
- Avocado
  - *Persea americana*
- Sassafras
  - *Sassafras albidum*
- Pondspice
  - *Litsea aestivalis*
- Northern Spicebush
  - *Lindera benzoin*
- S. Spicebush (pondberry)
  - *Lindera melissifolia*
- Lancewood
  - *Ocotea coriacea*
- Love vine, Devil's gut
  - *Cassytha filiformis*
- Pepperleaf sweetwood
  - *Licaria triandra*
- Camphor tree
  - *Cinnamomum camphora*



Current Distribution:

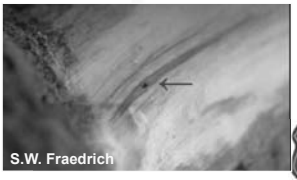
- 9 States
- All counties in Florida
- Still moving!

Range of redbay (*Persea borbonia* L.)



Laurel Wilt: Symptoms

- Initial beetle hits:
  - Happen on healthy trees
  - Cryptic, difficult to find
  - May not be successful breeding attempts, but serve to inoculate the host
- Initial sign of infection:
  - drooping and discoloration of leaves

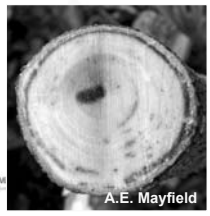


Laurel Wilt: Symptoms

September 2005 → Same tree, May 2006

Eventually crown wilts with a reddish to purplish brown discoloration. Dead leaves tend to remain a year or more.

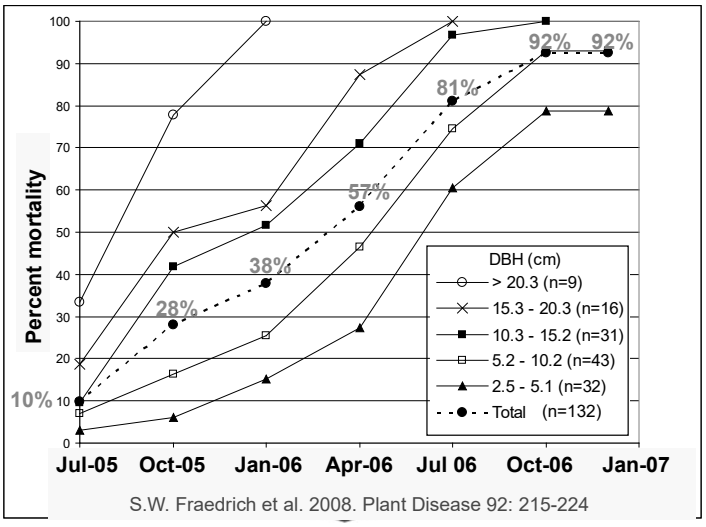
Symptoms: dark discoloration in sapwood



Symptoms

- Sawdust tubes: result of attacks by
  - *X. glabratus*
  - other ambrosia beetles
- Occurs after tree wilts & dies
- Female *X. glabratus* emerge to attack and infect new hosts

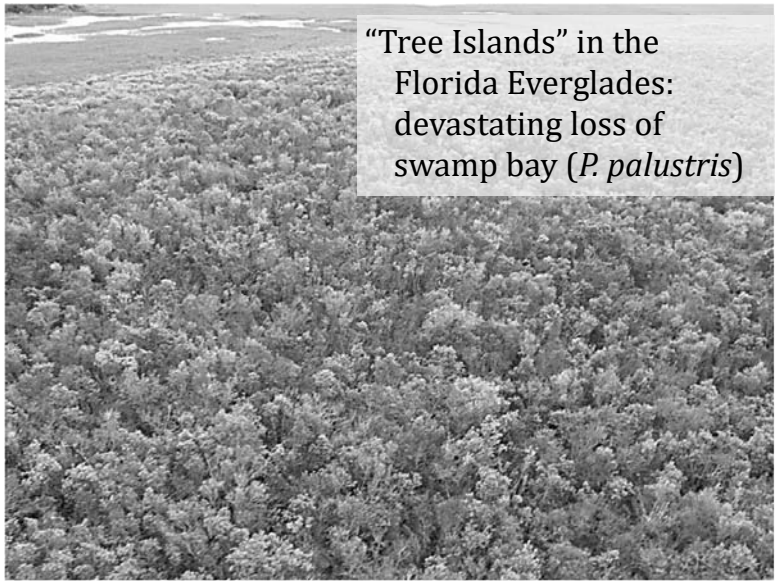
Redbay mortality curve at Ft. George Island, FL



S.W. Fraedrich et al. 2008. Plant Disease 92: 215-224

Impact

- Nearly all mature redbays dead in areas affected 3-5 yrs
- Redbay seedlings, sprouts <1" diameter are still abundant
- Shade trees in residential neighborhoods parks = costly removals



"Tree Islands" in the Florida Everglades: devastating loss of swamp bay (*P. palustris*)

Heads Up: Laurel Wilt in Sassafras

- Previously thought to be a less-suitable host.
- Many recent detections now in sassafras, with no redbay nearby.
- After infection: leaves wilt, then drop off.
- Spreads through shared root systems.

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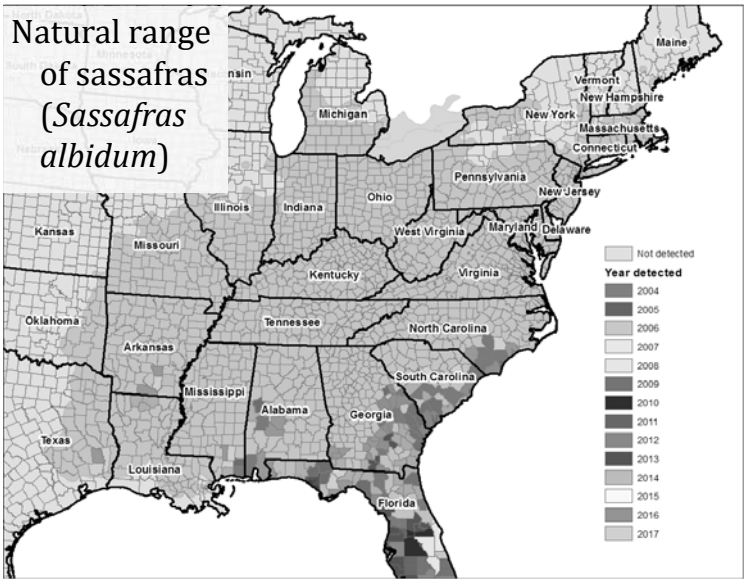

Avocado Monitoring
at Ft. George Island 2006-2007

- Where laurel wilt was first found in Florida
- 16 avocados planted Jul-Oct 2006
  - Cvs: 4 'Day', 12 'Donnie'
  - 2-6 cm base diameter
- RAB and *Raffaelea* sp. recovered from 2 dying 'Donnie' plants

Laurel Wilt in Avocado, Jacksonville, FL (Sept. 2007)

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Symptoms in avocado

- Staining in wood
- Death of major branches, progression may be more gradual
- Leaves wilt, then fall off (unlike with redbay)
- Sprouting from lower stem as disease progresses
- Not always immediately fatal.

From Ploetz et al.
Plant Pathology (2012) 61, 801–808

What to do with a dead tree?

- Burn or bury on site when possible.
- Chip and leave on site
- Don't carry it to un-infested areas!

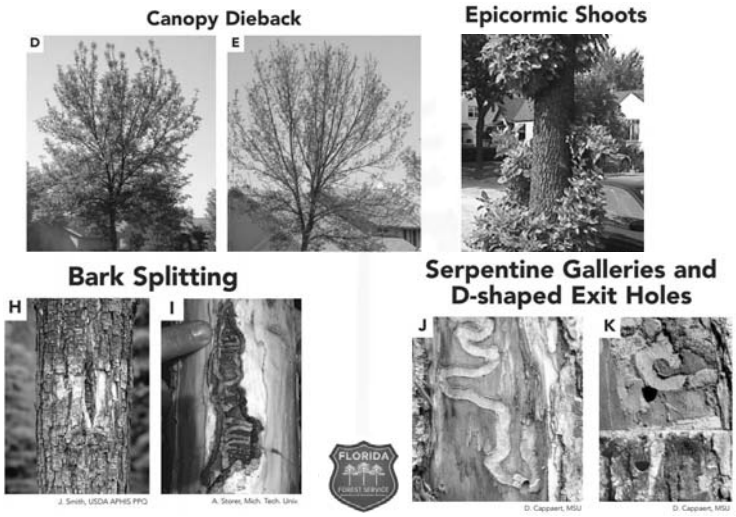
Any Good News?

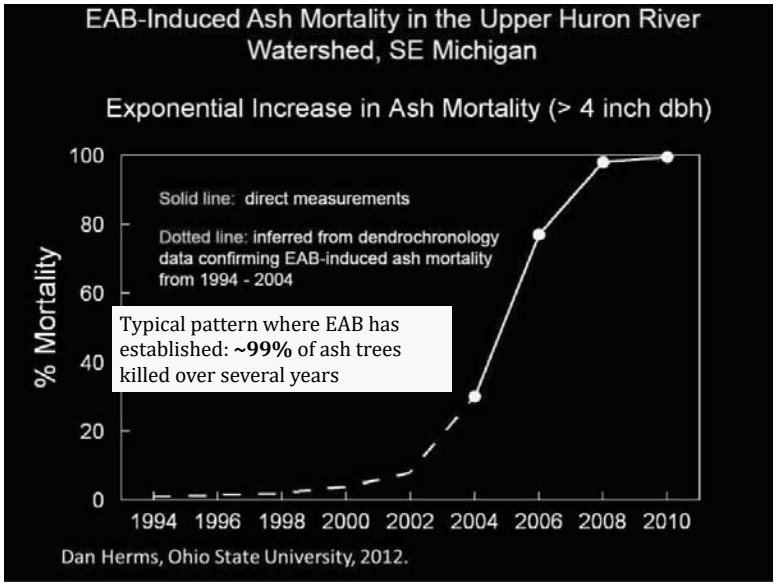
- Fungicide injection treatment still the best method of preventing laurel wilt.
- Marc Hughes/Jason Smith (UF-SFRC): Redbay "resistance" screening has had some success!

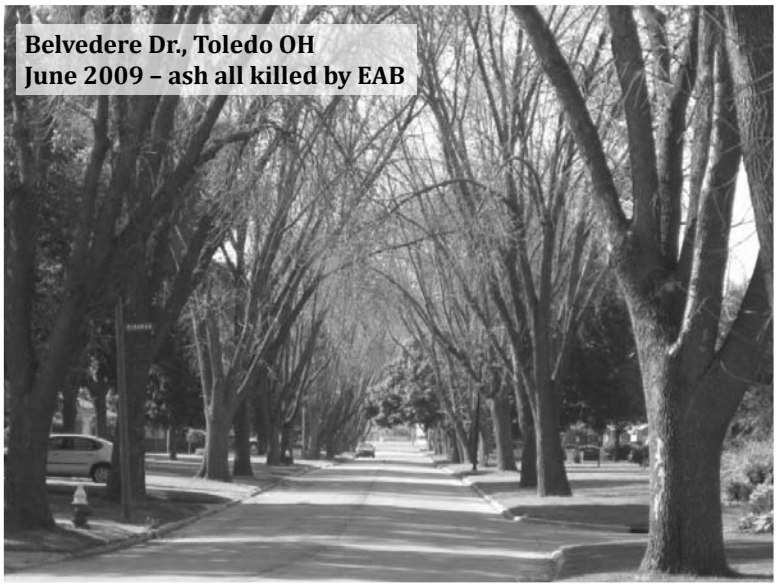
COMING SOON: Emerald Ash Borer (*Agrilus planipennis*)

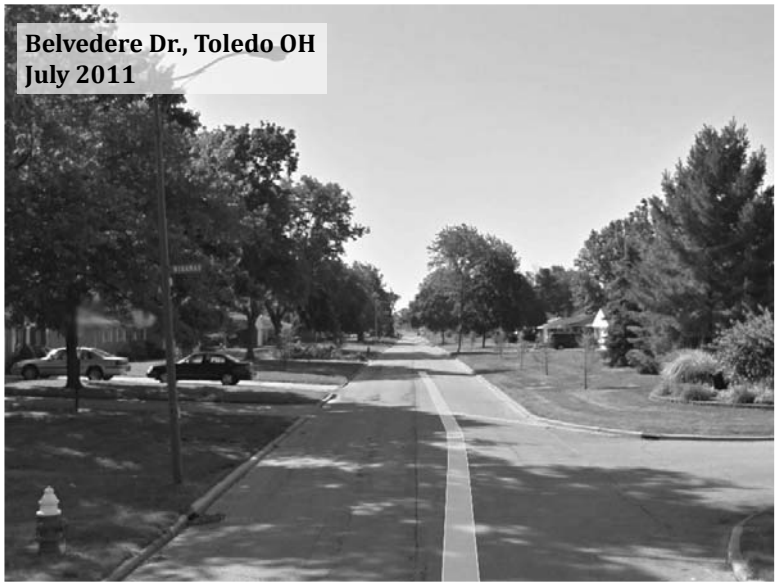
- Native to Asia, E. Russia
- Originally detected in SE Michigan/SW Ontario, 2002
- Aggressively attacks and kills North American ash (*Fraxinus*) species

EAB – signs and symptoms









- Ash trees in forests also killed.
- Major component of northern hardwood forests.
- In FL: ash locally common around wetlands, rivers, hardwood forests with moist/rich soils.

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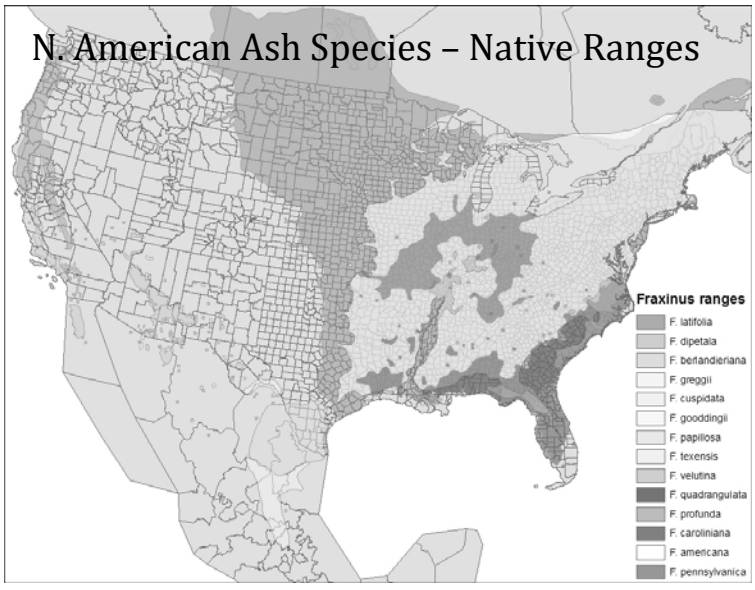
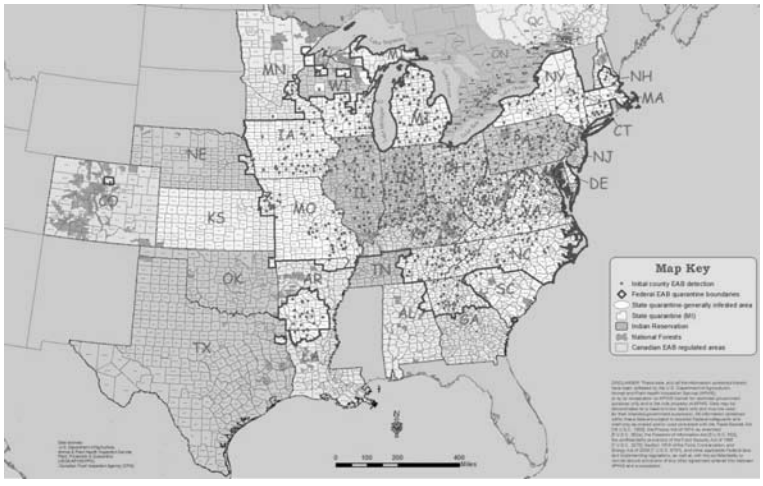
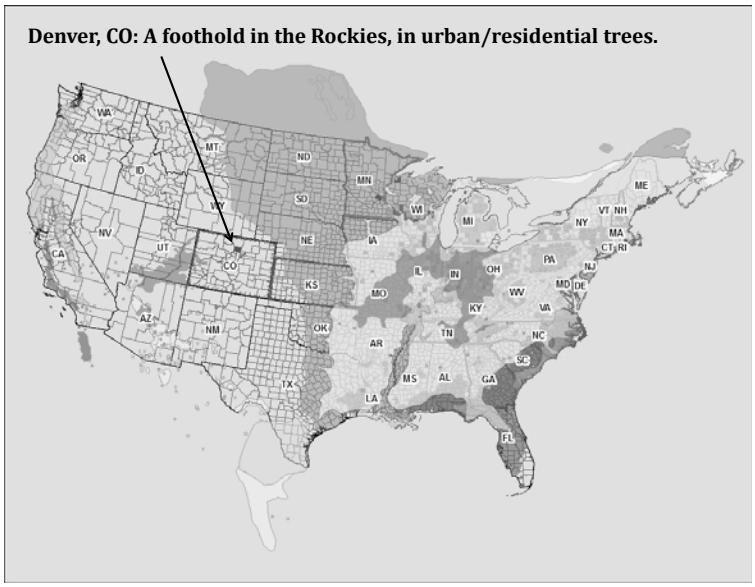


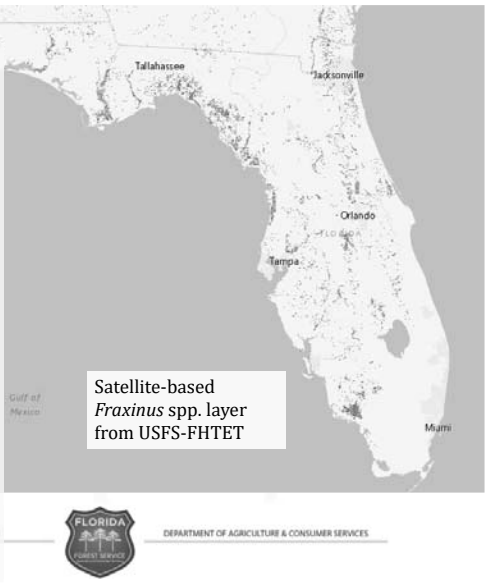
EAB: Current Known Distribution





The "good" news for Florida:

- Ash is a minor component of FL forests, not managed for timber.
- Not common as street trees, compared to other states.
- South FL winters may not be cool enough (?) to complete development



FLORIDA FOREST SERVICE — DEPARTMENT OF AGRICULTURE & CONSUMER SERVICES

Options for street trees:

- **Do nothing.**
  - **Remove street trees as they die.**
- **Proactively remove live ash & replant other species**
- **Protection/treatment**
  - **Soil injection/drench**
  - **Stem injection**
  - **Systemic bark spray**
  - **Bark/foliage surface sprays**
- **Advance planning needed!**

Six Rivers Cooperative Invasive Species Management Area (CISMA)

Partner Representation - 14 agencies and organizations in 5 Florida counties, 3 Alabama Counties

Functions

- **Prevention** – Review EDDMapS data, review watch species, create early detection reports, address regulatory guidelines, assist CISMA in defining focus species
- **Education** – Coordinate outreach, training, and events; create materials, identify private landowners for education
- **Monitoring/Mapping** – Record invasive species from field observations into CISMA EDDMapS quarterly
- **Funding** – Maintain a list of funding opportunities/cost-share programs which can serve partners, public and private landowners, research fundraisers for work days
- **Control** – Develop list of known invasive species, document acres treated/maintained on public lands, coordinate 2 work days per year

Upcoming Events

- **HalloWeed 2017: October 28 – November 5**
- **EDDMapS Training**

Six Rivers
Cooperative Invasive Species Management Area

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UF IFAS Extension UNIVERSITY of FLORIDA

SS-AGR-260

Herbicide Application Techniques for Woody Plant Control[1]

Jason Ferrell, Stephen Enloe, and Brent Sellers[2]

The encroachment of trees and other woody plants into pastures, fencerows, ditch banks, rights-of-way, and other areas is a common occurrence. These woody species can be particularly troublesome and require control since they will compromise fence integrity, vehicle safety, impede canal drainage, interfere with transmission of electricity. Additionally, some species (such as cherry trees) are highly poisonous to livestock. The aim of this publication is to detail the techniques for the removal of woody plants. For information on controlling similar species in natural areas or in forestry settings, consult UF/IFAS publications SP242, *Integrated Management of Nonnative Plants in Natural Areas of Florida* (http://edis.ifas.ufl.edu/wg209) and Circular 1477, *Primer on Chemical Vegetation Management in Florida Pine Plantations* (http://edis.ifas.ufl.edu/fr160).

Control of woody perennials can be difficult, but several control techniques are available. Mowing is a commonly used control procedure for small brush because the equipment is readily available and the results are immediate. However, this method generally provides only short-term success because it leaves live stumps and root-stocks that re-sprout. Mowing some species, like Chinese tallow, worsens the situation by replacing a single stemmed plant with a stump with multiple re-sprout stems. Another strategy that can reduce some troublesome species is fire. However, fire can be tricky to manage, and it is difficult to generate a fire with sufficient heat capacity to kill most hardwood species along fencerows, ditch banks, and other sites with low plant density.

Herbicides are often the most effective and inexpensive means of controlling woody plants. There are several application techniques that can be used to control trees and brush of various sizes. Not all brush species are equally susceptible to herbicides. Therefore, results may vary for any of these application methods, relative to brush size and species. Each application technique will be subsequently discussed.

Foliar Application

Foliar application directs an herbicide/water mixture directly onto the leaves of a plant (Figure 1). This technique can be highly effective on smaller species (6 to 8 feet in height). Auxin-type herbicides (such as triclopyr) are generally most effective early in the season, while enzyme-inhibiting herbicides (imazapyr and others) are most effective in the late summer or fall. Glyphosate is most effective in late summer or fall, prior to change in leaf color for deciduous species.

1. This document is SS-AGR-260, one of a series of the Agronomy Department, UF/IFAS Extension. Original publication date January 2006. Revised December 2015. Visit the EDIS website at http://edis.ifas.ufl.edu.

2. Jason Ferrell, professor; Stephen Enloe, associate professor, Agronomy Department; and Brent Sellers, associate professor, Agronomy Department, Range Cattle Research and Eduation Center; UF/IFAS Extension, Gainesville, FL 32611.

Figure 1. Foliar application with a backpack sprayer.
Credits: Stephen Enloe, UF/IFAS

Adequate control with foliar applications can be difficult to accomplish. This is because complete coverage of all foliage is essential for control, but over-application (which leads to spray runoff) will reduce effectiveness. Therefore, foliar applications commonly require multiple follow-up treatments before control is accomplished. It is important to control spray drift when making foliar applications. Certain desirable hardwood and crop species are highly sensitive to spray drift and can be inadvertently damaged. It is also advisable to include a tracer dye with the spray solution to ensure that some plants are not sprayed twice while others are missed entirely.

What about mowing before treatment? Mowing decreases foliage while maintaining a large root mass, making control even more difficult. If plants have been mowed, it is important to allow them to regrow to a height of 3 or 4 feet before herbicide application.

Basal Application

Basal application combines the herbicide with an oil penetrant and applies the mixture directly to the bark of a standing tree. For trees that are less than 6-inches in diameter and have smooth bark, this method is frequently successful. However, it is important that the lower 12 to 18 inches of the stem be treated on all sides with the herbicide/oil mixture (Figure 2). Adequate coverage is essential, since treating only one side of the stem will result in controlling only half of the tree. Basal applications can be made any time of the year, but control may be reduced when trees are flushing new growth in the spring. Winter is often the easiest time to do basal treatments as temperatures are cooler and many tress and surrounding herbaceous plants are dormant.

Basal applications will not provide rapid control. Herbicide injury is often not observed for several weeks after treatment, and complete control may require several months. Additionally, basal treatment is not effective on older trees greater than six inches in diameter or trees with very thick bark. For these situations, other application techniques should be employed.

Figure 2. Basal bark application with herbicide/oil mixture.
Credits: Stephen Enloe, UF/IFAS

Hack and Squirt

The hack-and-squirt technique is ideal for control of large trees that cannot be managed with basal applications. This method requires that you use a machete or hatchet to cut through the thick bark and into the sapwood. The hacks should be made at a downward angle of approximately 45 degrees. This will create a "cup" to hold the herbicide solution. If the hack does not hold herbicide solution, the treatment will not be effective. Most labels specify 0.5 to 1.0 ml of solution per hack. This is important to note, as small spray bottles commonly sold in garden supply stores may apply as much as 3.5 ml per stroke. This makes accurate application very difficult, but the most important aspect is not to overfill the hack. The recommended spacing of hacks around the circumference of the tree is specified on the herbicide label and may be described as slightly overlapping, continuous, or evenly spaced. (Figure 3) The addition of a basal oil is not recommended for this procedure.

This method of application is advantageous because it is highly selective and injury to surrounding species is not common. It can also be done at any time during the year,

but effective treatment of some species in the spring can be reduced because of heavy sap flow pushing the herbicide from the cut surfaces. Finally, the hack and squirt method should only be used where dead standing trees are acceptable from an aesthetic and safety standpoint. Therefore, it is not recommended along roadsides or in parks where hazard trees cannot be tolerated.

Figure 3. Hack-and-squirt application technique.
Credits: Stephen Enloe, UF/IFAS

Cut Stump

This technique is employed after cutting a tree to eliminate, or greatly reduce, resprouts from the stump or lateral roots. The herbicide should be applied to the cut surface as quickly as possible after the sawdust has been removed. If applied immediately, an herbicide/water solution is sufficient. If herbicide treatment is delayed and the cut surface has begun to dry, an herbicide/basal oil mixture must be used instead and applied to the top and around the collar of the stump.

For stumps greater than 3 inches in diameter, thoroughly wet the outer edge while avoiding herbicide runoff (Figure 4). This is because the only living tissue in larger trees is around the outer edge. Covering the entire cut surface will require more herbicide, most of which will provide little effect. For smaller stems it is appropriate to cover the entire cut surface (Figure 5). For this procedure, herbicides can be applied using a backpack sprayer, squirt bottle, or paint brush. Regardless of how the herbicide is applied, a tracer dye should be included to ensure treatment of all individual stumps.

Figure 4. Application of herbicide to larger cut stumps only requires treatment of the outer edge.
Credits: Stephen Enloe, UF/IFAS

Figure 5. Application of herbicide to smaller stumps requires complete coverage.
Credits: Stephen Enloe, UF/IFAS

Table 1. Recommended herbicides for each application procedure.

Herbicide	Application Rate	Comments
Foliar Application		
Imazapyr (Arsenal, others)	1–3%	Excellent control of sweetgum and maples. Use higher rates for oaks and cherry. A non-ionic surfactant is required.
Glyphosate (Several)	5–8%	Cover as much of the foliage as possible and spray until wet. If the brush has been cut, delay application for approximately 1 year. Retreatment is commonly required control.
triclopyr + 2,4-D (Crossbow)	1–1.5%	For control of various herbaceous and woody species. This product contains 2,4-D ester; precautions to manage drift must be employed. Repeat applications are often required.
Triclopyr ester (Remedy Ultra, others)	0.5–2%	Best when applied in late spring or early summer. If the brush has been cut, delay application for approximately 1 year. Thoroughly wet all leaves, but not to the point of runoff.
Triclopyr + fluroxypyr (Pasturegard HL)	2–4 qt/100 gal of spray	
Aminocyclopyrachlor Method 240 SL	8–16 oz/100 gal of spray	For best results, apply near the top of the tree and allow the spray to trickle down into the canopy. Full coverage of canopy is necessary, but do not allow runoff. Apply with 1% v/v methylated seed oil (MSO).
Aminopyralid Milestone	0.25–0.75% solution	For control of a wide variety of woody plants. For best results, mix with glypohosate (3-5%) and imazapyr (0.5%) or triclopyr at 1% plus a surfactant. Do not exceed 7 oz/A of Milestone.
Basal Bark		
Imazapyr (Stalker, others)	8–12 oz/gal	Best for trees less than 4 inches DBH (diameter at breast height). Be aware that imazapyr is highly active in the soil. If desirable plants are near to a treated individual, it is possible for the herbicide to wash off into the soil and injure or kill the desirable plant. Make sure to choose an imazapyr product that is soluble in basal oils.
Aminocyclopyrachlor Method 240 SL	10–20% solution	Best for trees less than 6 DBH. Spray until run-off at the ground line is noticeable. This herbicide significant soil activity, so be aware that desirable trees in the vicinity may be injured by these applications.
Triclopyr ester (Pathfinder)	100%	Pathfinder is a "ready to use" product that is formulated and dosed correctly for this type of application. Apply Pathfinder at 100% strength as directed.
Triclopyr ester (Remedy Ultra or others)	25% + 75% basal oil	Best for trees less than 6 inches DBH. Generally most effective 6 weeks prior to leaf expansion, until 2 months after. Most effective on trees with smooth bark. Thick bark trees may require retreatment. These herbicides have little or no soil activity.
Triclopyr + fluroxypyr (Pasturegard HL)	25% + 75% basal oil	
Hack-and-Squirt		
Imazapyr 4 lb/gal (Arsenal AC)	6 oz/gal	One hack per 3 inches DBH.
Triclopyr amine (Garlon 3A, others)	50–100%	One hack per 3 or 4 inches DBH. Apply 0.5 ml undiluted herbicides or 1 ml of 50% solution in water.
Hexazinone (Velpar)	100%	One hack per 4 inches DBH. Use undiluted herbicide.
Glyphosate (several)	50%	1 ml per 2 or 3 inches DBH, applied below the branches. For larger trees, best results are observed from applying glyphosate in a continuous frill around the stem.
Aminopyralid (Milestone)		Make a series of slightly overlapping hacks around the trunk. Apply 1 ml of the solution per hack.

Cut Stump		
Imazapyr (Arsenal AC or Stalker)	6 oz/gal (for Arsenal AC) or 8-16 oz/gal (for Stalker)	Apply to the top and side of a freshly cut stump. Garlon 3A is excellent for this use. If surface of stump has began to dry prior to herbicide treatment, apply Chopper or triclopyr ester product in basal oil or recut the stump and apply to the freshly cut surface. Garlon 3A will not effectively mix with basal oils.
Triclopyr amine (Garlon 3A)	50–100% in water	
Triclopyr ester (Remedy Ultra or others)	25% solution in water or basal oil	
Triclopyr + fluroxypyr (Pasturegard HL)	25% solution in water or basal oil	
Aminocyclopyrachlor Method 240 SL	5–10% solution in basal oil	Spray the stump surface and thoroughly wet the cambium layer all the way around.
Glyphosate (several)	50–100%	Apply to cut stumps immediately after cutting. Glyphosate is not effective on stumps that have started to dry after cutting. If immediate treatment is not possible, other herbicides should be selected since glyphosate will not mix with basal oils.
Aminopyralid (Milestone)	10%	Apply solution to cambium area around the entire circumference of the stump. Apply immediately after cutting.

UF IFAS Extension UNIVERSITY of FLORIDA

SS-AGR-108

Single-Nozzle Backpack or ATV Sprayer Calibration[1]

B. A. Sellers, J. A. Ferrell, G. E. MacDonald, and Dennis C. Odero[2]

Many growers have isolated patches of weeds that should be controlled to prevent their spread. In this case, spot spraying with a herbicide would be the most economically feasible approach. Some herbicide labels allow for spot-treatments. However, the recommended amount is often given in % volume of herbicide per volume of water, or a certain amount of herbicide per 1,000 square feet.

Before adding any herbicide to the spray tank, it is extremely important that the output of the sprayer is known. That is, it must be properly calibrated. This allows for reduced herbicide costs and optimum weed control. A simple calibration test for a single-nozzle backpack or ATV sprayer is shown in Table 1. No math is required for this calibration, and the end result is a known output volume for your sprayer in gallons per acre (GPA).

Hints for calibration:

- Keep speed constant. This will ensure that you are walking the same speed at all times.
- Keep the nozzle at the same height at all times—a height that is comfortable.
- Modify the wand by adding a pressure gauge. Try to keep the pressure as constant as possible. Do not let the pressure fall below 10 psi.

Next the amount of herbicide to be added to the spray tank needs to be calculated. To do this multiply the amount of herbicide needed for 1 gallon by the number of gallons in the spray tank.

Example: A sprayer is calibrated with an output of 40 GPA and the tank holds 10 gallons. If the desired herbicide rate is 1 quart per acre, from Table 2, the amount of herbicide for 1 gallon of water is 4.75 tsp. Since the spray tank holds 10 gallons, 40.75 (41) tsp are needed, which is approximately equal to 7 fl oz.

Useful Conversions:

1 teaspoon = 0.17 fl oz

1 tablespoon = 0.5 fl oz

3 teaspoons = 1 tablespoon

1 pint = 16 fl oz = 32 tablespoons = 2 cups

1. This document is SS-AGR-108, one of a series of the Agronomy Department, UF/IFAS Extension. Original publication date January 2006. Revised April 2016. Visit the EDIS website at http://edis.ifas.ufl.edu.

2. B. A. Sellers, assistant professor, Range Cattle Research and Education Center; J. A. Ferrell, assistant professor, Agronomy Department; G. E. MacDonald, associate professor, Agronomy Department; and Dennis C. Odero, Extension weed specialist and assistant professor, Agronomy Department, Everglades Research and Education Center; UF/IFAS Extension, Gainesville, FL 32611.

Use herbicides safely. Read and follow directions on the manufacturer's label.

Table 1. A no-math method for calibrating single-nozzle backpack or ATV wand sprayers for spot spraying herbicides.

Step 1	Measure a calibration plot that is exactly 18.5 feet by 18.5 feet.			
Step 2	Spray the calibration plot uniformly with water. Repeat 3 times and record the average number of seconds needed to spray the entire plot.	Time Required	____	Seconds
Step 3	Spray into a clean bucket for the amount of time recorded in Step 2.			
Step 4	Measure the number of ounces of water in the bucket.	Volume Sprayed	____	Ounces
Step 5	The number of ounces collected from the bucket is equal to the number of gallons per acre the sprayer is delivering.	Output Volume	____	Gallons/Acre
Step 6	Determine the volume of the spray tank.	Tank Volume	____	Gallons
Step 7	Determine the number of acres covered in one tank. Divide tank volume (gallons; Step 6) by output volume (gallons/acre; step 5).	Area covered per tank	____	Acres
Step 8	Determine the amount of herbicide to add to the tank from Table 2.	Herbicide/Acre	____	tsp, tbsp, mL, oz, cups

Table 2. Amount liquid herbicide to add to 1 gallon of water. Abbreviations: tsp=teaspoon, fl oz=fluid ounces.

Volume (GPA)	**Recommended Herbicide Rate per Acre**				
	1 pint	**1 quart**	**2 quarts**	**3 quarts**	**4 quarts**
20	5 tsp	10 tsp	3.25 fl oz	4.75 fl oz	6.33 fl oz
30	3 tsp	6 tsp	2 fl oz	3.25 fl oz	4.25 fl oz
40	2.33 tsp	4.75 tsp	1.66 fl oz	2.33 fl oz	3.25 fl oz
50	2 tsp	3.75 tsp	1.25 fl oz	2 fl oz	2.5 fl oz
60	1.66 tsp	3.25 tsp	6.33 tsp	1.66 fl oz	2 fl oz
70	1.33 tsp	2.75 tsp	5.5 tsp	1.33 fl oz	1.75 fl oz
80	1.25 tsp	2.33 tsp	4.75 tsp	7.25 tsp	9.5 tsp
90	1 tsp	2 tsp	2.25 tsp	6.33 tsp	8.5 tsp
100	1 tsp	2 tsp	3.75 tsp	5.75 tsp	7.66 tsp

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SS-FOR19

Controlling Invasive Exotic Plants in North Florida Forests[1]

Chris Demers, Patrick Minogue, Michael Andreu, Alan Long, and Rick Williams[2]

Of the more than 4,000 known plant species growing in Florida, approximately 30% are not native to Florida or the Southeast. Organisms are considered non-native when they occur artificially in locations beyond their known historical native ranges. The term non-native can refer to species brought in from other continents, regions, ecosystems, and habitats. The most important aspect of a non-native (exotic) plant is how it responds to a new environment. An invasive species is one that displays rapid growth and spread, allowing it to establish over large areas. Invasive species are free from the complex array of natural controls, including herbivores, parasites, and diseases, that are present on their native lands. The term noxious is a legal designation used specifically for plant species that have been determined to be major pests of agricultural ecosystems and are subject by law to certain restrictions.

Known ecological impacts of invasive plants include reduction of biodiversity; loss of and encroachment upon endangered and threatened species; loss of habitat for native insects, birds, and other wildlife; alterations to the frequency and intensity of fires; and disruption of native plant-animal associations such as pollination, seed dispersal, and host-plant relationships. In addition, invasive plants can hybridize with native plants and alter their genetics; they grow rapidly, sometimes girdling native shrubs and trees; they increase the incidence of plant stress in forested areas; and they reduce the amount of space, water, sunlight and nutrients that would otherwise be available for native species. The US Fish and Wildlife Service estimates that invasive exotic species cost the United States $120 billion in damages each year (USFWS 2012).

In all forest operations it is important to consider that any mechanical disturbance of the soil with heavy equipment could potentially promote the establishment and spread of invasive exotic plants. It is important to monitor all mechanically managed sites for subsequent invasive plant establishment. Early detection and removal of invasive plants is the key to successful management. This publication describes many of the current methods used to manage some of the more common and troublesome invasive exotic plants in north Florida forests. These pest species may occur in established forest stands or when establishing

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new plantations. Consult the sources referenced in this paper for additional details about these and other methods. Control methods usually involve some combination of fire and mechanical and chemical treatments. Biological control agents for some of these plants are currently under investigation. Pictures of these species can be found at: http://plants.ifas.ufl.edu/, http://edis.ifas.ufl.edu/ag108, or in Langeland and Burks's book, *Identification and Biology of Non-Native Plants in Florida's Natural Areas*. http://ifasbooks.ifas.ufl.edu/p-197-identification-and-biology-of-non-native-plants-in-floridas-natural-areas.aspx

Alternative Ways to Control Woody Plants

Prescribed fire is an important and natural means to manage forest vegetation. Sometimes fire is used in combination with hand weeding, mechanical removal or herbicide treatment to manage invasive vegetation and also to restore native vegetation. Unfortunately, most invasive plants in forests, including cogongrass, Chinese tallowtree, Chinese privet and Japanese climbing fern, cannot be controlled by fire alone.

Hand-weeding can be effective when removing new infestations and when plants are small, but often this labor-intensive approach is impractical. The use of machinery in invasive weed management may include mowing, disking, plowing, grinding (masticating), root-raking/wrenching, and other approaches. However, many invasive species re-sprout to reoccupy the site unless all plant parts are removed, particularly the roots. When using heavy equipment to remove invasive exotic plants, please make sure that all equipment is cleaned off before it leaves the treatment site to prevent further spread of the problem species.

Chemical treatment recommendations described in this publication have provided acceptable levels of control in experimental trials and operational experience, and are consistent with product labeling. *Always* follow current herbicide label instructions for determining approved application use sites (i.e., "forests"), herbicide application rates, mixing instructions, personal protective equipment, and use precautions. Additional information about various herbicides used in forestry applications may be found in:

Osiecka, A. and P. J. Minogue. 2014. *Herbicides registered for pine management in Florida—2014*. CIR1475. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/fr158

Osiecka, A., and P. J. Minogue. 2011 (Revised 2014). *Forest herbicide characteristics*. FOR283. University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/fr345

Osiecka, A., and P. J. Minogue. 2010 (Revised 2014). *Considerations for developing effective herbicide prescriptions for forest vegetation management*. FOR273. University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/fr335

Ferrell, J., K. Langland, and B. Sellers. 2012. *Herbicide application techniques for woody plant control*. SS-AGR-260. University of Florida Institute of Food and Agricultural Sciences Circular. https://edis.ifas.ufl.edu/ag245

Trees/Shrubs

Heavy machinery, such as bulldozers, may be used to physically remove large trees or shrubs. This is a common approach to prepare land for tree plantation establishment, but using large equipment in established stands to remove invasive trees and shrubs may cause excessive soil and root disturbance and damage to desired vegetation. Hand tools, such as shovels or root-wrenches, may be used to remove small trees and shrubs (Miller et al. 2010), but this is labor intensive and may not be effective in removing all of the roots.

Periodic prescribed fire is an important tool to manage invasive trees and shrubs, and is most effective on thin-barked species, smaller stems and when burns are conducted during the growing season.

Backpack or hand-held sprayers, ground machinery, and sometimes aircraft are used to apply herbicides to control invasive trees, shrubs and other plants in forests. Herbicide treatments may be broadcast for large infestations, but applications to individual plants provide better selectivity, minimizing adverse effects to desired vegetation. Individual stem approaches also use the least amount of herbicide. Several approaches employed for individual plant control are described below. The choice of application method depends on the size of the plants, the density of the infestation, and the extent of the area to be treated.

- **Broadcast** herbicide applications may be made with ground-based sprayers or aircraft where large continuous infestations are present.
- **Cut stem** treatment involves cutting through the bark of trees or large shrubs at a downward angle using a hatchet or machete, and then applying a small amount of herbicide solution into the cut using a common garden squirt bottle or similar straight-stream sprayer

such as the Spraying Systems Gun-Jet® applicator (Glendale Heights, IL).

- **Cut stump** treatment is used for recently felled trees, saplings and large shrubs. A small amount of diluted herbicide solution is applied to the cambium layer. The cambium is an actively growing, light green or brown ring just inside the bark.

- **Basal bark** treatment involves applying diluted herbicide solution or oil emulsion to the lower 12 to 16 inches of the stem or stems of undesirable saplings or shrubs. This approach is most effective when stem diameters are less than 3 inches and is often chosen when stem density is high (many small stems). Larger trees (4–6 inches in diameter) that have very thin bark may also be controlled with this method. However, this is often highly species specific.

- **Backpack foliar** sprays are used to control individual invasive trees and shrubs where their crowns may be reached with backpack or hand held sprayers. This approach is chosen when stems are scattered and the tallest crowns are less than 8 feet tall. It is difficult to get adequate coverage on taller trees and spray contact to desired vegetation is more likely as spray height increases. To control taller invasive trees or shrubs cut stem or cut stump treatments (after tree felling) are more effective to selectively remove invasive trees.

Application Timing: For **deciduous** trees and shrubs, foliar broadcast or backpack foliar individual stem applications are effective from full leaf-out in spring until just prior to the onset of fall colors. Some **evergreen** species such as coral *Ardisia* may be treated with foliar sprays during the dormant season, which may lessen negative effects to desired vegetation nearby. Cut stem, cut stump and basal bark treatments can be performed at any time of the year. However, early spring treatments may not be effective when strong upward sap flow may force herbicide from the cuts or treated surface.

When deciding on the best treatment approach for the invasive tree or shrub species listed below, consider the plant size and infestation density to select the appropriate application method (broadcast foliar, backpack foliar, cut stem, cut stump, or basal bark) and refer to Tables 1–9 for application rates and special concerns. Often a combination of approaches for different species or stem sizes is most efficient. Always read and follow all label directions.

CHINESE TALLOW (*TRIADICA* OR *SAPIUM SEBIFERA*)

Chinese tallow, a.k.a. popcorn tree or tallowtree, was introduced by Benjamin Franklin from France as a source of candle wax and widely introduced from China in the early 1900s as an ornamental. It has since invaded most southeastern states. It is a small tree whose large, fleshy seeds are widely dispersed by birds and water runoff. The tree's attractive, light green, broadly ovate leaves that yield bright yellow and orange fall colors have made it a popular ornamental. It is also used by beekeepers for honey production in spring. However, this tree is threatening to become the prominent component of marshes, river margins, and dry uplands within its expanding range. Further planting of this tree is prohibited by the Florida Department of Agriculture and Consumer Services (FDACS), and it is listed as a noxious weed by the US Department of Agriculture (USDA) and as a Category 1 invasive weed by the Florida Exotic Pest Plant Council (EPPC).

Control

For control of Chinese tallow in pine plantations, Arsenal® AC or Chopper® (both contain the active ingredient imazapyr) are commonly used. Southern pines are tolerant to these persistent soil-active herbicides but can still sustain some injury if the trees are stressed or if high concentrations of herbicide are applied. Hardwood trees and shrubs are susceptible to damage from these herbicides and will likely be injured or killed if their roots extend into the treated area. When managing Chinese tallow in hardwood forests, or where close to desired vegetation, apply Garlon® (triclopyr) or Accord® XRT II (glyphosate) to provide better selectivity. Please see Table 1 for methods of application and herbicide rates.

MIMOSA OR SILK TREE (*ALBIZIA JULIBRISSIN*)

Mimosa is a small to medium-sized tree with attractive, fern-like leaves and showy pink flowers. It establishes vigorously on disturbed areas, often spreading by seed from nearby ornamentals. It was introduced to the United States as an ornamental in 1745 and continues to be used as such because of its attractive form, foliage, and flowers. It reproduces both vegetatively and by seed. If cut or top-killed, it will re-sprout quickly, growing in height to three feet or more in a single season. Due to its ability to grow and reproduce along roadways and disturbed areas, and its tendency to readily establish after escaping from cultivation, mimosa is considered a Category II invasive by Florida's Exotic Pest Plant Council.

Control

Mimosa can be controlled with the use of mechanical (repeated cutting, chopping, mowing) and chemical treatments. Because this tree is prone to re-sprout following cutting, chemical treatments are most effective for complete control. Mimosa is a legume and these plants are particularly susceptible to Milestone® (aminopyralid), Escort® (metsulfuron methyl) and Transline® (clopyralid) herbicides. Most native perennial grasses show tolerance to these herbicides, so damage to desired species should be minimal during restoration efforts. Arsenal and Chopper are not effective for control of legumes and are not recommended for mimosa control. See Table 2.

CHINESE PRIVET (*LIGUSTRUM SINENSE*), JAPANESE PRIVET (*LIGUSTRUM JAPONICUM*), AND GLOSSY PRIVET (*LIGUSTRUM LUCIDUM*)

These members of the olive family are shade-tolerant, tall, evergreen-leaved shrubs that can grow to about 30 feet in height. They spread by bird-dispersed seeds or

underground runners and form dense stands that prevent pine and hardwood regeneration and/or land access. These plants were introduced from Asia.

Control

Adequate control of these shrubs can be achieved through a variety of herbicide application methods and several herbicide products are effective. The addition of 1% methylated seed oil (MSO) additive to foliar sprays improves herbicide uptake through the waxy cuticle of invasive privets. Often dense thickets of privet need to be cut down or mowed to gain access and the new sprouts treated with herbicides. See Table 3.

CORAL ARDISIA (*ARDISIA CRENATA*)

Coral ardisia, or spice ardisia, is an evergreen shrub, 2–6 ft tall, with dark green, scallop-margined leaves. Flowers and fruit are produced in axillary, not terminal, clusters, usually drooping below the foliage. Fruit are small, bright red, one-seeded drupes. It was introduced into Florida for ornamental purposes in the early 1900s and has spread and become naturalized in hardwood hammocks across the north and central parts of the state. It does not grow well in full sunlight. Seedlings of native plant species are shaded out where it forms dense stands.

Control

Seedlings can be hand-pulled. Mowing can keep the plants at ground level and inhibit seed production, but most effective control of this plant can be achieved through herbicide application. With the recommended herbicide treatments application timing in mid to late fall, when many native desirable plants are dormant, improves selectivity in control. See Table 4.

Vines

KUDZU (*PUERARIA MONTANA*)

Kudzu was introduced into the United States at the Philadelphia Centennial Exposition in 1876. By 1900 kudzu was available through mail order as an inexpensive livestock forage, and was later promoted by the USDA for erosion control along rights-of-way and gullies. It now persists in impenetrable patches as large as 100 acres and will overtop and kill trees, even after they are mature. Kudzu is an aggressive leguminous vine capable of growing 1 foot per day. It can easily grow 60 feet in a single growing season. It also roots at the nodes, establishing new root crowns on vines growing on the ground. Kudzu patches may become difficult to traverse as vines layer on top of each other and often conceal stumps or old gullies.

Control

Special effort is required to control kudzu. The older the patch, the harder it will be to control and the longer it will take for complete eradication. In severe cases, follow-up spot treatments may be required for several years.

It is best to first evaluate the kudzu problem by determining the age of the patch. Do this by looking at the root crowns (the top of the primary root). If the root crowns are 2 inches or larger in diameter, the patch is about 10 years of age or older. For older kudzu stands, the higher end of labeled rates are recommended. For easiest access, it is best to evaluate kudzu problems in winter, when vines and foliage are withered.

The most effective treatment for kudzu control is a combined application of Escort and Accord XRT herbicides in high application volume (Table 5). However, even this treatment will require annual spot treatment of emerging crowns to eradicate the infestation. The Escort in the mix has soil residual and will injure nearby trees or shrubs by root uptake.

Where kudzu is draping trees, a foliar application of Transline (Table 5) provides effective control. Transline treatments require many sequential annual applications to gain control. Please see Table 5 for a list of the 25 Florida counties where it is permissible to use Transline.

AIR POTATO (*DIOSCOREA BULBIFERA*)

This invasive vine from Africa was introduced into Florida in 1905. It quickly grows to 60–70 feet in length, high enough to overtop and shade out native trees. The air potato is a member of the yam family and produces many aerial tubers (potato-like growths) called bulbils that are attached to the vines. Bulbils eventually establish and grow into new plants. It is listed as a Category I invasive by FL-EPPC.

Control

Begin by collecting all bulbils, if any, from the ground and removing them from the site. Dispose of the bulbils by putting them in a garbage bag and placing it with yard debris for pick-up or by burning. Composting is not effective. Municipalities dispose of them by incinerating them or incorporating them into hard turf. Bear in mind that many tubers will be underground: either dig them up or apply herbicide to their emergent vines before they can produce more bulbils.

Once this is done, adequate control can be achieved with the use of herbicides. Guidelines for herbicide control are listed below. Follow-up treatments may be necessary in all cases. See Table 6.

Biological Control

The air potato leaf beetle *(Lilioceris cheni)* is a rather large (approximately 9 mm or about 3/8 inch long) orange-red Asian leaf beetle in the subfamily Criocerinae (see image), It was first collected in Nepal in 2002, and later in China in 2010 and 2011. The beetle is a host-specific specialist that feeds and develops only on the air potato vine. This insect has been effective at controlling the plant since its first release in 2012. By the end of 2015, approximately 450,000 beetles have been released at more than 2000 locations in Florida (Center 2015).

JAPANESE CLIMBING FERN (LYGODIUM JAPONICUM) AND OLD WORLD CLIMBING FERN (LYGODIUM MICROPHYLLUM)

Japanese climbing fern is native to Asia. It is a perennial, delicate looking, climbing vine that forms dense stands that can cover trees and shrubs. Introduced from Japan as an ornamental, it is naturalized throughout the lower portions of Alabama, Georgia, Louisiana, South Carolina, North Carolina, and south into central Florida. Further planting of this vine is prohibited by FDACS.

Old World climbing fern is native to Asia and Australia. It also climbs rapidly into trees and shades out native vegetation. It now covers hundreds of acres in south and central Florida. Old World climbing fern has the ability to "re-sprout" from almost anywhere along each climbing leaf. Dense growth of the plant can also be a fire hazard, frequently enabling small ground fires to reach into tree canopies and kill the growing branches.

Japanese and Old World climbing ferns are presently the only non-native invasive ferns in the South. At this time, Old World climbing fern has been a problem for many years in central and south Florida but it is moving north. The northern edge of its advance is now near Jacksonville. Both ferns reproduce readily by wind-blown spores.

Animals, equipment, and even people that move through an area with climbing fern are very likely to pick up spores and move them to other locations on the property or even to other properties. Both plants are listed as Category I on the FL-EPPC list.

Control

Adequate control of both climbing ferns has been achieved with multiple applications of glyphosate. Old World climbing fern is controlled with broadcast applications of Escort, to which grasses and some other native plants are tolerant. As with most invasive plants, repeated treatments may be necessary. Spot treatments of triclopyr are also effective for Old World climbing fern. However, triclopyr is highly injurious to many shrubs and trees. See Table 7.

Grasses

COGONGRASS (*INMPERATA CYLINDRICA*)

Cogongrass is a fast-growing, rhizomatous (spreading with underground stem), perennial grass that has become one of the most troublesome weeds in the world. It was accidentally introduced from Japan as packing material in Mobile, Alabama, in 1911. It was later intentionally introduced from the Philippines into Mississippi as forage. The Mississippi population was shared with the University of Florida, USDA Plant Introduction Station, and Soil Conservation Service in 1937 for forage and soil stabilization. It has proved to be an excellent soil stabilizer, but it is extremely difficult to prevent its escape into unintended areas. It spreads predominantly by transported rhizomes in soil. Cogongrass is listed as a noxious weed by FDACS and USDA, and it is ranked among the 10 most invasive weeds in the world.

Control

Recommendations to control cogongrass are to treat these infestations in the late summer and early fall with glyphosate and/or imazapyr herbicides (Miller 2003; Faircloth et al. 2005). Fusilade® (fluazifop) may also be an effective option. Because of the extensive rhizomes of cogongrass, repeated applications of herbicide are always necessary to obtain eradication. Remember to thoroughly wet the plants with the herbicide mixture when they are green and growing, not during droughts or time of plant stress. For all recommendations, retreat as necessary. See Table 8.

BAHIAGRASS (*PASPALUM NOTATUM*), BERMUDAGRASS (*CYNODON DACTYLON*), GIANT FESCUE (*FESTUCA ARUNDINACEA*), AND JOHNSONGRASS (*SORGHUM HALEPENSE*)

These grasses have been widely established for livestock forage, but they can present problems for forest landowners wanting to establish pine stands and/or restore native groundcover on sites where the invasive grasses dominate. Introduced as improved pasture grasses from the Mediterranean region of Europe and Africa, they are now distributed worldwide.

Control

Adequate control of these grasses can be achieved with a summer application of Accord XRT followed by a spring application of an Arsenal AC and Oust ® (sulfometuron) tank mix. Metsulfuron is also highly effective on bahiagrass. See Table 9.

Conclusion

The invasive exotic species described in this publication represent those most likely to be found in forestlands in north Florida. More complete information on these and other non-native plants can be found in Langeland and Burks's *Identification and Biology of Non-native Plants in Florida's Natural Areas* (1998) and Langeland and Stocker's *Control of Non-native plants in Natural Areas of Florida* (1997). Another good source of information on invasive plants can be found in Miller's *Non-native Invasive Plants of Southern Forests* (2012).Other resources, including several on the web are listed below.

Learn to identify these invasive plants, and if they show up on your property treat them quickly before they can spread and increase the difficulty of controlling them. Treated areas should be periodically examined to determine if retreatment is necessary. It is normal for areas infested with invasive plants to receive multiple treatments to effectively reduce the impact and presence of these plants. The University of Florida's Center for Aquatic and Invasive Plants is a good place to find images and more information about these and many other species: http://plants.ifas.ufl.edu/.

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Web Resources

Cogongrass.org, http://www.cogongrass.org/

Invasive and Exotic Species of North America. http://www.invasive.org/

The Plant Conservation Alliance's Alien Plant Working Group. Weeds Gone Wild: Alien Plant Invaders of Natural Areas, http://www.nps.gov/plants/alien/index.htm

UF/IFAS Center for Aquatic and Invasive Plants, http://plants.ifas.ufl.edu/

Table 1. Herbicide treatments for control of Chinese tallow.

Method	Herbicide	Treatment
Broadcast Foliar		This approach is for large and severe infestations only. For Arsenal AC + Accord XRT, this treatment is non-selective; all vegetation will be killed or severely affected. Calibrate broadcast helicopter or ground spray equipment to deliver 10 to 20 gallons total spray solution per acre to the canopy. This will prepare the site for re-planting.
	Arsenal AC+ Accord XRT	Apply 20 oz product Arsenal AC (or 40 oz Chopper) plus 2.5 qts Accord XRT product per acre.
	Clearcast	Apply 64 oz product per acre with methylated seed oil at 1 qt per acre. This treatment can be selectively used over oaks, but will severely injure willows and cattails.
Cut Stem		This approach targets individual stems and is selective, avoiding herbicide injury by other plants. Using a sharp hatchet, make cuts through the bark and cambium at a downward angle, with cuts spaced as described for each product, and spray 1 milliliter (1 ml, usually one pull on a typical squirt bottle) into each cut.
	Arsenal AC	Make one cut per 3 inches stem diameter and apply 1 ml of a solution of 6 oz Arsenal AC product per gallon water. May injure non-targeted hardwoods, shrubs, and herbaceous plants if their roots extend into the treated area.
	Garlon 3A (3 lb amine)	Make overlapping cuts completely around the tree and spray 1 ml of a 50% solution of Garlon 3A product in water into each cut. Some basal sprouting may occur after this treatment.
Cut Stump		This selective approach involves cutting trees, saplings or seedlings and applying diluted herbicide solution to the freshly cut surface. It is important to treat the growing cambium area, the green or brown ring just inside the bark.
	Chopper	Mix 8 to 16 oz Chopper product in 1 gallon water, diesel oil, or penetrating oil, and spray or brush onto the cambium area. Use sparingly to avoid damage to non-target hardwood trees and shrubs by uptake of this herbicide from the soil near treated stumps.
	Forestry Garlon XRT (4 lb ester)	Apply 15% Garlon XRT in oil, and spray the root collar area (where the stump contacts the soil), sides of the stump, and the outer portions of the cut surface, including the cambium, until thoroughly wet, but not to the point of runoff.
	Accord XRT	Apply 50% Accord XRT product to the cut surface, ensuring that the cambium layer is treated. This herbicide has no soil residual.
Basal Bark (Basal Stem)		This approach targets clumps of small diameter stems by applying diluted herbicide to the basal portion of stems. Straight-steam sprayers help to target applications to individual stems.
	Chopper	Mix 8 to 12 oz Chopper product in 1 gallon of diesel oil or penetrating oil. Spray this mixture on the lower 12-18 inches of stems to control trees less than 4 inches in diameter. May injure non-target trees, shrubs and herbaceous plants if sprayed or if their roots extend into the treated area.
	Forestry Garlon XRT	Apply 15% Garlon XRT in oil to a treated zone on the bark 6 inches in height and within 12 to 24 inches of the ground. See label for various approaches; used for stems less than 4 inches in diameter.
Backpack Foliar		This approach targets scattered individual trees less than about 8 feet in height. Care must be taken to direct the spray only to target vegetation.
	Arsenal AC + Accord XRT	Mix 1 oz Arsenal AC (or 2 oz Chopper) product plus 4 oz Accord XRT product per gallon water and apply a light spray coverage to the entire crown. Use sparingly, damage to non-target hardwoods, shrubs and herbaceous plants may occur if they are sprayed or if their roots extend into the treated area.
	Forestry Garlon XRT	Mix 2% Garlon XRT product in water and apply to the entire crown. This is a volatile herbicide and may damage non-target vegetation by vapors.
	Accord XRT	Mix 5% Accord XRT in water and spay the entire crown avoiding any contact of the spray to desired vegetation.
	Clearcast	Mix 2% v/v in water with MSO at 1% v/v in water and spray the entire crown.

Table 2. Herbicide treatments for control of mimosa.

Method	Herbicide	Treatment
Broadcast Foliar		This approach is for large and severe infestations only. It is non-selective; all vegetation will be killed or severely affected. Calibrate broadcast helicopter or ground spray equipment to deliver 10 to 20 gallons total spray solution per acre to the canopy. This will prepare the site for re-planting.
	Accord XRT + Escort	Apply 2.5 qts Accord XRT product plus 2 oz Escort product per acre.
	Milestone	7 fl oz/ac applied between late June and early October when tree is actively growing.
Cut Stem		This approach targets individual stems and is selective. Using a sharp hatchet, make cuts through the bark and cambium at a downward angle, with cuts spaced as described for each product, and spray 1 milliliter (1 ml, usually one pull on a typical squirt bottle) into each cut.
	Garlon 3A (3 lb amine)	Make overlapping cuts completely around the tree and spray 1 ml of a 50% solution of Garlon 3A product in water into each cut.
	Milestone	Spray 10% solution in stem cuts.
Cut Stump		This selective approach involves cutting trees, saplings or seedlings and applying diluted herbicide solution to the freshly cut surface. It is important to treat the growing cambium area, the green or brown ring just inside the bark.
	Forestry Garlon XRT (4 lb ester)	Apply 15% Garlon XRT in penetrating oil (see label) and spray the root collar area (where the stump contacts the soil), sides of the stump and the outer portions of the cut surface, including the cambium, until thoroughly wet, but not to the point of runoff.
	Accord XRT	Apply 50% Accord XRT product to the cut surface ensuring that the cambium layer is treated. This herbicide has no soil residual.
Basal Bark (Basal Stem)		This approach targets clumps of small-diameter stems by applying diluted herbicide to the basal portion of stems. Straight-steam sprayers help to target applications to individual stems.
	Forestry Garlon XRT	Apply 15% Garlon XRT in oil to a treated zone on the bark 6 inches in height and within 12 to 24 inches of the ground. See label for various approaches; used for stems less than 4 inches in diameter.
Backpack Foliar		This approach targets scattered individual trees less than about 8 feet in height. Care must be taken to direct the spray only to target vegetation.
	Transline + Garlon 3A	Apply 0.25% Transline product plus 4% Garlon 3A product in water from July to September [(1)]. Transline shows selectivity, such that grasses and many native plants are tolerant.
	Forestry Garlon XRT	Mix 2% Garlon XRT product in water and apply to the entire crown. This is a volatile herbicide and may damage non-target vegetation by vapors.
	Accord XRT	Mix 5% Accord XRT in water and spay the entire crown, avoiding any contact of the spray to desired vegetation.
	Milestone	Mix 0.25% v/v in water and wet all foliage. Avoid spraying desired legumes.

[1] Miller et al. 2010

Table 3. Herbicide treatments for control of privets.

Method	Herbicide	Treatment
Basal Bark (Basal Stem)		This approach targets clumps of small-diameter stems by applying diluted herbicide to the basal portion of stems. Straight-steam sprayers help to target applications to individual stems.
	Chopper	Mix 8 to 12 oz Chopper product in 1 gallon of diesel oil or penetrating oil. Spray this mixture on the lower 12–18 inches of stems to control trees less than 4 inches in diameter. May injure non-target trees, shrubs and herbaceous plants if they are sprayed or if their roots extend into the treated area.
	Forestry Garlon XRT	Apply 15% Garlon XRT in oil to a treated zone on the bark 6 inches in height and within 12 to 24 inches of the ground. See label for various approaches for stems less than 4 inches in diameter.
Backpack Foliar		This approach targets scattered individual trees less than about 8 feet in height. Care must be taken to direct the spray only to target vegetation. The optimal timing is late fall for foliar treatments.
	Arsenal AC + Accord XRT	Mix 1 oz Arsenal AC (or 2 oz Chopper) product plus 4 oz Accord XRT product per gallon water and apply a light spray coverage to the entire crown. Use sparingly, damage to non-target hardwoods, shrubs and herbaceous plants may occur if sprayed or if their roots extend into the treated area.
	Forestry Garlon XRT	Mix 2% Garlon XRT product in water and apply to the entire crown. This is a volatile herbicide and may damage non-target vegetation by vapors.
	Accord XRT	Mix 5% Accord XRT in water and spay the entire crown, avoiding any contact of the spray to desired vegetation.

Table 4. Herbicide treatments for control of coral ardisia.

Method	Herbicide	Treatment
Backpack Foliar		This approach targets scattered individual trees less than about 8 feet in height. Care must be taken to direct the spray only to target vegetation.
	Forestry Garlon XRT	Mix 2% Garlon XRT product in water and apply to the entire crown. This is a volatile herbicide and may damage non-target vegetation by vapors.
	Garlon 3A	3% v/v is the standard under hardwoods.
Basal Bark (Basal Stem)		This approach targets clumps of small-diameter stems by applying diluted herbicide to the basal portion of stems. Straight-steam sprayers help to target applications to individual stems.
	Forestry Garlon XRT	Apply 15% Garlon XRT in oil to a treated zone on the bark 6 inches in height and within 12 to 24 inches of the ground. See label for various approaches.

Table 5. Herbicide treatments for control of kudzu.

Method	Herbicide	Treatment
Broadcast Foliar		This approach is for large and severe infestations only. It is non-selective; other vegetation in the treated area may be killed or severely affected.
	Escort XP + Accord XRT	Apply 4 oz product Escort XP plus 2.5 qts Accord XRT product per acre in June through September using 50 to 100 gallons total spray per acre. Spot-treat emerging crowns in June or July annually to ensure eradication prior to re-planting trees.
	Transline	When kudzu is growing among desirable pine or hardwood trees, broadcast 1.33 pint Transline product in 20 gallons total spray solution per acre to the kudzu foliage and vines (not to exceed 1 1/3 pint per year) in April to May when plants are less than 6 inches tall. Avoid any contact to the foliage of desired vegetation. Multiple applications in subsequent years will be needed to manage the infestation. Transline may be used only in Baker, Bay, Bradford, Calhoun, Columbia, Escambia, Franklin, Gadsden, Gulf, Hamilton, Holmes, Jackson, Jefferson, Lafayette, Leon, Liberty, Madison, Okaloosa, Santa Rosa, Suwannee, Taylor, Union, Wakulla, Walton and Washington County, Florida.
	Milestone	7 fl oz/ac applied between late June and early October, as long as the vines are actively growing and not under drought stress. The ideal time to apply is during vigorous growth and just prior to or during flowering.

Table 6. Herbicide treatments for control of air potato.

Method	Herbicide	Treatment
Foliar sprays		This approach targets scattered individual vines. Backpack sprayers can be used to treat the vines and foliage to about 8 feet in height. Care must be taken to direct the spray only to target vegetation.
	Forestry Garlon XRT or Garlon 3A	Thoroughly wet foliage with 2% Garlon XRT or 2% Garlon 3A product in water (8 oz per 3 gallon mix) [(1)]. Garlon XRT is a volatile herbicide and may damage non-target vegetation by vapors.
Cut vines		For safety to surrounding plants, cut climbing vines at just above the soil surface and immediately treat the cut surface with herbicide solution.
	Garlon 3A	Apply a 50% solution of Garlon 3A (6 quarts to 3 gallons mix) to freshly cut surfaces [(1)].

[1] Miller et al. 2010

Table 7. Herbicides for control of Japanese and Old World Climbing Fern.

Method	Herbicide	Treatment
Backpack Foliar		This approach targets scattered individual patches of climbing fern. Herbicide may be sprayed on trellising vines to about eight feet in height. Care must be taken to direct the spray only to target vegetation.
	Accord XRT	Spray the leaves with a 2% solution of Accord XRT (or other glyphosate product) from July to October. Follow up with annual applications as needed to control new plants that germinate from spores.
	Escort XP	Spray 1 to 2 ounces (mass) Escort XP product per acre. Mix 0.3 to 0.6 dry ounces Escort per 3 gallons of water. Add 0.25% non-ionic surfactant.

[1] Miller et al. 2010
[2] UF/IFAS Center for Aquatic Invasive Plants

Table 8. Herbicide treatments for control of cogongrass.

Method	Herbicide	Treatment
Broadcast Foliar		This approach is for large infestations. With the exception of Fusilade, which primarily controls grasses, treatments are non-selective; all vegetation will be killed or severely affected. Calibrate broadcast spray equipment to deliver 30 to 50 gallons total spray solution per acre to the grass canopy. Re-treatment to regrowth of cogongrass should be planned for several years.
	Arsenal AC+ Accord XRT	Apply 32 oz product Arsenal AC (or 64 oz Chopper) plus 2.5 qts Accord XRT product per acre.
	Fusilade	Treat with 0.5 qt. per acre herbicide plus label-recommended surfactant.[1]
Backpack Foliar (spot treatmnet)		This approach is for new infestations and small patches.
	Arsenal AC or Chopper	Treat with 1% Arsenal or 2% Chopper solution with 0.25 to 1% non-ionic surfactant or 1% methylated seed oil (MSO) in September or October. Mowing, burning, and/or disking in the spring prior to treatment can enhance the effectiveness of herbicide treatments.[2, 3, 4] Imazapyr, the active ingredient in both Chopper and Arsenal, is a persistent, soil-active herbicide that will kill or severely damage hardwood trees or shrubs, although pines are tolerant. In hardwood stands, the use of Fusilade or Accord is preferred.
	Accord XRTII	Treat with a 3% solution of the product formulation when the plants are green and growing. Plant absorption of glyphosate products can be enhanced with addition of 1% methylated seed oil.

[1] Langland and Stocker 1997
[2] Miller 1999
[3] Jose et al. 2002
[4] Miller 2003

Table 9. Herbicides for control of non-native grasses in reforestation.

Method	Herbicide	Treatment
Broadcast Foliar at site preparation prior to planting		This approach uses a broad-spectrum herbicide to control grasses and other weeds prior to planting
	Accord XRT	Treat with 2.5 qts Accord per acre using 10 to 20 gallons of water in late summer before planting. Then follow up after planting pines with a tank mixture of Arsenal AC + Oust XP (see below).
Broadcast or **Banded** over pines after planting		Using a calibrated sprayer, apply 4 oz Arsenal AC plus 2 oz Oust XP over pines in early spring (late March–April) but at least one month after planting to ensure pine vigor and better herbicide tolerance. Do not add surfactants. Where planted rows are present, herbicides may be applied in a 6-ft-wide band centered on the row.

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FOR284

Emerald Ash Borer: A Potential Future Threat to Ash Trees in Florida[1]

Don Spence and Jason Smith[2]

Overview

The emerald ash borer (EAB) is an invasive, exotic beetle that was first detected in the United States in 2002. To date, it has killed tens of millions of ash trees (*Fraxinus* spp.). It is very likely that the EAB will reach Florida in the years to come. This beetle will likely cause a significant decline of ash species in both urban and natural settings. Slowing the spread of the EAB has been difficult in the Midwest, but due to restrictions on the movement of firewood, some progress in slowing the spread has been achieved. The newest outbreak this year was in Tennessee, which is over 200 miles from the southern end of its distribution in Kentucky, far beyond the natural dispersal ability of the beetle. The Tennessee invasion is therefore likely due to human-assisted movement of the beetle on firewood or nursery stock. In order to prevent entry of the EAB and other damaging pests into Florida, residents are urged to refrain from moving firewood into and around the state.

Introduction

The emerald ash borer (EAB), *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae) was first reported in North America in June 2002 (Haack *et al.* 2002, Muirhead *et al.* 2006, Keller *et al.* 2008). The insect has since moved from Michigan into 15 states, triggering many states to set up sentinel watch programs (USDA 2010a). Figure 1 illustrates the range of the beetle as of May 2011.

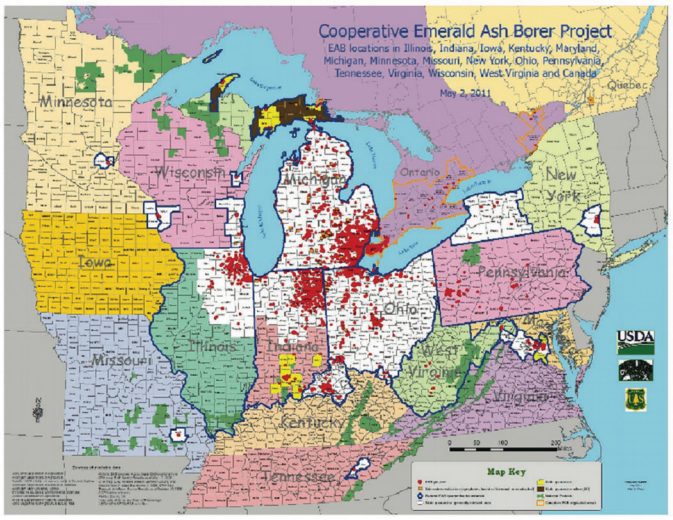

Figure 1. Map showing the range of the emerald ash borer as of May 2011. Note the dots in Missouri and Minnesota, indicating that the beetle has moved far beyond its natural dispersal ability. These infestations are likely due to the movement of firewood or nursery material infested with the emerald ash borer. http://www.emeraldashborer.info/files/MultiState_EABpos.pdf

Since its introduction, the beetle has moved further west, south and east. As of yet, no climatic or biological barrier has been observed; there seems to be little stopping the beetle and it is not known how far it will move. To date, this beetle has killed tens of millions of ash trees (emeraldashborer.info 2011).

The EAB is native to China, Japan, North Korea, and Taiwan (Haack *et al.* 2002). In its native range, EAB has not

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led to the wholesale destruction of hardwood forests or ash trees (*Fraxinus* spp.) (Haack *et al.* 2002). Yang *et al.* (2005) note that native Asian trees in the genera of *Fraxinus*, *Juglans*, *Ulmus*, and *Pterocarya* are reported as hosts for EAB. Additionally, the North American ornamental ash species, *Fraxinus velutina*, *F. americana*, and *F. pennsylvanica* planted in urban settings in China were attacked by the EAB. Interestingly, in North America, the genera of *Juglans* and *Ulmus* have not yet been attacked by the EAB (Anulewicz *et al*. 2006).

Potential for EAB to occur in Florida

Florida faces a high probability of infestation from EAB since several ash species are native to the state and the beetle is tolerant of the warm climate in Taiwan, which geographically lies further south than Florida. From the Midwest to Florida, there are enough ash species in the urban and natural landscape for the EAB to naturally disperse here. Florida has three (or four depending on your taxonomic classifications) species of ash, two of which are common in the Midwest.

Ash species common in both Florida and the Midwest are white ash (*F. americana*) and green or pumpkin ash (*F. pennsylvanica*). A third species, Carolina or pop ash (*F. caroliniana*), occurs throughout Florida and ranges into the Appalachian piedmont. White ash is an upland species; Carolina and green ash are either obligate or facultative wetland species (Plant Atlas 2010).

If the EAB does arrive in Florida, tree mortality here will likely be perceived differently from ash mortality in the Midwest. This is because ash trees are not commonly used in the urban landscape in Florida as they are in the Midwest; the two more common species in Florida are restricted to wetlands. In the Midwest, ash was often used to replace elm trees killed by Dutch elm disease. As a result, a monoculture of green ash is common in many residential and urban areas. In the Midwest, management has focused on the removal of EAB-infested trees in urban areas. Since many ash trees in Florida are associated with wetlands, the presence of the EAB is not likely to be as big a concern for homeowners. It also means that there will be limited management of infested trees due the difficulty of working in wetlands. Therefore, the EAB population in Florida could explode, and decimate Florida's population of native ash trees.

Description and Biology

The emerald ash borer is a member of the Buprestidae family, a group of insects known as metallic, jewel, or flathead borers (Borror *et al.* 1989). Seen from the side, the beetle has an iridescent green exoskeleton and a yellowish/gold abdomen (figure 2). Bupresids are beetle species that attack both living and non-living trees and create conspicuous holes on the trunks of trees. Adult EAB range in size from 1–1.5 cm (3/4 inch to 5/8 inches) and often have a metallic, coppery green sheen. The elytra (stiff outer wings) cover the entire abdomen of the beetle. If the elytra are separated, six iridescent reddish segments can be seen. The antennae of the beetle are serrate in form, arise from just below the eyes, and have eleven segments (Choate 2003).

Figure 2. An adult emerald ash borer.
Credits: David Cappaert, Michigan State University, Bugwood.org

In the summer after the adults emerge, females lay between 30–60 bright yellow eggs that turn a tawny brown color. Larvae hatch in about two weeks, develop a creamy white appearance and have companulate (bell-shaped) segments with dark spines at their posterior end (Anulewicz *et al*. 2006), (Figure 3). Larvae feed on phloem cells and may bore into the sapwood to some degree. The larvae overwinter under the bark, emerging in May or June. When they emerge as adults they leave behind a characteristic "D" shaped exit hole (Figure 4.). Adults mate within a few weeks of emergence to start the cycle again (Liu *et al*. 2003, Yang *et al*. 2005, Anulewicz *et al*. 2006). During the summer when the adult beetles are outside the tree, they will feed on ash leaves; damage may or may not be obvious (Cappaert *et al*. 2005).

Ash tree decline and death is the result of the EAB larvae feeding on the sugar and water conducting cells that occur just beneath the bark. Feeding damage by the beetles disrupts the water flow in a tree, eventually starving it of water and nutrients.

Figure 3. Emerald ash borer larva.
Credits: David Cappaert, Michigan State University, Bugwood.org

Figure 4. Conspicuous "D" shaped emergence holes of the EAB.
Credits: Toby Petrice, Forest Service, Bugwood.org

Management

In Florida, the EAB survey program is a joint effort between the USDA – Cooperative Agriculture Pest Survey program (CAPS) and the Florida Department of Agriculture and Consumer Services – Division of Plant Industry (FDACS-DPI). Currently, there are approximately 200 traps being monitored by CAPS and DPI personnel across Florida (FDACS-DPI).

The EAB outbreak in the Midwest was only on ash trees, and researchers have been able to demonstrate that in North America, the beetle preferentially chooses *Fraxinus* species over *Ulmus* (elm), *Juglans* (walnut), *Carya* (hickory), and *Celtis* (hackberry) (Anulewicz *et al.* 2008). As long as EAB does not widen its host range, the urban management of ash trees in Florida will primarily consist of removing infested and dead trees and protecting non-infected trees in urban areas. There have been attempts to manage newly infested trees through chemical control. A variety of pesticide control techniques have been explored by Cappaert *et al.* (2005), including macro- and micro-insecticide injections, soil drenches, and protective cover sprays. As of yet, it does not appear that 100% control can be achieved. Some insecticide management has worked to keep individual trees alive, but success is affected by initial tree health, species or varieties treated, environmental conditions, and frequency of reapplication. It appears that as long as the EAB is present, chemical treatments will have to continue if ash trees are to be kept alive (Herms *et al.* 2009).

When trees die from EAB infestations, the wood should never be transported outside of the range of the nearest solid waste landfill or wood disposal site. The transport of diseased trees has greatly increased the rate at which EAB and other wood-boring insects move across the landscape (USDA 2010b).

In August 2010, in response to the threat of exotic wood boring insects, the Florida Legislature developed a rule to limit the transport of unfinished wood products in Florida, FAC Chapter 5B-65. The rule specifically targets the movement of firewood and other untreated forest products more than 50 miles. This rule exempts the movement of trees/wood that were grown for silviculture.

Wood Management Recommendations

- Do not transport firewood into Florida from other states or move wood from place to place within Florida. Emerald ash borer and other dangerous pests and diseases can hitchhike on firewood and infest new areas.
- When building a fire, use local firewood only.
- Burn all firewood at your campsite before you leave.
- Do not take any firewood home with you from a camping trip.
- Do not move nursery stock of known hosts from infested areas to non-infested areas.

Agencies and Institutions Working on the Emerald Ash Borer

Florida Department of Agriculture and Consumer Services, Division of Plant Industry

Illinois Department of Agriculture, Division of Natural Resources

Maryland Department of Agriculture

Michigan Department of Agriculture

Minnesota Department of Agriculture

New York State Department of Environmental Conservation

Pennsylvania Department of Agriculture, Department of Conservation and Natural Resources

Purdue University, Purdue Extension

The Ohio State University EAB Outreach Team

United State Department of Agriculture, Animal and Plant Health Inspection Service

United States Forest Service

University of Kentucky, School of Agriculture

University of Missouri Extension

Virginia Department of Agriculture & Consumer Services

West Virginia Department of Agriculture

Wisconsin Department of Agriculture, Trade & Consumer Protection

Websites with information on EAB:

http://na.fs.fed.us/fhp/eab/

http://www.emeraldashborer.info

http://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/index.shtml

FDACS Division of Plant Industry website: Emerald Ash Borer

http://www.freshfromflorida.com/Divisions-Offices/Florida-Forest-Service/Our-Forests/Forest-Health/Forest-Insects/Emerald-Ash-Borer

FDACS Division of Forestry flyer: Keep an Eye Out for the Emerald Ash Borer

http://www.fl-dof.com/publications/fh_pdfs/Keep%20an%20Eye%20Out%20for%20the%20EAB.pdf

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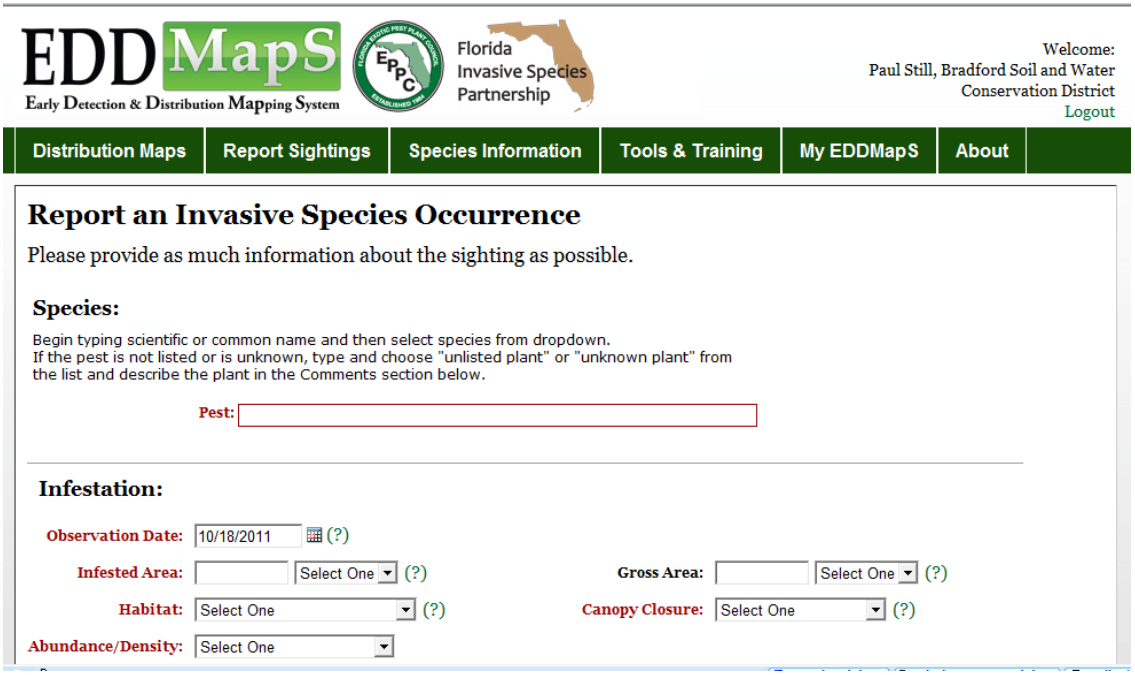
To enter mapping data you must first register. Just click on Register Now and fill in the information requested.

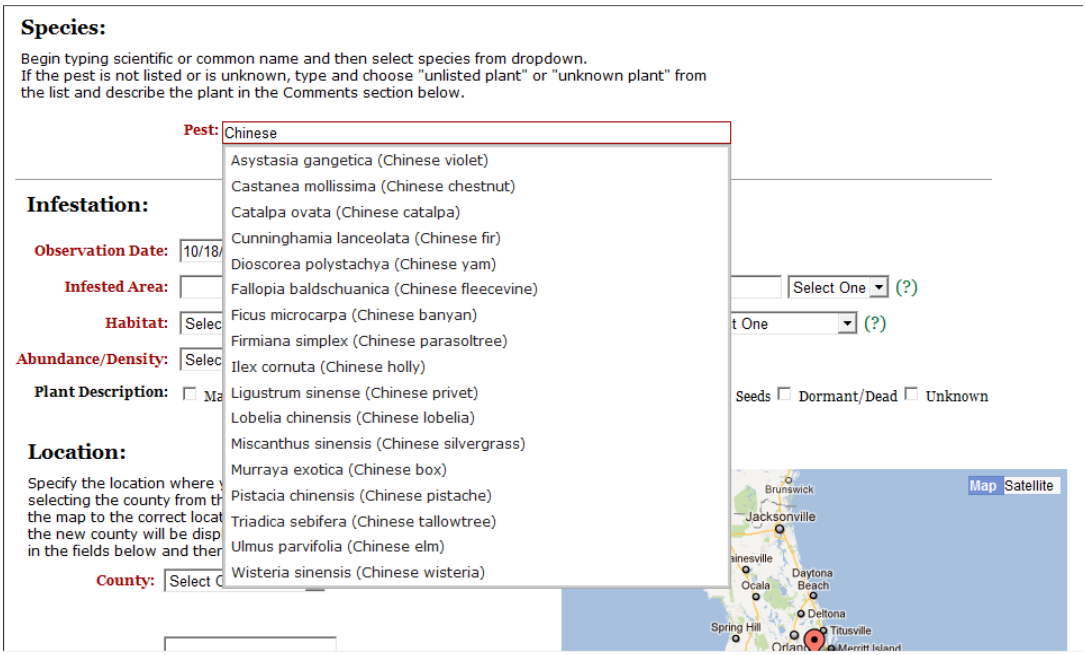
When you are logged in you get this screen.

Click on report sightings and click on Florida on the map or in the state list to get to the screen below. Click on plants.

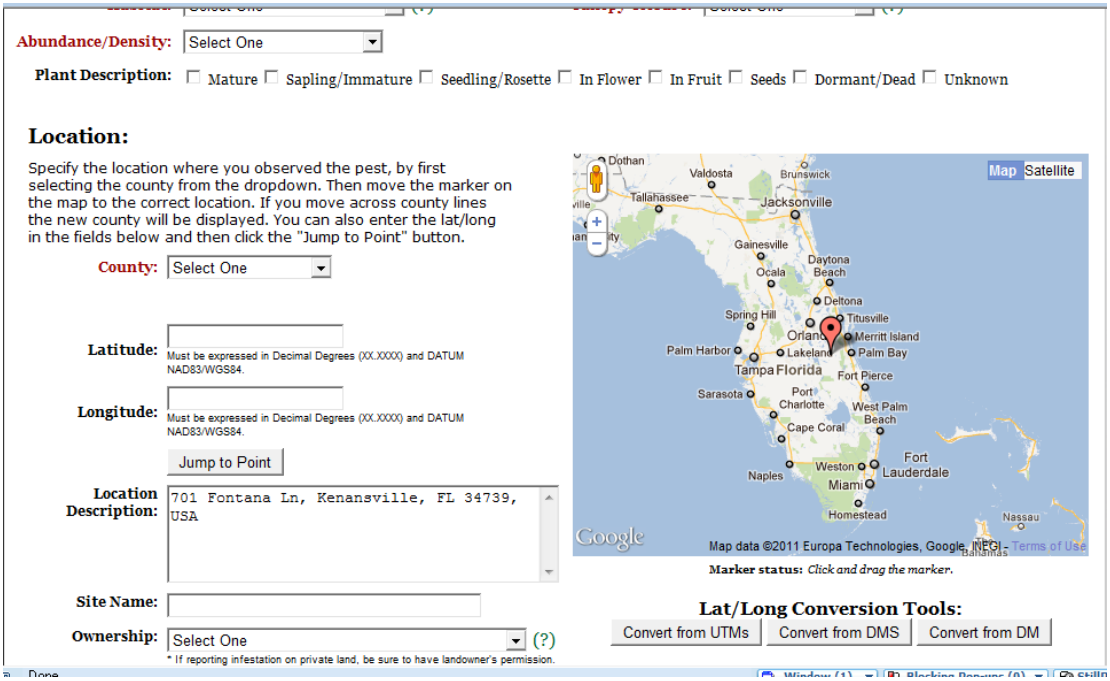
Begin reporting by typing the common or scientific name of the plant.



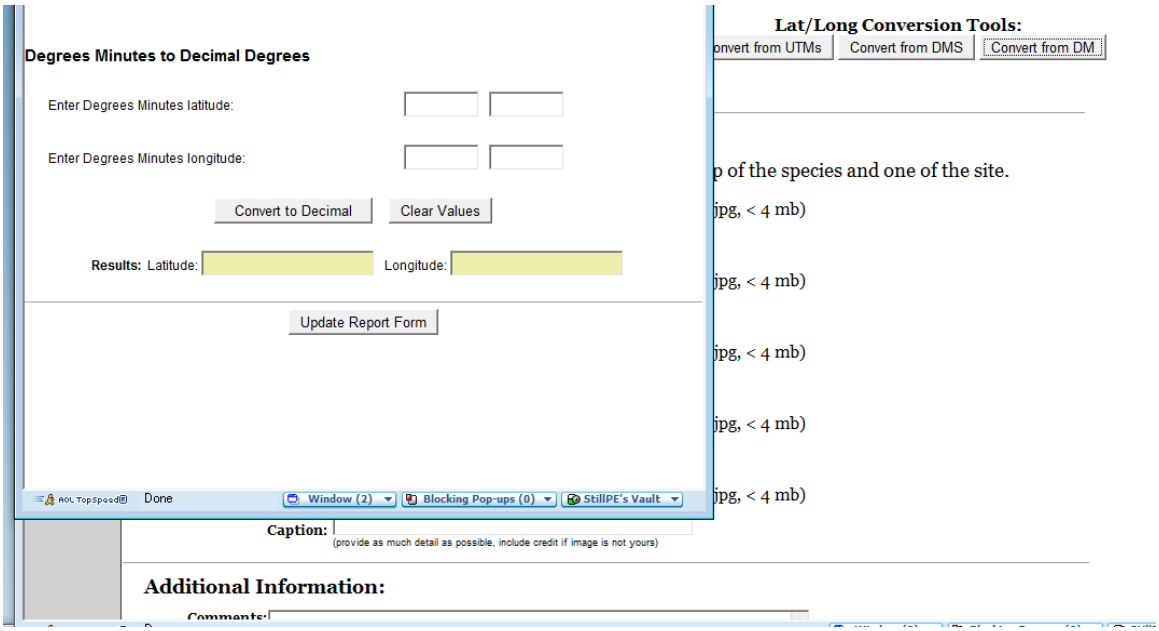
A drop down list will appear. Choose the plant you are reporting. Fill in the other information requested.



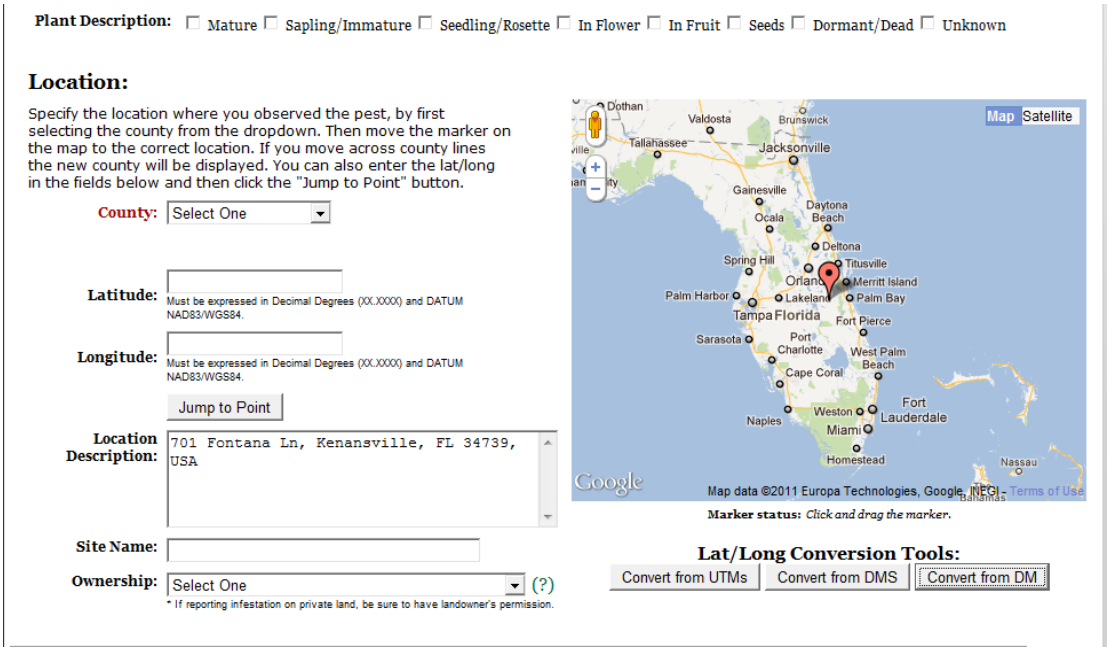
There are several ways to select the location of the plant. First enter the county. The map will then center on the county selected. You can zoom in and move the marker to the location, or you can enter lattitude and longitude in degrees.



If you have lattitude and longitude in degrees and minutes or degrees minutes and seconds, you can use the convert function under the map. After entering location data, click on Convert to Decimal and then click on Update Report Form.



Once you have the longitude and latitude entered click on Jump to Point and the address will be entered in the Location Description box. If you do not click on Jump to Point the address in the Location box will be the centered default address.



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Introduced and Invasive Species in Florida — Online Resources

Prepared by: Dr. Steve A. Johnson, Associate Professor, Dept. of Wildlife Ecology, University of Florida

Invasive Species Websites of General Interest

Florida Invasive Species Partnership—FISP: This website is an invaluable resource for land managers in Florida. An excellent resource provided by FISP is its "Florida Landowners Incentives Program", which lists more than 25 potential sources of funds available to managers of private and public lands for control of invasive species. Other features of this site include an up-to-date calendar of events and news on invasive species, details for Florida's Cooperative Invasive Species Management Areas (CISMAs), and information on reporting and mapping observations of invasive plants and animals. This is a MUST VISIT site for anyone responsible for managing Florida's natural areas!

http://www.floridainvasives.org/index.html

The National Invasive Species Council—NISC: NISC is consortium of US federal agencies working together to address a myriad of invasive species nationally. NISC provides high-level interdepartmental coordination of federal invasive species actions and works with other federal and non-federal groups to address invasive species issues at the national level. Be sure to check out the 2008-2012 National Invasive Species Management Plan, which can be downloaded from NISC.

http://www.invasivespecies.gov/index.html

INVASIVES.ORG Center for Invasive Species and Ecosystem Health: The University of Georgia, in partnership with the USDA, hosts this great website and it's worth a visit. There you will find links to species profiles and a diversity of reports and publications, a library of digital images, and much more. This site provides information on invasive plants, invertebrates, vertebrates, and diseases. Click the "Maps" button at the top of the home page to go to the EDDMapS where you can report observations of introduced animals and plants. You will want to bookmark this web page for sure.

http://www.invasive.org/

USDA National Invasive Species Information Center: This site is a "gateway to invasive species information; covering Federal, State, local, and international sources." Although the information provided here for invasive vertebrates is relatively sparse, it is a great source of information for invasive insects, plants, and aquatic species. It also includes links to recent news and events on invasive species from a national perspective.

http://www.invasivespeciesinfo.gov/index.shtml

eXtension: "eXtension is an interactive learning environment delivering the best, most researched knowledge from the smartest land-grant university minds across America." This site provides resources for a variety of species of North American wildlife, including invasive vertebrates such as feral hogs and armadillos. There is also a great deal of additional information potentially valuable to natural resource managers.

http://www.extension.org/

Florida Fish and Wildlife Conservation Commission—Nonnative Species: This site provides a general background on invasive species and the problems they cause, numerous links to invasive species resources, and rules and regulations governing non-native animals in Florida. This FWC site is especially valuable because it is the clearinghouse for information on the status of introduced animals in Florida. Here you will also find brief profiles for virtually all of the state's introduced animals.

http://www.myfwc.com/nonnatives

Species Profiles and Management Resources

eXtension

- Feral Hogs: http://www.extension.org/feral_hogs
- Armadillos: http://www.extension.org/pages/8781/armadillo-damage-management#.Uo6eGulyga8

Internet Center for Wildlife Damage Management

- Armadillos: http://icwdm.org/handbook/mammals/armadillos.asp
- European Starlings: http://icwdm.org/handbook/birds/EuropeanStarlings.asp

Florida Fish & Wildlife Conservation Commission

- Armadillos: http://myfwc.com/wildlifehabitats/profiles/mammals/land/armadillo/
- Coyotes: http://myfwc.com/wildlifehabitats/profiles/mammals/land/coyote/faqs/
- Outdoor Cats: http://myfwc.com/wildlifehabitats/nonnatives/mammals/feral-cats/
- Feral Hogs: http://myfwc.com/media/2102702/6staffreport-wildhog_presentation.pdf
- Feral Hogs: http://myfwc.com/wildlifehabitats/profiles/mammals/land/wild-hog/
- Mallard/Mottled Ducks: http://myfwc.com/wildlifehabitats/profiles/birds/waterfowl/mottled-ducks/
- Mallard Ducks: http://myfwc.com/license/wildlife/nuisance-wildlife/mallard-control/

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- Armadillos: http://edis.ifas.ufl.edu/uw362
- Coyotes: https://edis.ifas.ufl.edu/uw397
- Feral Hogs: http://edis.ifas.ufl.edu/uw322
- Iguanas: http://edis.ifas.ufl.edu/in528
- Purple Swamphen: http://edis.ifas.ufl.edu/uw317
- European Starling: http://edis.ifas.ufl.edu/uw300
- Cuban Treefrog: http://ufwildlife.ifas.ufl.edu/cuban_treefrog_inFL.shtml & http://edis.ifas.ufl.edu/uw259
- Cane (Bufo) Toad: http://edis.ifas.ufl.edu/uw345
- Burmese Python: http://edis.ifas.ufl.edu/uw333 & http://edis.ifas.ufl.edu/uw286

Florida Museum of Natural History

- Iguanas: http://www.flmnh.ufl.edu/herpetology/kk/pdf/2007_Krysko_et_%20al-Iguana_iguana.pdf

Emerald Ash Borer Information Network: http://emeraldashborer.info/

American Bird Conservancy

- Outdoor Cats: http://www.abcbirds.org/abcprograms/policy/cats/index.html

US Department of Agriculture

- Feral Hogs: http://www.aphis.usda.gov/wildlife-damage/stopferalswine
- Feral Hogs (Immunocontraception) : http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1102&context=icwdm_usdanwrc

Education and Training Resources

University of Florida Institute of Food and Agricultural Sciences

- UF Wildlife**:** This is a website with information about invasive vertebrates, their natural history, and management. Online guides to Florida's Snakes and Florida's Frogs & Toad can be found here too, as well as resources for educators. Be sure to check out the page for the *Invader Updater* (click the "Invasive Vertebrates" link), a quarterly newsletter focused primarily on providing information on invasive vertebrate animals in Florida and the southeastern US. http://ufwildlife.ifas.ufl.edu/
- Reptile Early Detection and Documentation (REDDy): This is a free, online training module focused on identification and reporting of observations on large constrictors and carnivorous lizards in Florida. Numerous supplemental resources are provided. http://ufwildlife.ifas.ufl.edu/reddy.shtml
- Buyers Guide to Pet Reptiles: This brochure offers advice on the purchase of pet reptiles. It is available as a tri-fold brochure at the second link below.
  http://edis.ifas.ufl.edu/uw357
  Options for Unwanted Pets: This brochure offers advice on suitable options for unwanted exotic pets. A similar version is available as a tri-fold brochure at the second and third links below.
  http://edis.ifas.ufl.edu/uw353
  http://edis.ifas.ufl.edu/pdffiles/UW/UW35300.pdf
  http://ufwildlife.ifas.ufl.edu/pdfs/PARC%20Pet%20Brochure.pdf

The Nature Conservancy

- Python Patrol: The Nature Conservancy conducts workshops that provide participants with hands-on training for safe and effective methods to capture large constrictors. http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/florida/howwework/stopping-a-burmese-python-invasion.xml

Florida Fish and Wildlife Conservation Commission

- FWC Pet Amnesty Program: The FWC conducts several "Pet Amnesty" events each year throughout the state. Anyone is allowed to surrender unwanted, exotic pets (no dogs, cats, etc.) with no questions asked. After a veterinarian examines each animal, those deemed healthy are sent home with pre-approved, adoptive parents. FWC can also help place needy animals with adopters upon request. http://myfwc.com/wildlifehabitats/nonnatives/amnesty-program/events/

National Park Service

- "Don't Let It Loose": This educational campaign provides numerous resources for educators on the issue of invasive species. The curriculum consists of numerous classroom activities targeted at middle school-aged students. "Interactive games and classroom activities instill students with the importance of responsible pet selection and ownership."
  http://www.nps.gov/ever/forteachers/dlil.htm

Aquatic Nuisance Species Task Force

- Habitattitude: This program is a partnership among several federal agencies—the USFWS is the lead—and the pet industry to educate the public about not releasing nonindigenous fish and aquatic plants.
  http://www.habitattitude.net/

Center for Invasive Species and Ecosystem Health

- Early Detection & Distribution Mapping System—EDDMapS: Developed by the University of Georgia with support from several federal agencies, EDDMapS is the portal for reporting and mapping observations of nonindigenous animals and plants in Florida. Here you can report observations and check current distribution maps for introduced plants and animals. You can also download smartphone apps for reporting your observations.
  http://www.eddmaps.org/

I hope you find these resources useful. If you have any suggestion, such as websites to add, please don't hesitate to email Steve Johnson at tadpole.ufl.edu.

NOTES

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