10 Years: Past, Present, Future

Lori G. Eckhardt, Ph.D.
Director, Forest Health Cooperative
Co-Director, Forest Health Dynamics Laboratory
School of Forestry and Wildlife Sciences
Auburn University, AL

Grants & Students Trained

- External Funding:
  - Secured over $5 million (as PI or co-PI) research support from the US Department of Agriculture, National Science Foundation, USDA Forest Service, Department of Defense, and several other national and international government and non-governmental organizations
- Students:
  - 19 graduate students (5 PhD and 14 MS); a postdoctoral fellow; 7 visiting scholars as well as 33 undergraduates and 4 high school students
  - These students have published 50 articles and reports, gave 356 scientific presentations (regionally, nationally and internationally) and won over 70 awards

History

- Forest Health Cooperative began in 2008
- To bring together parties interested in maintaining forest health, productivity, and sustainability
- Membership for those managing for or purchasing forest products, wildlife and endangered species
- Address important and current forest health issues with real world management as a focus

Forest Health Dynamics Laboratory

Dr. Lori Eckhardt
Co-director

Dr. Scott Enebak
Co-director

Sudden Oak Death State Laboratory for Alabama & Mississippi

Dr. Lori Eckhardt - Director

Mission Statement

To provide for watershed sampling and laboratory detection of Sudden Oak Death causing pathogen in waterways outside of nurseries which have had infected nursery stock in Alabama and Mississippi

Staff

Luis Mendez – Res Asst
Jessica Ahl – Res Assoc

Forest Health Cooperative

Dr. Lori Eckhardt - Director

Mission Statement

To address important, current and pertinent forest health issues (disease, insect, invasive species) in a way that addresses real world management problems in the southern United States

Staff

Dr. Nancy Loewenstein – Ext Splt
Luis Mendez – Res Asst
Angelica Baker – Lab Mgr

Southern Forest Nursery Management Cooperative

Dr. Scott Enebak - Director

Mission Statement

To develop and disseminate available cultural, biological and chemical technologies using an integrated system for the economical production and utilization of forest tree seedlings in the southern United States

Staff

Dr. Ryan Nadel – Asst Res Prof
Nina Payne – Res Assoc
Will Harges – Res Assoc

Eckhardt, L.G., Weber, A.M., Menard, R.D., Jones, J.P., and Hess, N.J. 2007. Association of an insect-fungal complex with loblolly pine decline in central Alabama. For Sci 53:84-92

Pine Decline

Monoterpenes released

Insects respond

Abiotic Stressors

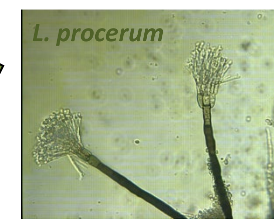
Topographic position
Fire
Edaphic
Weather

Insects Attack

Biotic Stressors

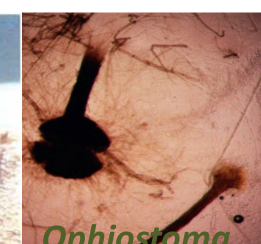
? Mutualistic ?

Fungi Colonize



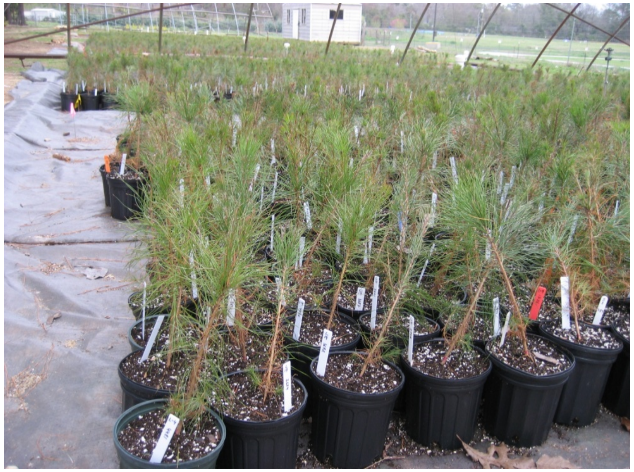
Death ← Decline

SPB Attack



Fungal-Host Interactions

Pathogenicity, Virulence & Resistance



George Matusick (PhD), Amritpal Singh (MS), Pratima Devkota (PhD)

Pathogenicity of *Leptographium* species to Southern Pines

George Matusick (PhD Candidate)

Study One: Variation in Virulence of Four Root-Inhabiting *Leptographium* species on Loblolly, Longleaf, and Slash Pine Seedlings

Questions

1. What is the relative virulence of four southeastern *Leptographium* species in southern pine seedlings?
2. Relative susceptibility of loblolly, longleaf, and slash pine seedlings to *Leptographium* species infection?

Study Two: The Pathogenicity and Virulence of Four Blue-Stain *Leptographium* species on Young Longleaf Pine Trees

Questions

1. Are southeastern *Leptographium* species pathogenic and virulent to young longleaf pine trees?

2. Does *Leptographium* infection cause significant vascular tissue dysfunction in young longleaf pine trees?

Essentially, what is the potential for *Leptographium* disease in young longleaf pine trees?

Study Two: The Pathogenicity and Virulence of Four Blue-Stain *Leptographium* species on Young Longleaf Pine Trees

Study Three: Virulence of *Leptographium serpens* on Longleaf Pine Seedlings Under Varying Soil Moisture Regimes

Questions

1. Is *L. serpens* pathogenic to longleaf pine seedlings?
2. Does soil moisture stress affect infection, or *L. serpens* pathogenicity?

Study Four: Variation in Pathogenicity and Virulence of Five Pathogenic Fungi in Healthy Loblolly and Slash Pine Roots

Conclusions

Loblolly Pine

- ✓ Controls
  - ➢ Wound Only = Wound + Sterile Media
- ✓ All Fungal Species Successfully Infected Roots
  - ➢ *L. procerum* and *L. serpens* were most proficient
  - ➢ *H. annosum* was less consistently isolated
- ✓ All Fungal Species Tested Cause a Significant Reaction
  - ➢ Pathogenic to loblolly pine roots
- ✓ Relative Virulence
  - ➢ *Leptographium huntii*
  - ➢ *L. serpens*
  - ➢ *L. terebrantis , H. annosum*
  - ➢ *L. procerum*

Slash Pine

- ✓ Controls
  - ➢ Family C: Wound Only= Wound + Sterile Media
  - ➢ Family D: Wound Only ≠ Wound + Sterile Media
- ✓ All Fungal Species Successfully Infected Roots
  - ➢ *L. serpens* and *L. terebrantis* were most proficient
- ✓ *Leptographium procerum* Did Not Cause Significant Reaction
  - ➢ All are pathogenic to slash pine roots, with exception of *L. procerum*
- ✓ Relative Virulence
  - ➢ *Leptographium huntii*
  - ➢ *L. serpens, L. terebrantis, H. annosum*
  - ➢ *L. procerum*

Study Five: Loblolly & Longleaf Pine Response to Root Inoculation with Four Blue-Stain *Leptographium* species





Conclusions

- ✓ Loblolly pine roots react significantly greater to wounds with sterile media
- ✓ All four *Leptographium* species can infect and cause a significant reaction in roots of loblolly and longleaf of all age classes tested and during both seasons
- ✓ Relative Virulence

Loblolly Pine	Longleaf Pine
1. *L. huntii*	1. *L. huntii*
2. *L. serpens*	2. *L. serpens*
3. *L. terebrantis*	3. *L. terebrantis*
4. *L. procerum*	4. *L. procerum*

- ✓ In loblolly pine, Larger lesions formed as a result of *L. huntii* infection in the spring
- ✓ In loblolly pine, Larger lesions formed as a result of *L. procerum* infection and control wound in fall
- ✓ In longleaf pine, larger lesions formed as a result of *L. huntii* infection in the older age class

Major Conclusions

1. The southeastern *Leptographium* species are on a whole pathogenic to loblolly, longleaf and slash pines
2. Virulence differences are apparent among the *Leptographium* species tested
   - *L. procerum* was found to be the least virulent species tested in each study
   - *L. huntii* was found to significantly more virulent than all other species in each study, with the exception of *L. serpens* in some instances
   - *L. serpens* appears to be slightly more virulent than *L. terebrantis* on the whole
3. All three pine hosts are susceptible to infection and disease
   - In immature tress longleaf pine appears to be more resistant and tolerant of infection
     - However, infection and damage was significant in longleaf pine roots
   - Large variability in the reaction to inoculation between trees in root inoculation studies
     - Much less variability in younger trees
       - Microsite Conditions?
       - Genetic Variability?

- Matusick*, G., Eckhardt, L.G., and Enebak, S.A. 2008. Pathogenicity of *Leptographium serpens* to longleaf pine seedlings under various moisture regimes. Plant Dis 92:1574-1576
- Matusick*, G. and Eckhardt, L.G. 2010. The pathogenicity and virulence of four ophiostomatoid fungi on young longleaf pine trees. Can J Plant Path 32:170-176
- Matusick*, G., Eckhardt, L.G., and Somers, G. 2010. The pathogenicity of four *Leptographium* species to mature longleaf pine roots. For Ecol Mgmt 260:2189-2195
- Matusick*, G. and Eckhardt, L.G. 2010. Variation in virulence among four root-inhabiting ophiostomatoid fungi on *Pinus taeda* L., *P. palustris* Mill., and *P. elliottii* Englem. seedlings. Can J Plant Path 32:361-367
- Matusick*, G., Somers, G., and Eckhardt, L.G. 2012. Root lesions in large loblolly pine (*Pinus taeda* L.) following inoculation with four root-inhabiting ophiostomatoid fungi. For Path 42:37-43
- Matusick, G., *Walker, D., *Hossain, M., Nadel, R.L., and Eckhardt, L.G. 2016. Comparative behavior of root disease pathogens in stems and roots of *Pinus* species. Fungal Biol 120:471-480.

Variation in Resistance of *Pinus taeda* and *Pinus elliottii* Families against *Leptographium* and *Grosmannia* Root Fungi

Amritpal Singh (MS Student)

Study One: Screening genetically improved seedling families for resistance to *Leptographium* spp.

Conclusions

General

- Variation among families
- Fungi vary in their virulence
- Localized symptoms
- Lesions found on almost all seedlings inoculated
- Mean root collar diameter and height not affected by fungi

Year One

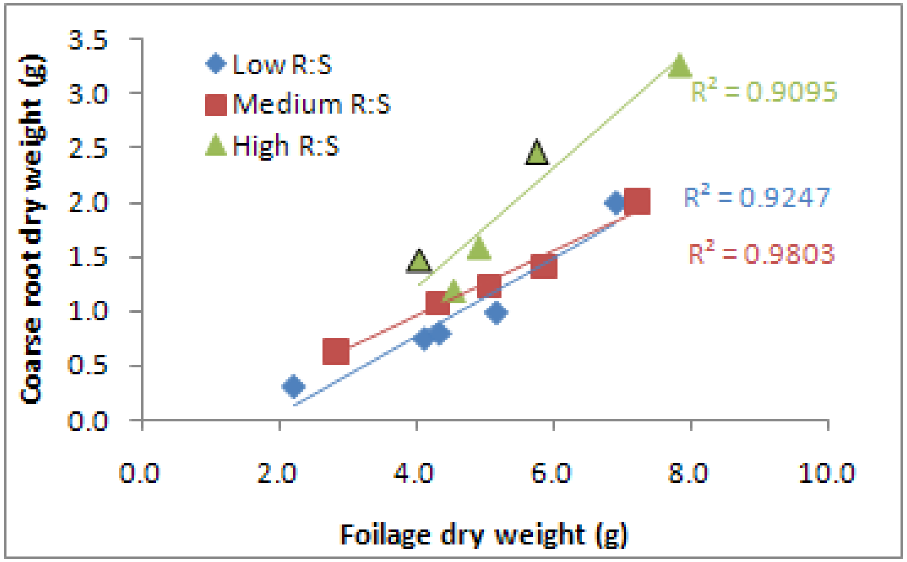
- Families L-5, L-8, L-13, and L-20 had consistently smaller lesions
- Families L-1, L-2, L-3, and L-4 developed consistently larger lesions
- No overall significant differences in *P. elliottii* families

Year Two

- Families L-42, and L-41 had consistently smaller lesions
- No significant differences between two *P. elliottii* families

Singh*, A., Anderson, D, and Eckhardt, L.G. 2014. Variation in resistance of loblolly pine (*Pinus taeda* L.) families against *Leptographium* and *Grosmannia* root fungi. For Path 44:293-298

Study Two: Assess the role of nitrogen and family morphological traits linked to *Leptographium* root infection

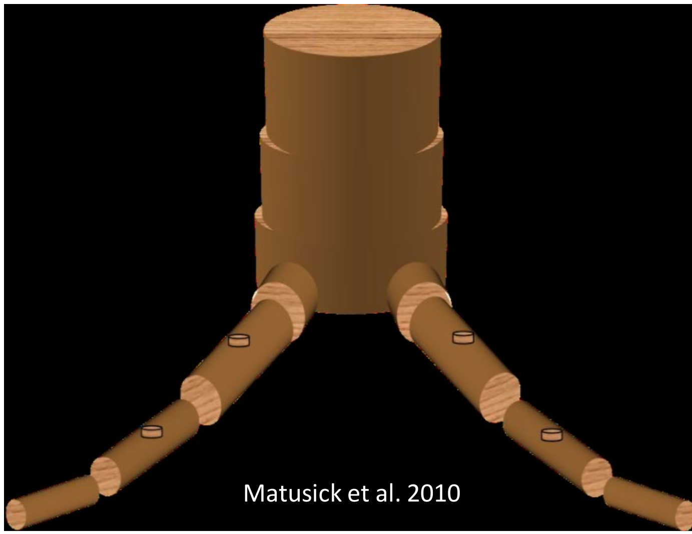


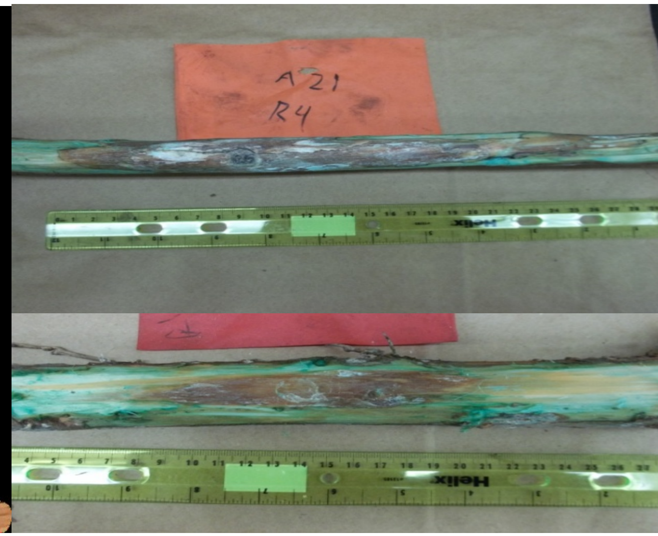
Conclusions

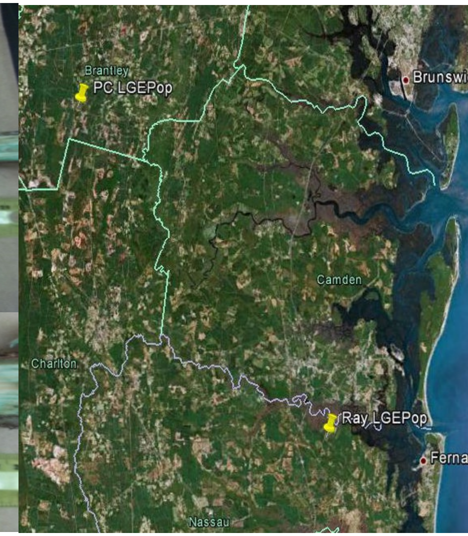
- Nitrogen nutrition did not affect susceptibility to *G. huntii*
- No significant relationship among lesion parameters and independent variables (N, R:S, Phenolic concentration)
- Lesion dimensions not the indicators of defense
- Nitrogen nutrition affected several seedling morphological variables (RCD, total dry weight)
- Family differences observed in stem total phenolic concentration

Amritpal Singh (MS)

Study Three: Screen mature tree families for *Leptographium* resistance







Conclusions

- Root lesions consistently observed across all treatments
- *Leptographium terebrantis* produced larger lesions
- Localized symptoms
- Root-feeding beetle activity
- No significant differences in lesion parameters among the families
- Diffused symptoms in long term studies

Response of *Pinus taeda* L. Families to Root Inhabiting Ophiostomatoid Fungi

Pratima Devkota (PhD Candidate)

School of Forestry and Wildlife Sciences – Auburn University

A performance comparison of bareroot and containerized *Pinus taeda* L. seedlings to the effect of ophiostomatoid fungi

Objective

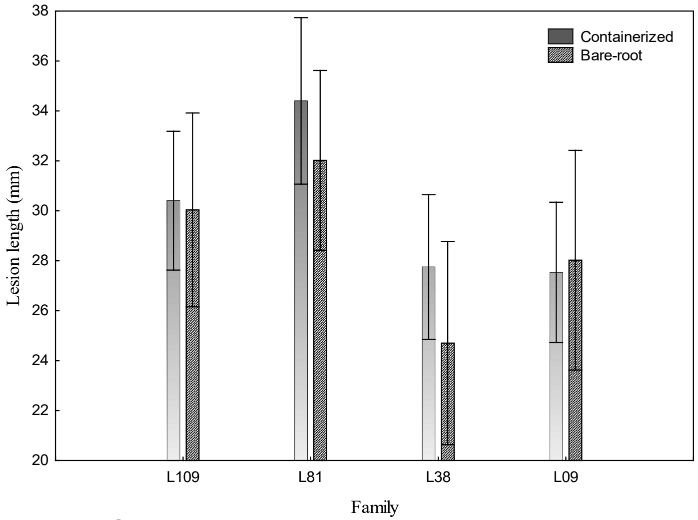
To evaluate responses of containerized and bareroot seedlings from the same *Pinus taeda* L. families to ophiostomatoid fungi

Approach

- Bareroot and container grown seedlings form four same families
- Artificial inoculation of fungi in root collar area
- Evaluation of infection and performance

Results

No significant differences between rootstocks from same family



Conclusions

- Seedlings from both *P. taeda* stockypes showed similar susceptibility to fungi
- Both seedling stocktypes can be used to screen the susceptibility of *P. taeda* families

Devkota*, P., Enebak, S.A., and Eckhardt, L.G. 2019. A performance comparison of bareroot and containerized *P. taeda* L. seedlings to the effect of ophiostomatoid fungi. Tree Planters Note (*In press*).

Intraspecific response of *Pinus taeda* L. to *Grosmannia huntii* and *Leptographium terebrantis* infection

Objective

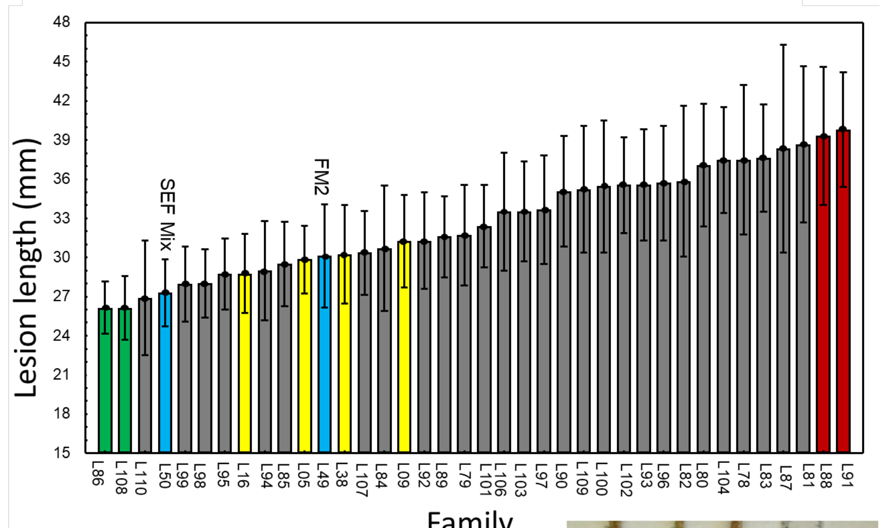
Rapid screening of large number of loblolly pine families to bark-beetle vectored fungi

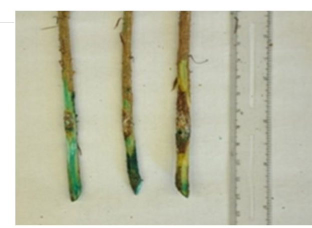
Approach

- 99 total families screened (years 2013-17)
- Robust experimental design
- Artificial Inoculation of fungal mycelia in the root collar area
- Evaluation of the fungal infection in individual seedling

Results

For instance (2014):





Conclusions

- Intra-species variation in tolerance to *L. terebrantis* and *G. huntii* exists
- Great potential for selection of ophiostomatoid fungi tolerant families

Devkota*, P., and Eckhardt, L.G. 2019. Intraspecific response of *Pinus taeda* L. to *Grosmannia huntii* and *Leptographium terebrantis*. For Path http://doi.org/10.1111/efp.12512

Intraspecies variation of mature *Pinus taeda* in response to root-infecting ophiostomatoid fungi

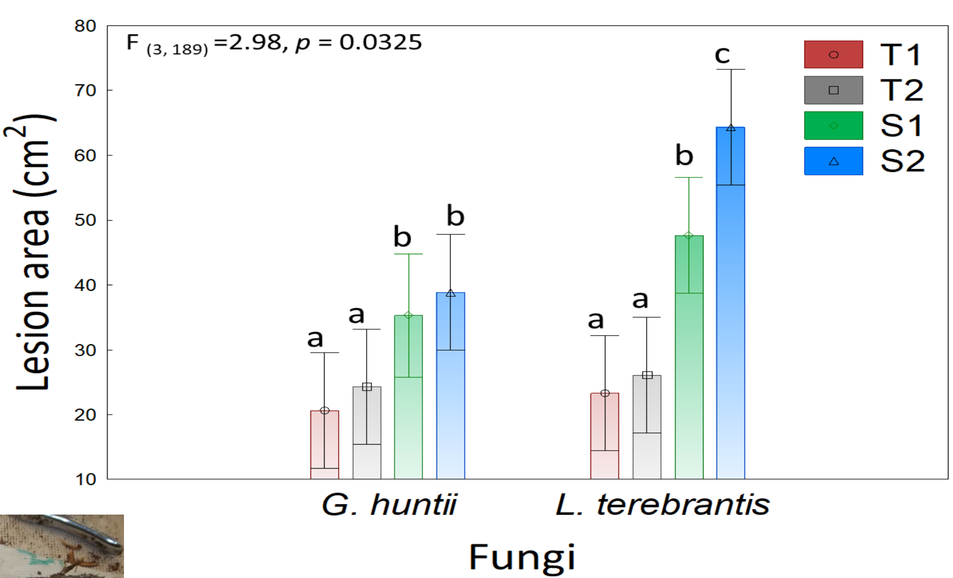
Objective

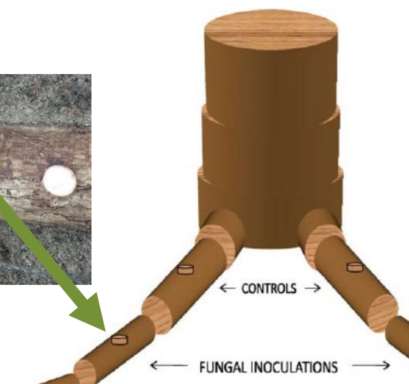
To determine the intra-species variation in tolerance of mature *P. taeda* families to root-infecting ophiostomatoid fungi

Approach

- Four loblolly pine families
- 2 tolerant and 2 susceptible to fungi
- Artificial root inoculation

Results





Matusick et al. 2010

Conclusions

- Intraspecies variation in tolerance of mature families to ophiostomatoid fungi
- Families had same patterns of tolerance independent of the tree growth stage
- Results support seedling screening studies

Devkota*, P., Nadel, R.L., and Eckhardt, L.G. 2018. Intra-species variation of mature *Pinus taeda* in response to ophiostomatoid fungi. For Path, https://onlinelibrary.wiley.com/doi/10.1111/efp.12415/full

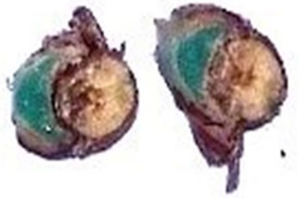
The impact of drought and vascular-inhabiting pathogen invasion in *Pinus taeda* health

Objectives

- Determine the combined effect of the drought and ophiostomatoid fungi in *P. taeda*
- Determine whether susceptibility of *P. taeda* families change under drought conditions

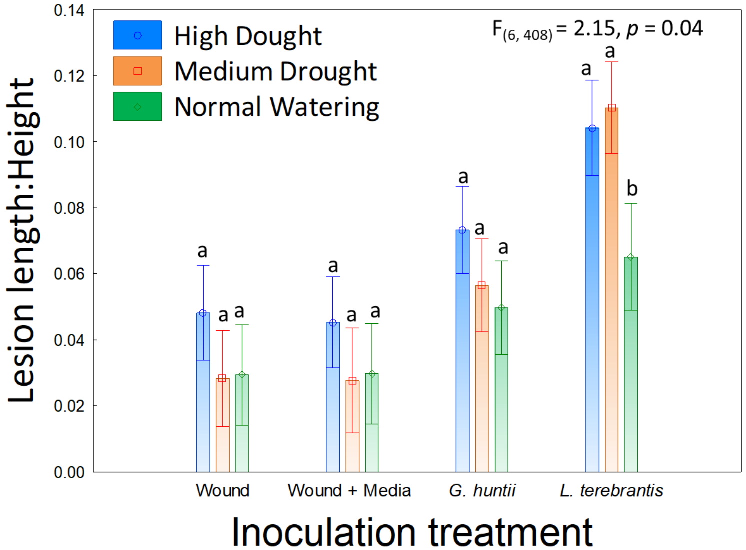
Approach

- Moisture Treatment: Normal moisture, Moderate drought, Severe Drought
- Fungal Treatment



Devkota*, P., Enebak, S.A. and Eckhardt, L.G. 2018. The impact of drought and vascular-inhabiting pathogen invasion in *Pinus taeda* health. Intl J For Res, https://doi.org/10.1155/2018/1249140

Results



Conclusions

- *L. terebrantis* was more pathogenic under moderate and severe drought than normal watering condition
- The susceptibility of the families to vascular-inhabiting fungi remained same under different watering treatments
- Drought and specific vascular-inhabiting fungi may negatively impact *P. taeda* stand health

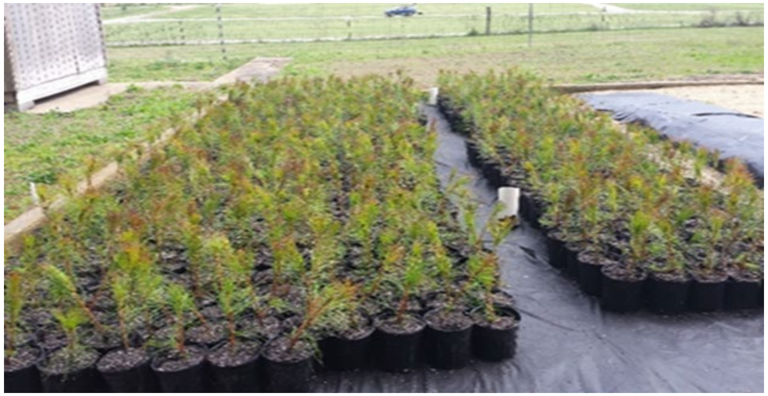
Variation in pathogenicity of different *Leptographium terebrantis* isolates to *Pinus taeda* L.

Objective

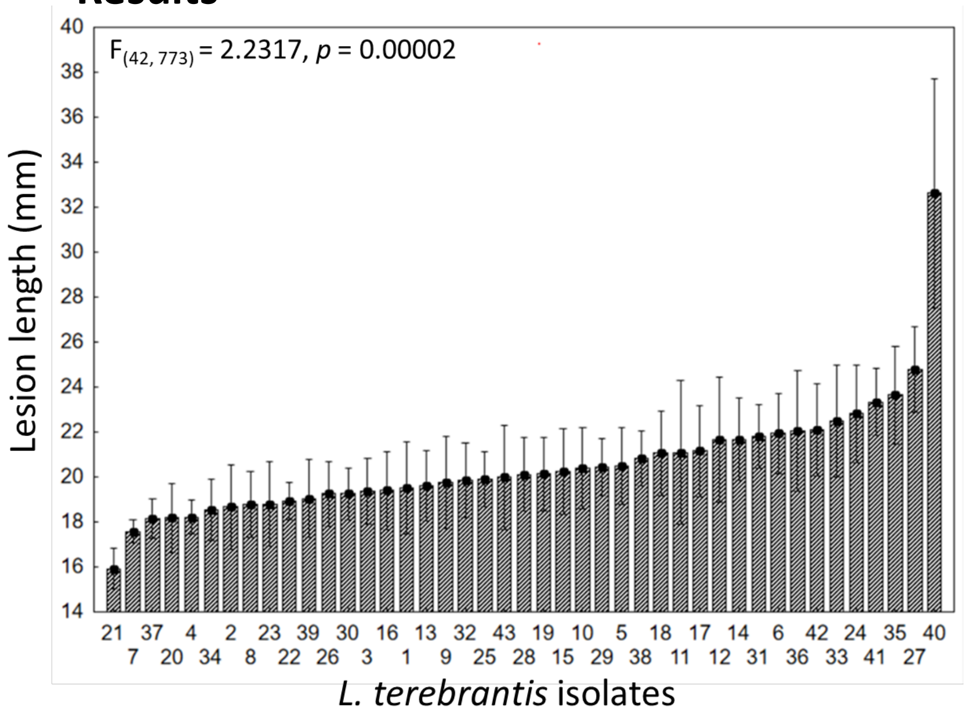
To determine the variation is pathogenicity among 41 isolates of *L. terebrantis*

Approach

- Single loblolly pine family
- 41 fungal isolates maintained in FHDL
- Inoculation at root collar area



Results



Conclusions

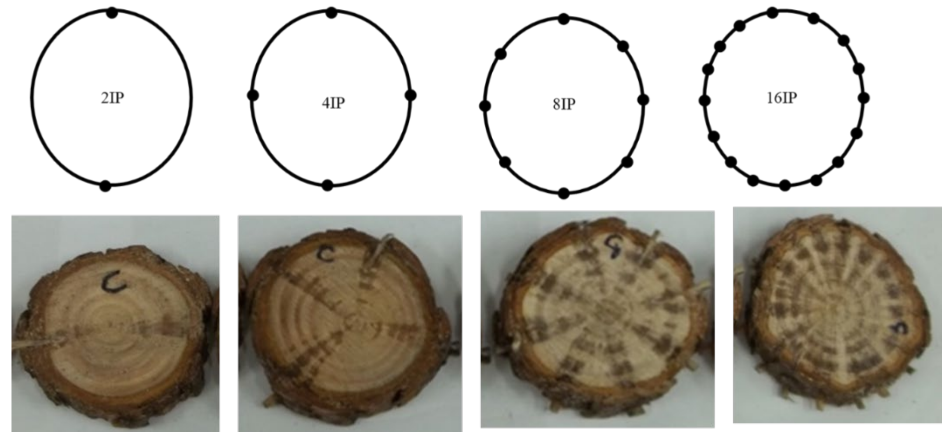
- *L. terebrantis* isolates have varying levels of virulence
- Most virulent isolate identified for QPD inoculation studies

Devkota*, P. and Eckhardt, L.G. 2018. Variation in pathogenicity of different *Leptographium terebrantis* isolates to *Pinus taeda* L. For Path, https://doi.org/10.1111/efp.12469

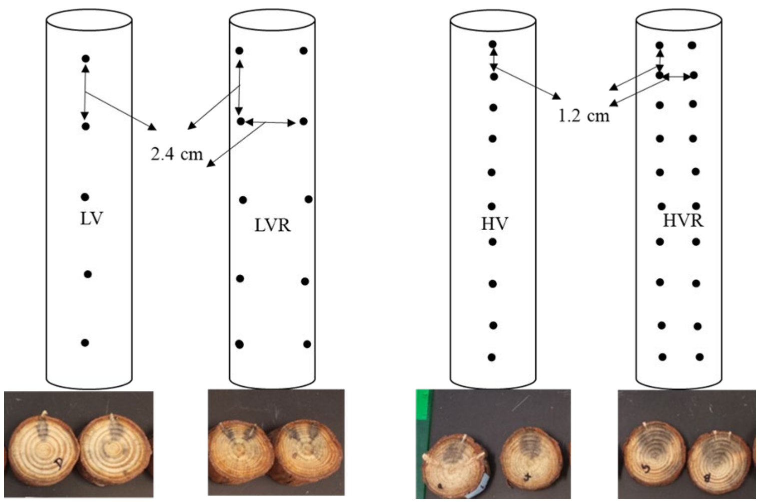
Pinus taeda L. response to differential inoculum density of *Leptographium terebrantis* colonized toothpicks

Objectives

- To develop a new inoculation technique that closely mimics natural inoculation of the fungus
- Determine the effects of radial inoculation densities in *P. taeda* saplings



Approach and Results



Conclusions

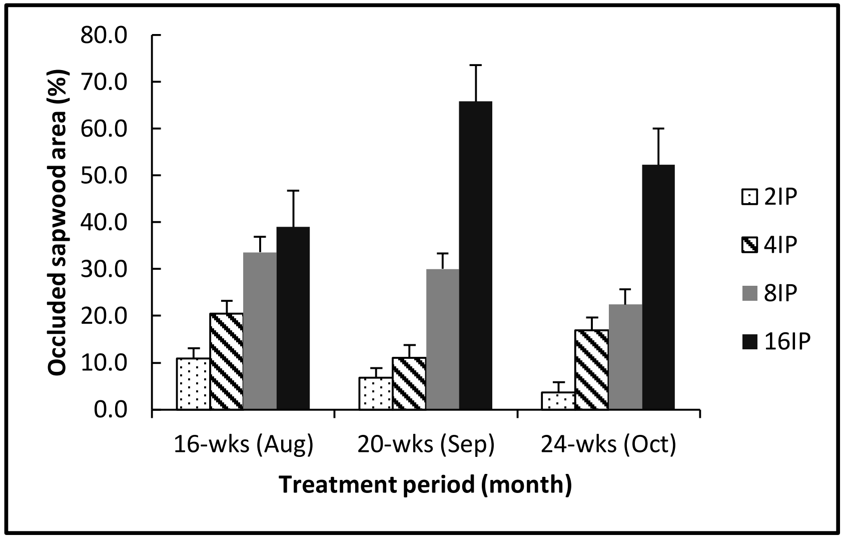
- The toothpicks served as a substrate for fungal growth and sporulation and showed utility in eliciting host's response to the pathogen.
- Percentage of tissue occlusion area, occlusion length and volume increased with increasing radial inoculum density
- The highest and lowest inoculum densities caused occlusions of 45.6 % and 9.0 %, respectively

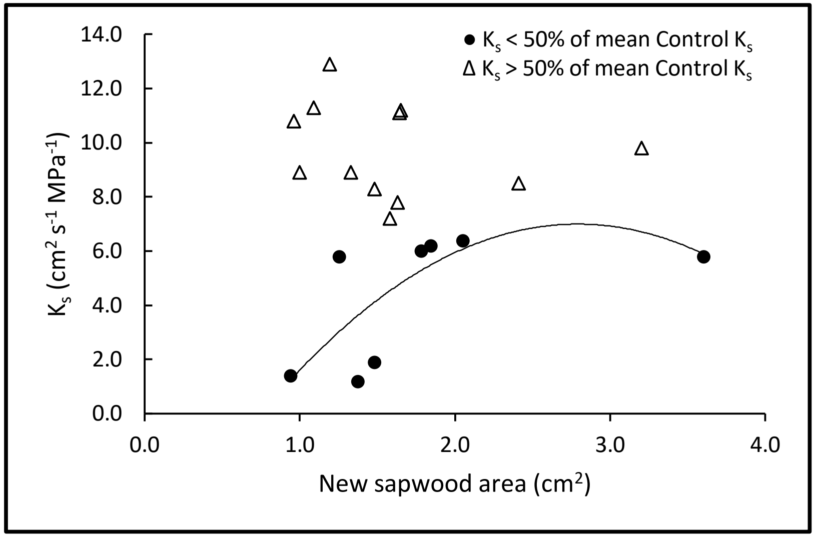
Devkota*, P., Mensah*, J.K., Nadel, R.L., Matusick, G. and Eckhardt, L.G. 2018. *Pinus taeda* L. response to differential inoculum density of *Leptographium terebrantis* colonized toothpicks. For Path, https://doi.org/10.1111/efp.12474

Physiological response of *Pinus taeda* L. saplings to four levels of stem inoculation with *Leptographium terebrantis*

Objective

Determine the relationships between pathogen inoculation density, sapwood occlusion, and sapwood function characterized by hydraulic conductivity and capacitance



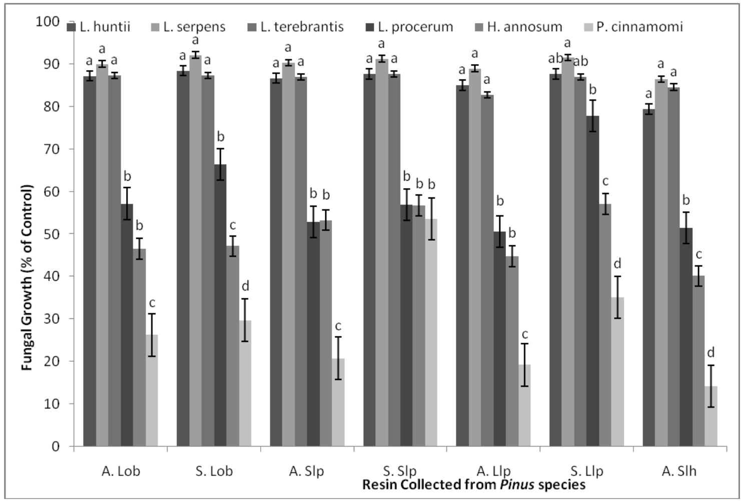


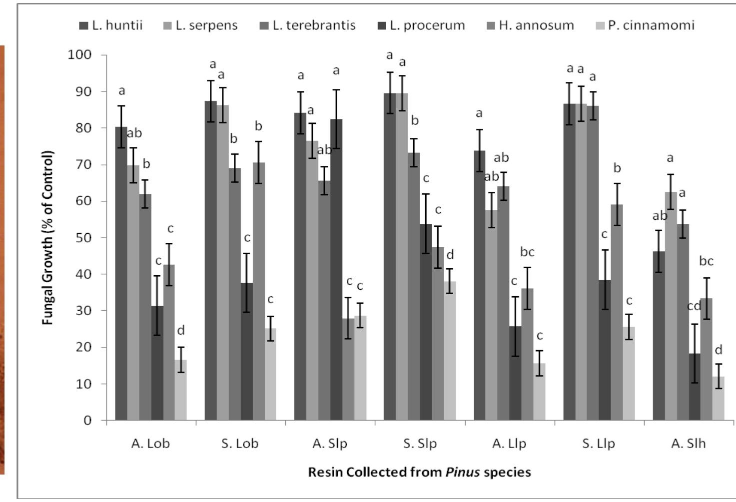
Conclusion

We observed decreases in stem hydraulic conductivity and capacitance as occluded sapwood area increased, and a positive correlation between the vertical spread of the pathogen and loss of stem capacitance

*Mensah, J.K., Sayer, M.A.S., Nadel, R.L., Matusick, G. and Eckhardt, L.G. (In preparation) Physiological response of *Pinus taeda* L. saplings to four levels of stem inoculation with *Leptographium terebrantis.* Tree Physiology

Effects of Oleoresins and Terpenoids on Fungal Growth associated with Pine Decline in the Southern United States





Conclusions:

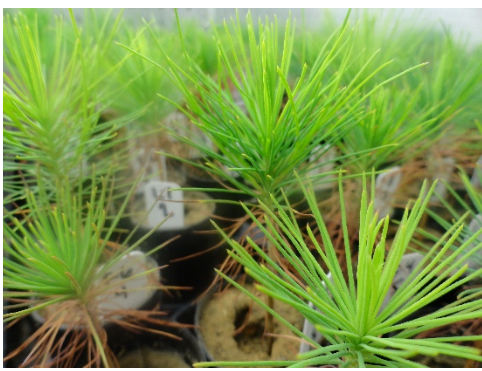
- Fungi differed in their sensitivity to crude oleoresin and terpenes
- *H. annosum* and *P. cinnamomi* were the most inhibited by both the oleoresin and terpenes
- Ophiostomatoid fungi were less inhibited, but *L. procerum* was more inhibited than *L. terebrantis* which was more inhibited than *L. serpens* and *L. huntii*
- Most of the time *L. procerum* was not different from *H. annosum* or *P. cinnamomi*

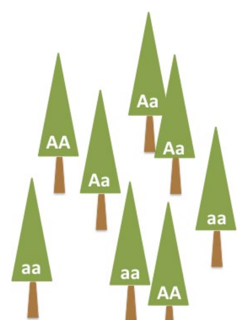
Eckhardt, L.G., Menard, R.D., and Gray, E. 2009. Effects of oleoresins and terpenoids on the fungal growth associated with pine decline in the southeastern United States. For Path 39:157-167

Fungal Pathogen Tolerance and Geographic Variation Influence Ectomycorrizal Traits of Loblolly Pine

Conclusions:

- Evidence of genetic correlations between fungal pathogen tolerance and *Thelephora*
- Evidence of genetic correlations between fungal pathogen tolerance and relative growth rate
- Outcome of genetic correlations differs among soil environments
- Loblolly pine interacts with EM species differently
- Environmental variation has more influence on mycorrhizal community than genetic variation
- Genetic correlations between mycorrhizal traits and other traits

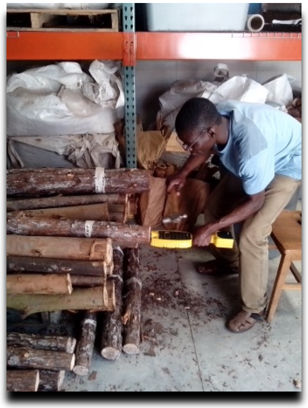




Piculell*, B.J. Nelson, C.D., Roberds, J., Eckhardt, L.G., and Hoeksema, J.D. 2018. Genetically determined fungal pathogen tolerance and soil variation influences ectomycorrhizal traits of loblolly pine. Ecol Evol. 8:9646-9656

Bridget Piculell (PhD)

Using Wood Chemistry to Model for Disease Resistance



Forest Products vs Disease Resistance

Low lignin, high cellulose

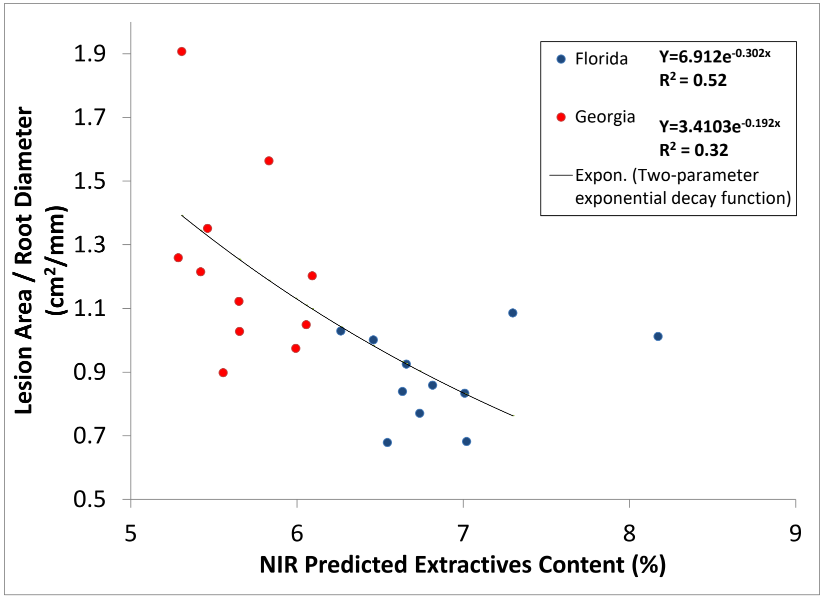
Is extractives a problem? Not for lumber but maybe for paper.

High extractives

Probably not high lignin (conflicts with products)

Family	Lignin	Cellulose	Extractives
A1	Low	Medium	Medium
A21	Low	Medium-Low	High
A13	Low	High	Low
A34	Low	Medium-Low	Medium-Low
F17	High	Medium	High
A33	High	Low	High
A37	High	Low	High
A10	Medium-Low	High	High

Control of Lesion Area through Enhanced Extractives Content



In cooperation with Dr. Via, Wood Products Development Center

Gifty Acquah (PhD), Charles Essien (PhD)

Fungal-Insect Interactions

Hylastes salebrosus

Hylobius pales

Hylastes tenuis

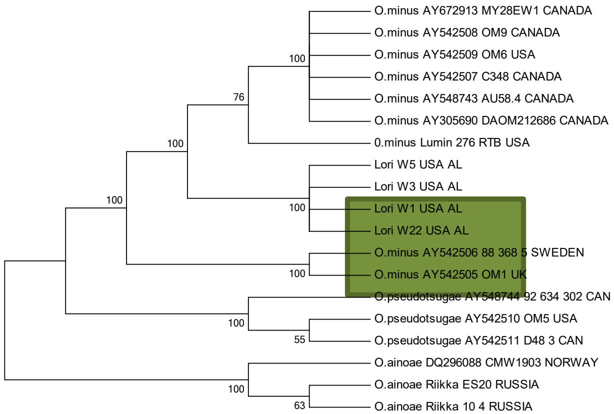
Dendroctonus terebrans

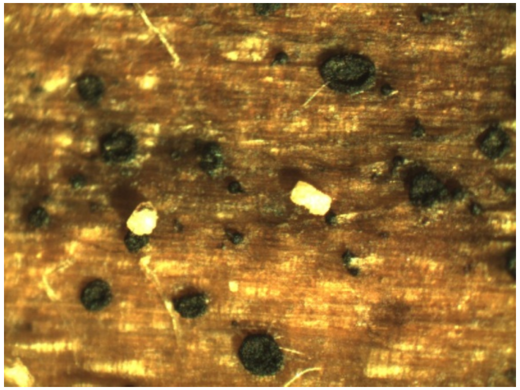
Djibo Zanzot (PhD), Yuan Zeng (MS), Jacob Thompson (MS), Ben Brunson (MS), Andrea Wahl (MS), Pratima Devkota (PhD), John Mensah (PhD), Jessica Ahl (MS)

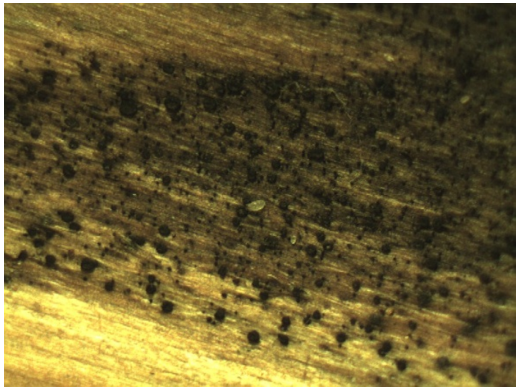
New Ophiostoma's (GA and AL)

Hylastes galleries infested with *Ophiostoma* in loblolly and longleaf pine

Djibo Zanzot (PhD), George Matusick (PhD), Tessa Bauman (PhD)





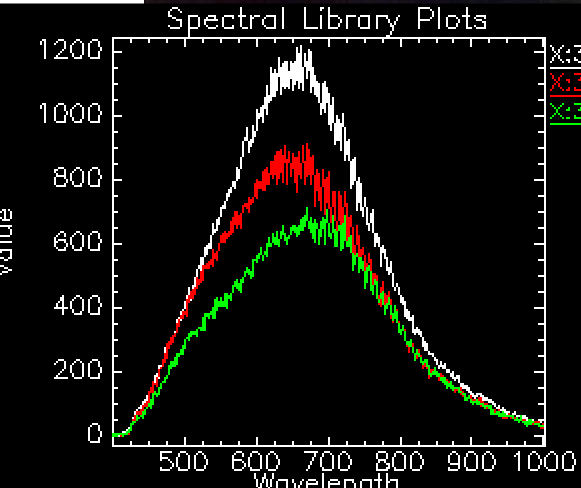


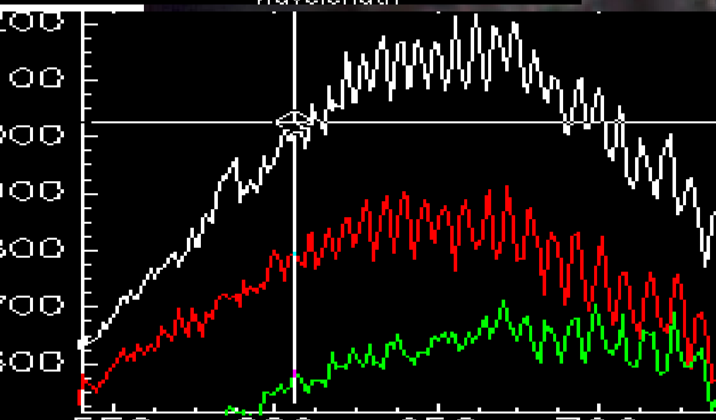
Eckhardt, L.G., *Bauman, T.A., de Beer, Z.W., Duong, T., Matusick, G., and Wingfield, M.J. (*In preparation*) New *Ophiostoma* species from *Hylastes salebrosus* and *Hylastes tenuis* galleries in Alabama and Georgia. Mycol. Res.

Using NIR to map fungal spores on insect body

```
File: Tube 3 - etalon Class Th 04

Class Name   Npts      Pct
----------   ----      ---
Unclassified [348563] 99.962%
X:339 Y:310  [133]    0.038%
```

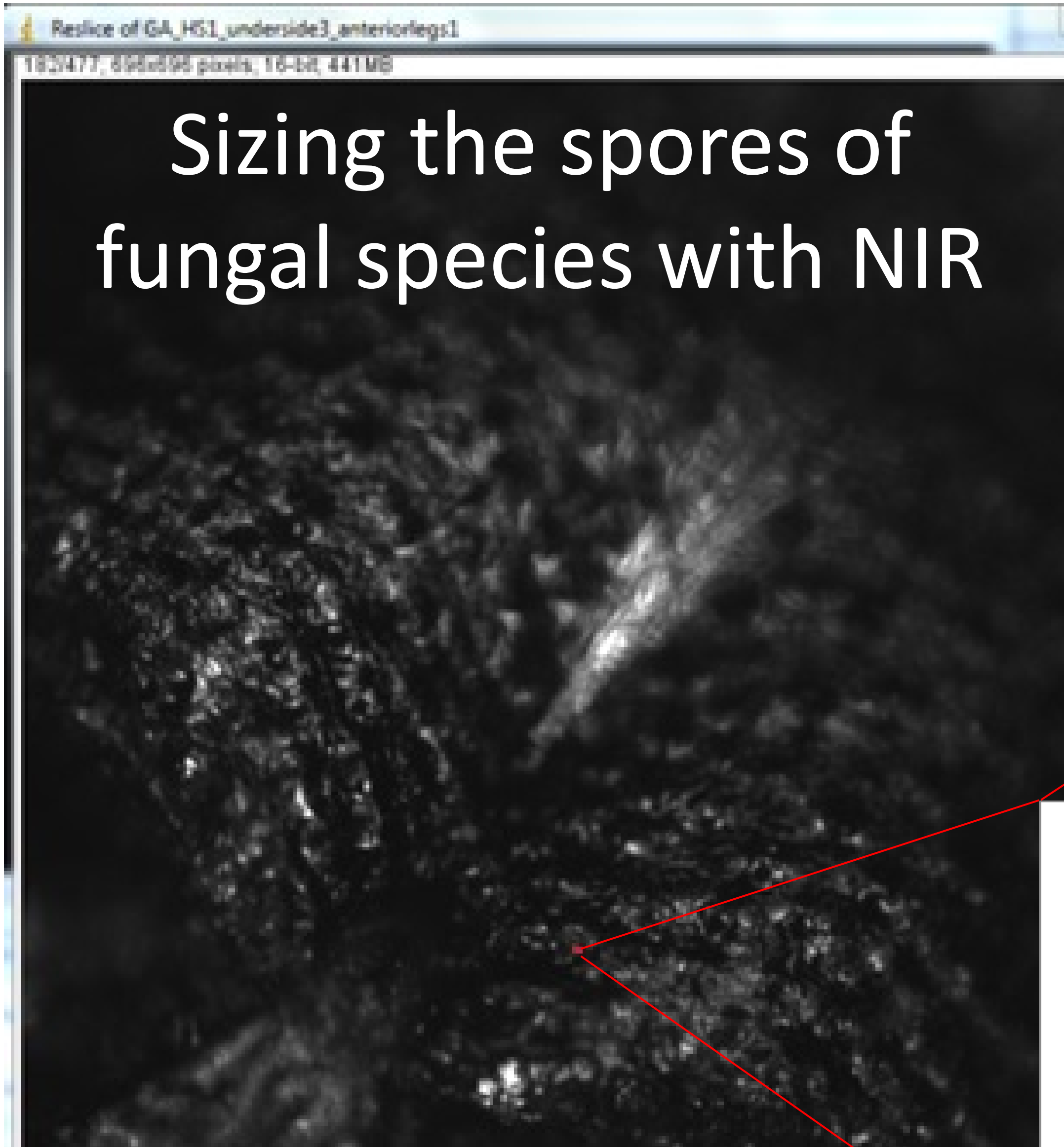


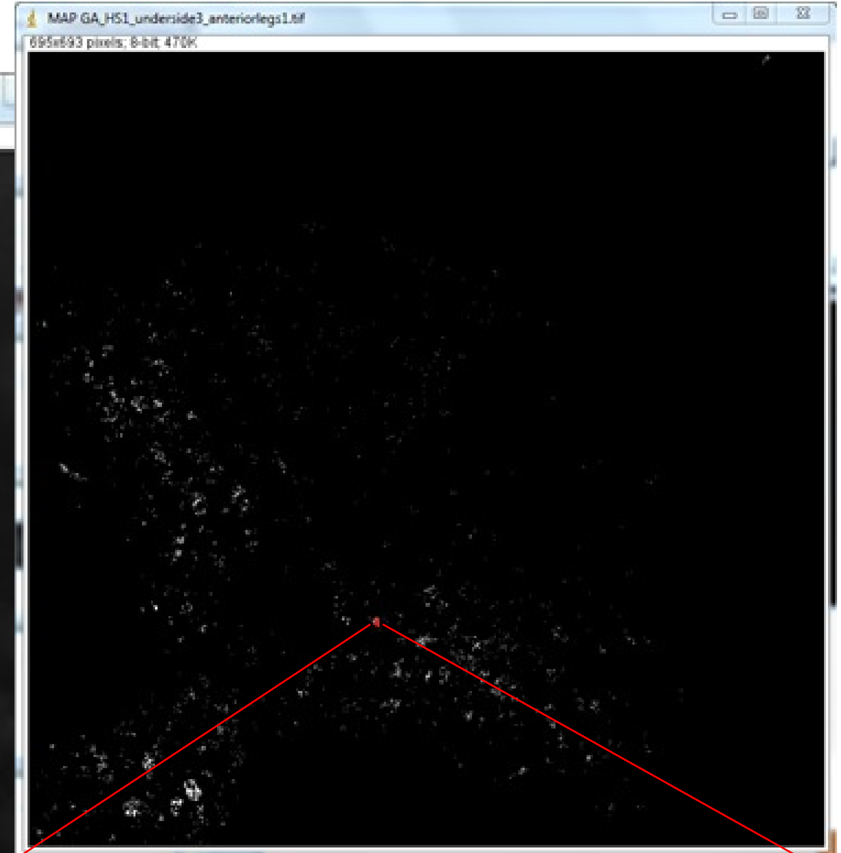


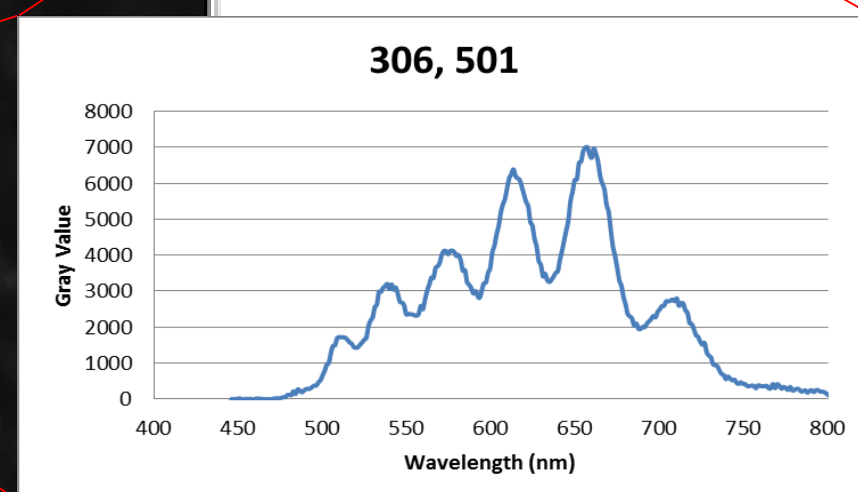
Hs: G. alacris map   Hs: G. alacris SL

Beach, J., Uertz, J., and Eckhardt, L. 2015. Hyperspectral interferometry: sizing micro-scale surface features in the pine bark beetle. Microsc Res Techniq 78:873-885

Sizing the spores of fungal species with NIR

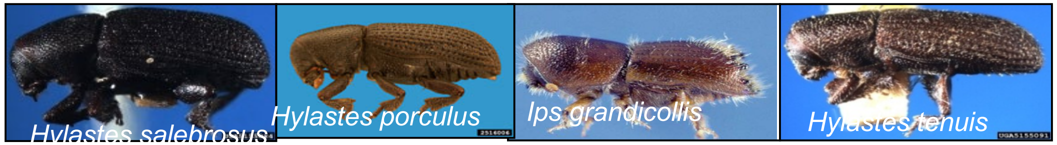






Ahl, J. and L. Eckhardt (*In Review*). Identifying fungal spores on the pine bark beetle with hyperspectral interferometry. Microsc Res Techniq.

Other Insect-Fungal Publications



- Zanzot*, J.W., Matusick, G., and Eckhardt, L.G. 2010. Activity of root-feeding insects and their associated fungi on longleaf pine in Georgia. J Econ Entomol 39:415-423
- Matusick*, G., Menard, R.D., Zeng, Y., and Eckhardt, L.G. 2013. Root-inhabiting bark beetles (Coleoptera: Curculionidae) and their fungal associates breeding in dying loblolly pine in Alabama. Fla Entomol March: 238-241
- Riggins, J.J., Little, N.S., and Eckhardt, L.G. 2014. Correlation between infection by ophiostomatoid fungi and the presence of eastern subterranean termite (*Reticulitermes* spp.) in loblolly pine (*Pinus taeda*) roots. Agric For Entol 16:260-264
- Clay, N.A., Siegert, C., Tang, J., Little, N., Eckhardt, L.G. and Riggins, J.J. (*Submitted*) Termite activity on loblolly pine wood differs between presence of four root-infecting bluestain (ophiostomatoid) fungi species. Fungal Ecology
- Eckhardt, L.G., *Bauman, T.A., de Beer, Z.W., Duong, T., Matusick, G., and Wingfield, M.J. (*In preparation*) New *Ophiostoma* species from *Hylastes salebrosus* and *Hylastes tenuis* galleries in Alabama and Georgia. Mycol. Res.

Host Stress Factors

Predisposing Stressors

- Abiotic
  - Topography
  - Edaphic
- Biotic
  - Gentic
  - Age

Contributing Stressors

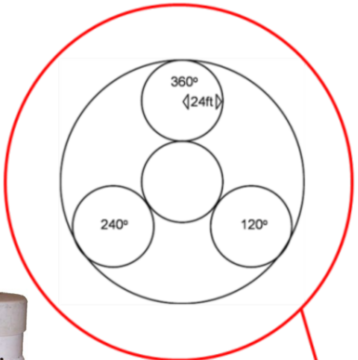
- Vector populations
- Inoculum potential

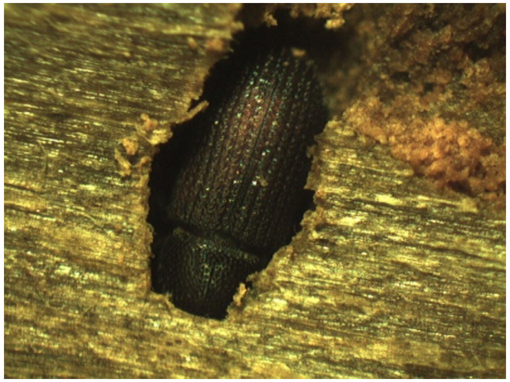
Inciting Stressors

- Anthropogenic disturbances
  - Silvicultural (any management)
  - Recreational (ie. off-road vehicles)
  - Training (ie. Military)
- Natural disturbances
  - Weather (ie. drought, flood, storm)
- Biotic issues
  - Stand density
  - Stand species composition
  - Understory vegetation density

Effects of Fertilization and Thinning on Root-feeding bark beetles (RW-19)

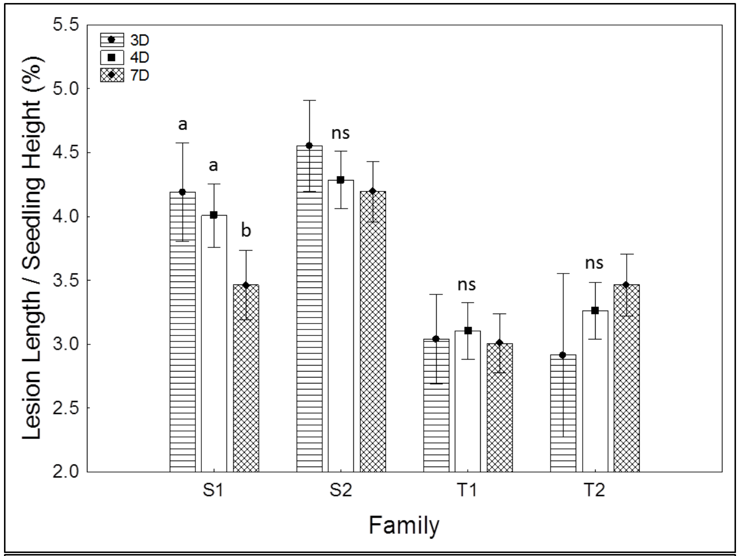
	BTB	Hpo	Hs	Ht	Pp	Hp
Fertilization						
Fertilizer	36 a	117 a	1481 a	272 a	6 a	35 a
No Fertilizer	35 a	82 b	1123 b	221 b	3 b	28 a
Thinning						
100	41 a	65 b	1389 a	260 a	6 a	35 a
200	38 a	99 b	1464 a	279 a	4 ab	32 a
300	46 a	128 a	1425 a	265 a	5 ab	32 a
500	18 b	108 a	931 b	183 b	2 b	27 a

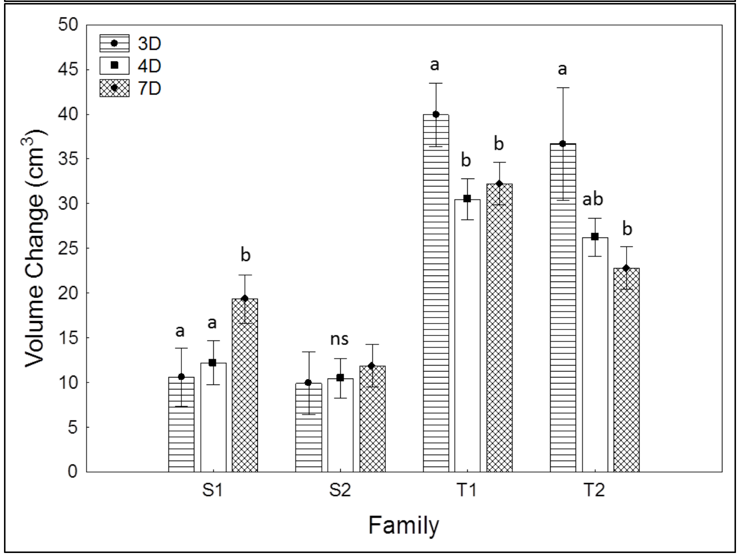




Zeng*, Y., Kidd, R., and Eckhardt, L.G. 2013. The Effect of thinning and clear-cut on changes in the relative abundance of root-feeding beetle (Coleoptera: Curculionidae) in *Pinus taeda* plantations in Central Alabama and Georgia. Pest Manag Sci 70:915-921

Effects of Moisture Stress on Southern Pine Decline



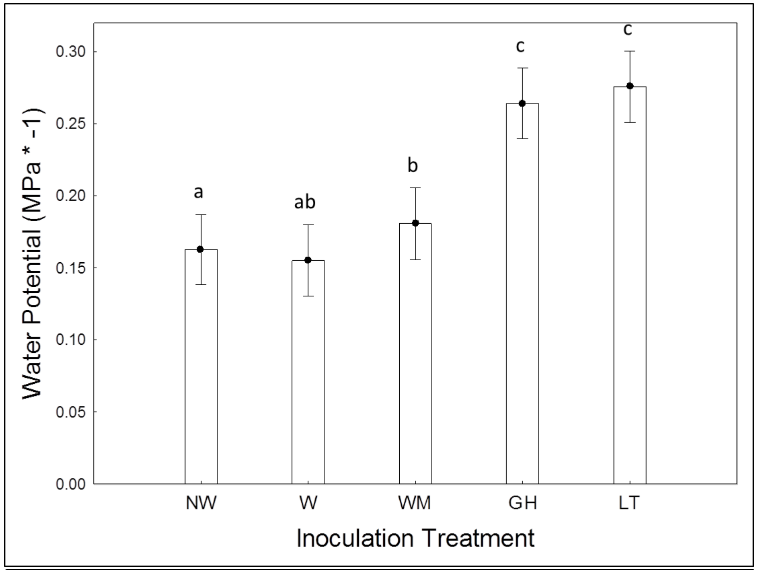


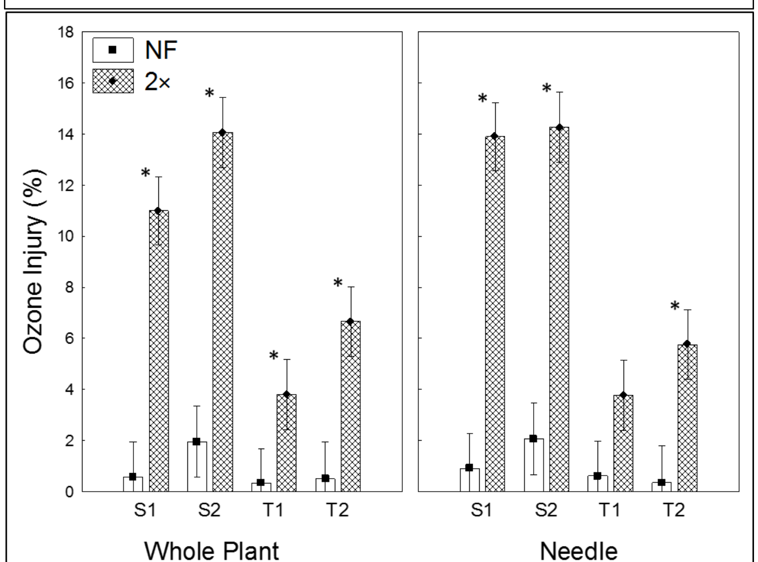
Conclusions:

- Families tolerant to SPD associated fungi are more tolerant to water stress
- Wound/lesion lengths increased with simulated climatic treatment
- Short-term responses may show increased growth/resilience to treatment effects, but the tolerance strategies may not be sustainable long-term

Chieppa, J.J., Eckhardt, L.G., and Chappelka, A.H. 2017. Simulated summer rainfall variability effects on loblolly pine (*Pinus taeda*) seedling physiology and susceptibility to root-infecting ophiostomatoid fungi. Forests 8:132-145

Effects of Ozone on Southern Pine Decline





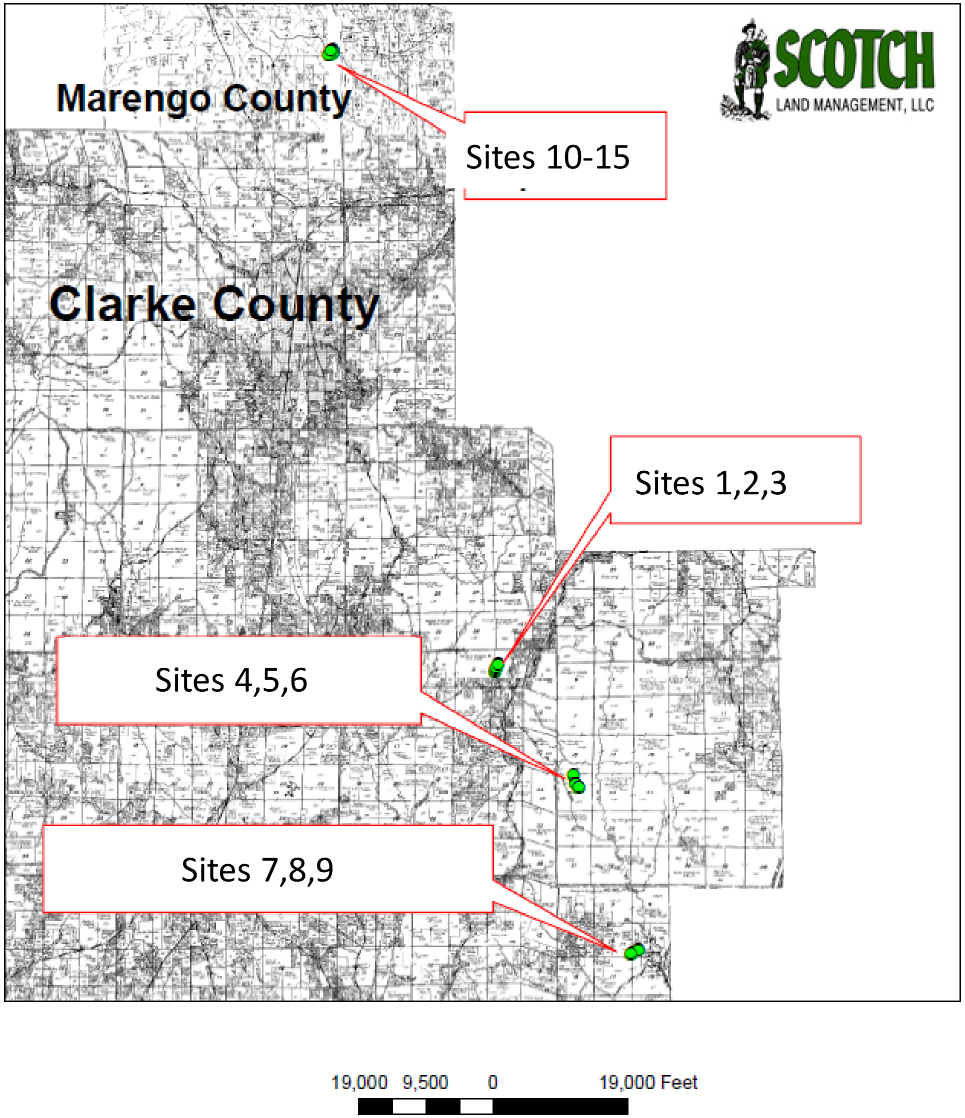
Conclusions:

- Families tolerant to SPD associated fungi are more tolerant to ozone
- Exposure to ozone makes seedlings more susceptible to wounds/injury
- Seedlings would likely succumb to reduced water uptake (inoculation), decreased chlorophyll content (ozone) and inhibited phloem function (both) over long periods

Chieppa*, J.J., Chappelka, A.H., and Eckhardt, L.G. 2015. Effects of tropospheric ozone on loblolly pine seedlings inoculated with root infecting ophiostomatoid fungi. Environ Poll 207:130-137

Jeff Chieppa (MS)

Fire Effects on Insect Populations in Managed Pine



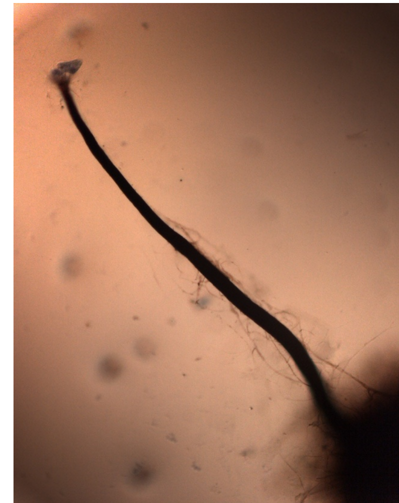
- Pest insect numbers were highest in the burned and symptomatic areas
- Pest insect numbers were lowest in the unburned area

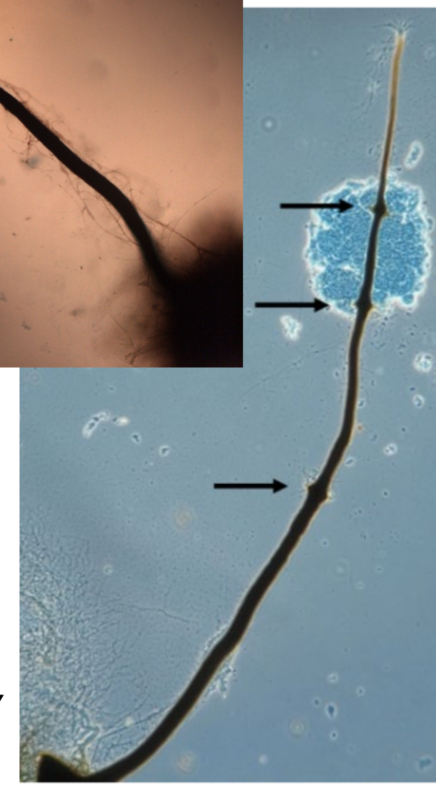
- Unburned and unmanaged control sites had the most severe and virulent pathogens
- Most severe pathogen species found on the sites with the lowest insect infestation levels

Tessa Bauman (PhD)

Feral Hogs & Ophiostomatoid Fungi

100 Wild Pigs sampled
2006, 2008, 2010

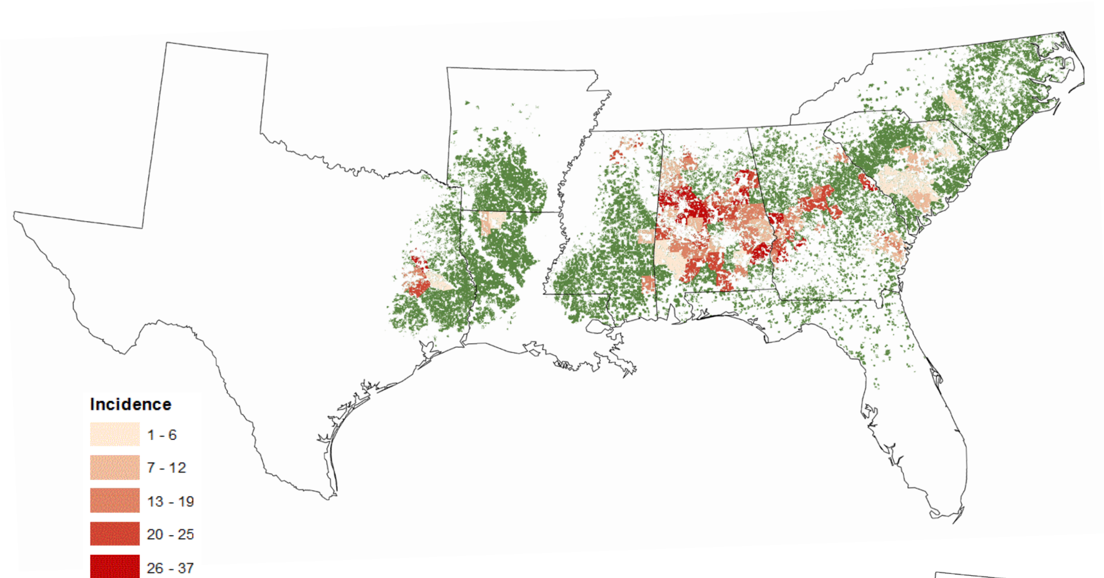


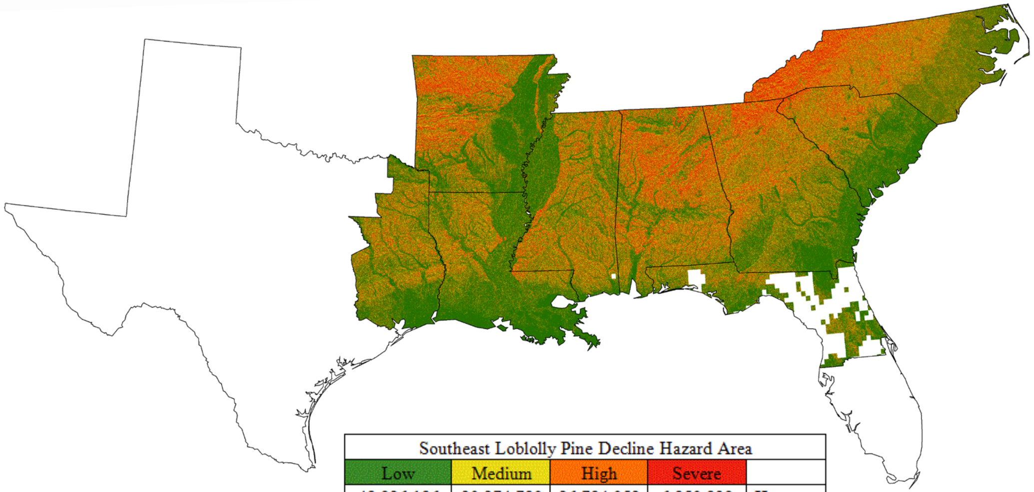


L. profanum	*O. sparsiannulatum*	*Sporothrix ditchkoffii*
48%	51%	67%

Management Tools

LPD Incidence & Risk across the Southeast U.S.



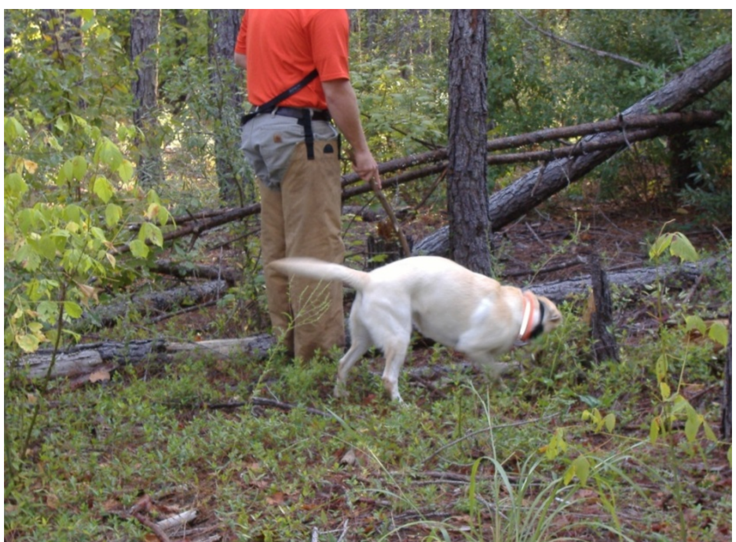


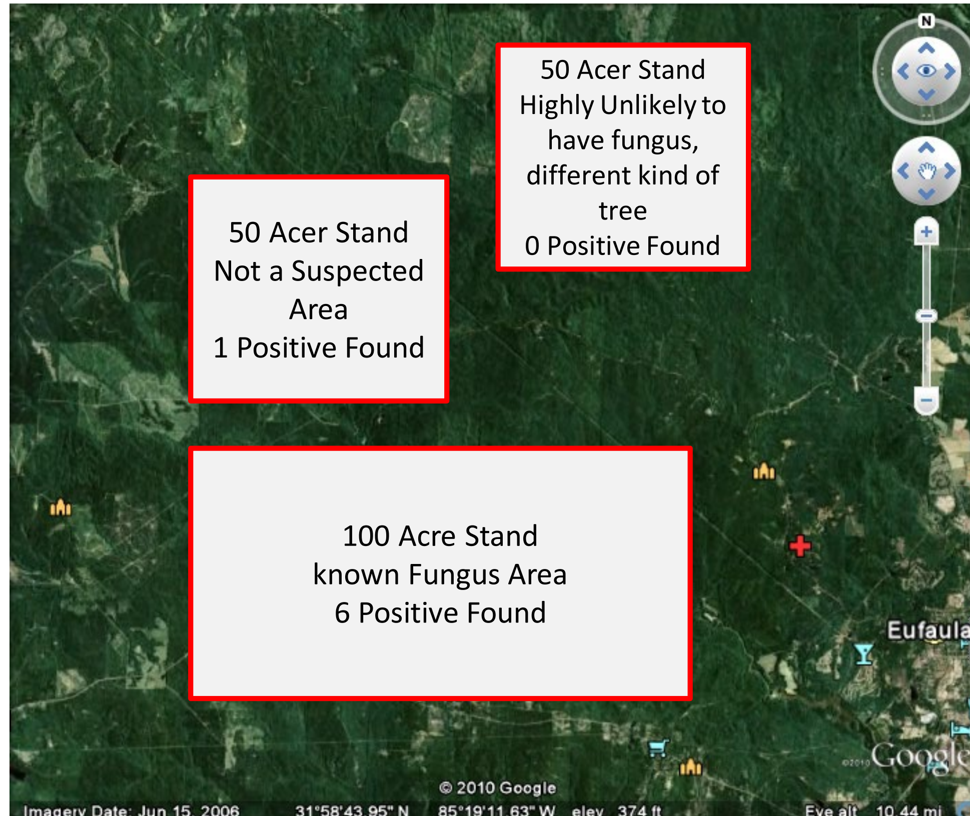
Southeast Loblolly Pine Decline Hazard Area				
Low	Medium	High	Severe	
48,926,186	20,274,780	26,784,052	6,850,839	Hectares
120,894,947	50,098,296	66,182,488	16,928,189	Acres

Eckhardt, L.G. and Menard, R.D. 2008. Topographic features associated with loblolly pine decline in central Alabama. For Ecol Mgmt 255:1735-1739

Timber Dogs

- Enhance forest management by finding fungus before above ground symptoms appear
- Pinpoint infected trees
- Remove unwanted trees
- Protect your surrounding forests





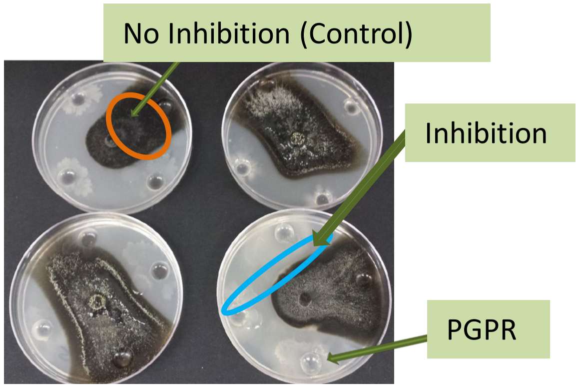
Towards biocontrol of ophiostomatoid fungi by Plant Growth-Promoting Rhizobacteria

Objective

To understand if specific strain of Plant Growth Promoting Rhizobacterial (PGPR) inhibits the growth of blue-stain fungi

Approach

Antibiosis assay-29 PGPR Strains



Results

- 22 PGPR strains inhibited the growth of the fungi *in vitro*
- PGPR may produce some metabolites which inhibit the growth of the fungi

*Devkota, P., Kloepper, J.W., Enebak, S.A. and Eckhardt, L.G. (*Submitted*) Towards biocontrol of ophiostomatoid fungi by plant growth-promoting rhizobacteria. Biocontrol Sci Tech

Objective

To understand if PGPR strains will induce the systemic resistance of loblolly pine to blue-stain fungi

Approach

- PGPR - *Serratia marcescens* (90-166), *Bacillus pumilus* (INR 7, and SE-34)
- Artificial inoculation of fungi (*G. huntii* and *L. terebrantis*) in *P. taeda* seedlings

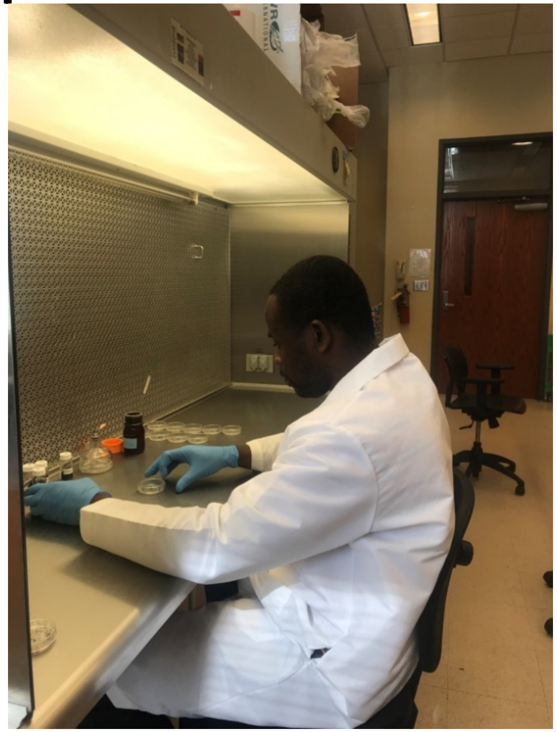
Results

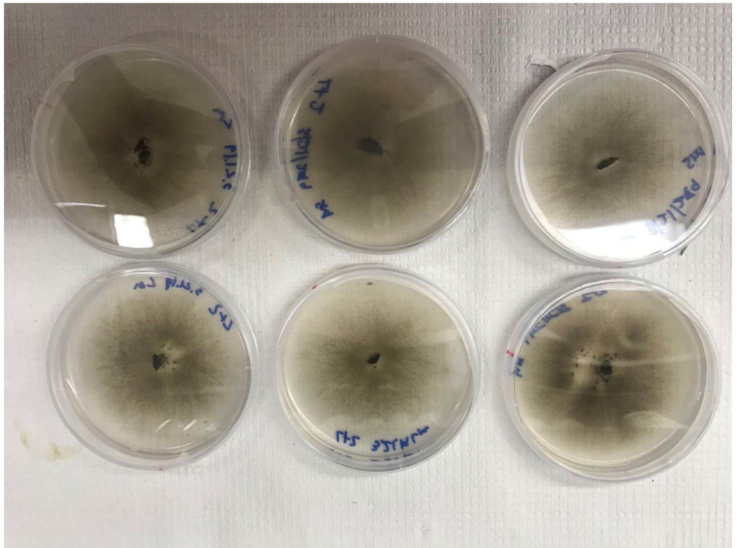
- Specific strains of PGPR offer biological control (induce systemic resistance) to ophiostomatoid fungi
- Promoted plant growth

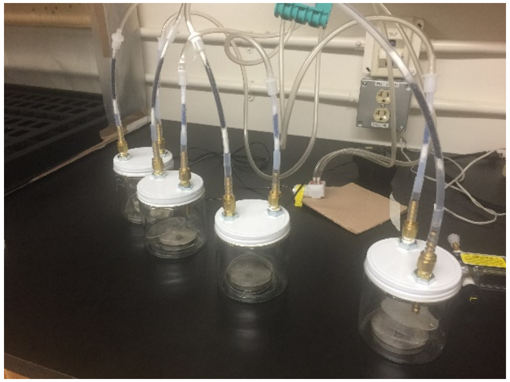
Overall Conclusions

1. Most of the studied PGPR strains inhibited the growth of the fungi.
2. Fungal sporulation was inhibited.
3. Study demonstrates that PGPR produce some metabolites which inhibit the growth of the fungi.

Emission of Volatile Organic Compounds by *Amylostereum* & Ophiostomatoid Fungi







In cooperation with Dr. Cale, University of Alberta, Edmonton

Sylvester Menanyih (MS)

Cogongrass Impacts on Loblolly Pine Susceptibility to Bark Beetles & Pine Decline

AFRI, CSREES, USDA 2010-85320-20363

Impacts of Cogongrass (*Imperata cylindrica* (L.) Beauv) on Populations of Root-feeding Bark Beetles associated with Southern Pine Decline

Conclusions:

Significant increase in insect populations with stand age and cogongrass infestation

- *Hylastes salebrosus*, *H. porculus*, *D. terebrans*, and *Hylobius pales* all with increased populations

Cogongrass affecting water availability to pine roots

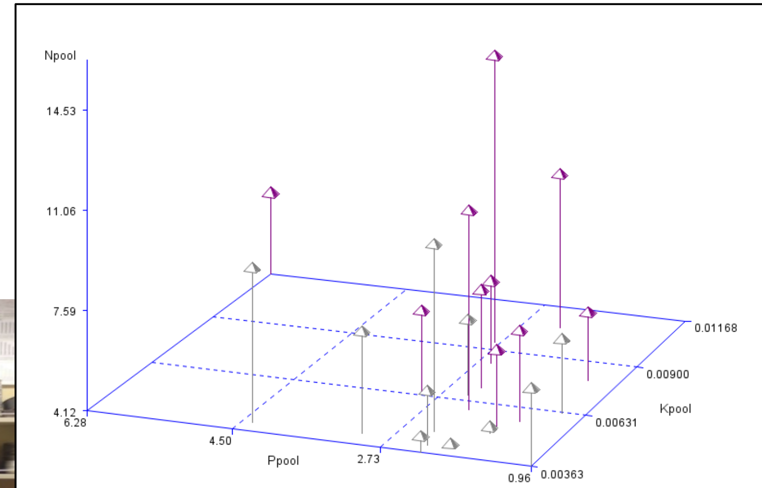
- Significant moisture differences in root zone

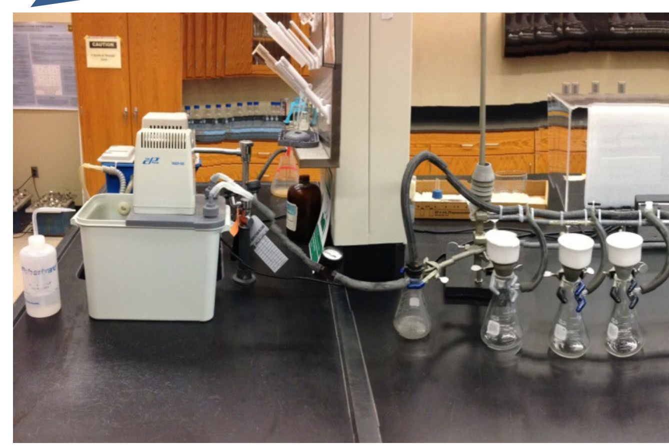
Cogongrass reducing pine root growth and radial growth

- Significant difference in 10-year radial growth

Ben Brunson (MS)

Microbial Activities and Abiotic Soil Conditions in Pine Stands Invaded by Cogongrass





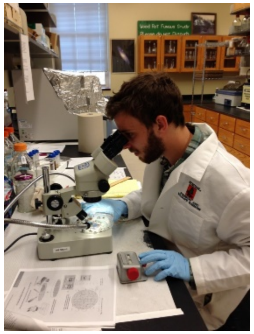
Differences are observed in microbial activity in the most active season

Nitrogen, Potassium and Phosphorus are found in varying abundances

Adam Trautwig (MS), Ben Brunson (MS)

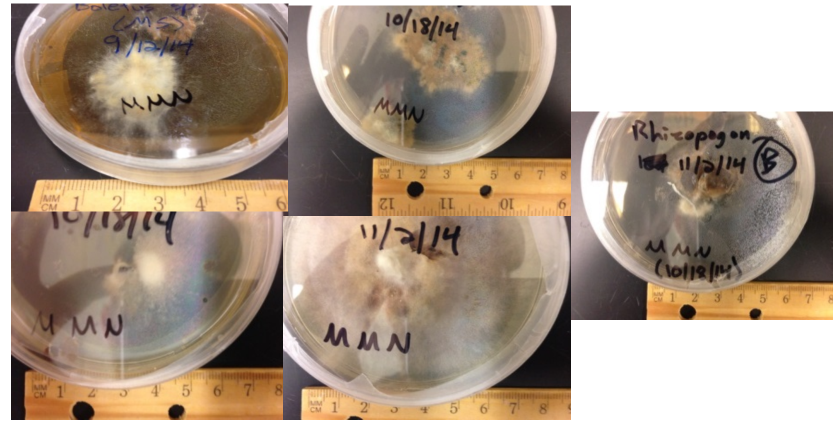
School of Forestry and Wildlife Sciences, Auburn University

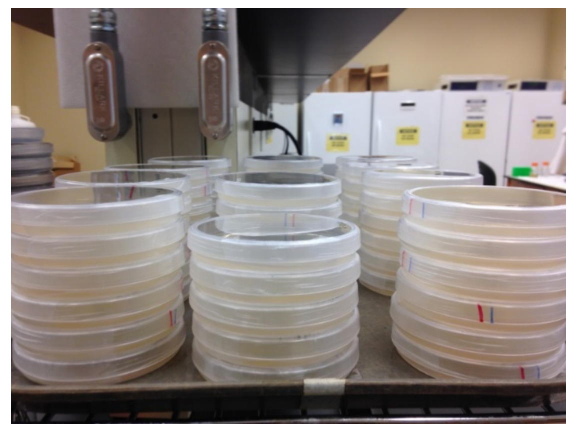
Mycorrhizal Communities in Cogongrass Invaded Pine Stands



Trautwig*, A. Eckhardt, L.G., Hoeksema, J., Carter, E.A., and Loewenstein, N. 2017. Mycorrhizal communities in *Imperata cylindrical* invaded and non-invaded commercial *Pinus taeda* stands. For Sci 62:10-16(17)

Growth of Mycorrhizal Fungi in the Presence of Cogongrass Exudates





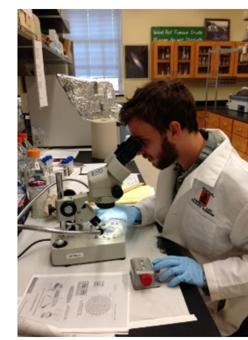


Table 2 Mean chemical composition of leachates collected from the rhizosphere of greenhouse-grown cogongrass monocultures and native polycultures. Compounds identified in previous studies are denoted, along with the source of the extract

Compound	Family	Previously reported?	Retention (min)	Molar concentration		Wilcoxon-Mann-Whitney*
				Cogongrass	Native	
Gallic acid	Phenolic acid		2.50	1.80×10^{-5}	5.28×10^{-7}	< 0.05
Caffeic acid	Phenolic acid	1 SH	3.77	4.74×10^{-6}	1.55×10^{-7}	< 0.05
Salicylic acid	Phenolic acid		12.41	4.41×10^{-6}	3.94×10^{-7}	< 0.05
Sinapinic acid	Phenolic acid		5.60	1.49×10^{-6}	2.39×10^{-8}	< 0.05
Benzoic acid	Aromatic acid	3 RH, RO	10.30	1.32×10^{-6}	2.24×10^{-7}	NS
Cinnamic acid	Aromatic acid	3 RO	15.92	8.40×10^{-7}	8.10×10^{-8}	< 0.05
Emodin	Trihydroxy anthraquinone		24.51	5.95×10^{-7}	BQ	< 0.05
Ferulic acid	Phenolic acid	1 SH, 3 RH, RO	6.10	5.79×10^{-7}	5.47×10^{-8}	NS
4-hydroxyphenylacetic acid	Phenolic acid		4.09	BQ	BQ	–
Cholorogenic acid	Phenolic acid	1 SH, 2 RO	2.50	BQ	BQ	–
Resorcinol	Meta dihydroxyl phenol		4.13	BQ	BQ	–

[a] Abdul-Wahab and Al-Naib (1972); [b] Hussain and Abidi (1991); [3] Xuan et al., (2009); *SH* extracted from shoots; *RH* extracted from rhizomes; *RO* extracted from roots; * <0.05, indicates that differences between treatments were statistically significant; NS, indicates that differences between means were not statistically significant; BQ, below limits of quantification (treated as a zero for non-parametric comparisons); NS –, indicates that comparisons not possible due to concentrations in both treatments being below limits of quantification

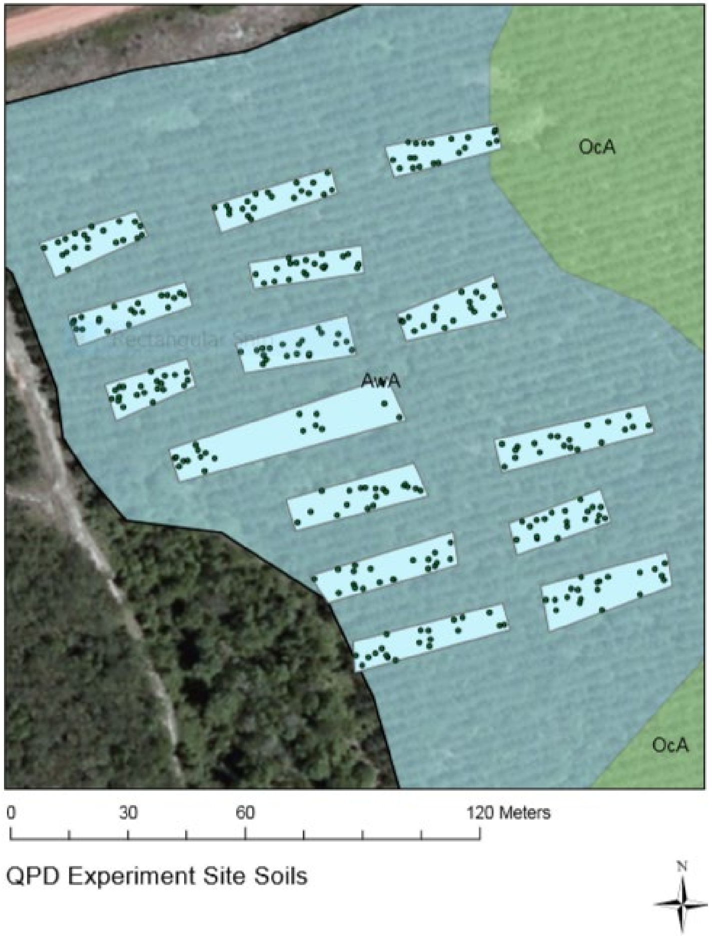
*Trautwig, A.N., Ha, M., Holmes, K., Hoeksema, J.D., and Eckhardt, L.G. (*Submitted*) Growth rate of soil fungi *in vitro* is influenced by common rhizosphere interactions. Mycologia

In cooperation with Jason Hoeksema, Ole Miss

Other Cogongrass Publications

- Enloe, S.F., Loewenstein, N.J., Held, D.W., Eckhardt, L.G., and Lauer, D.K. 2014. Impacts of prescribed fire, glyphosate, and seeding on cogongrass, species richness and species diversity in longleaf pine. Invas Plant Sci Mana 6:536-544
- Sells*, S.M., Held, D., Enloe, S., Loewenstein, N., and Eckhardt, L. 2015. Impact of cogongrass management strategies on generalist predators in longleaf pine stands. Pest Mgmt Sci 71:478-484

Quantifying the Impact of Root Disease on a Tree



John Mensah (PhD), Shrijana Duwadi (MS), Jessica Ahl (MS)

School of Forestry and Wildlife Sciences – Auburn University

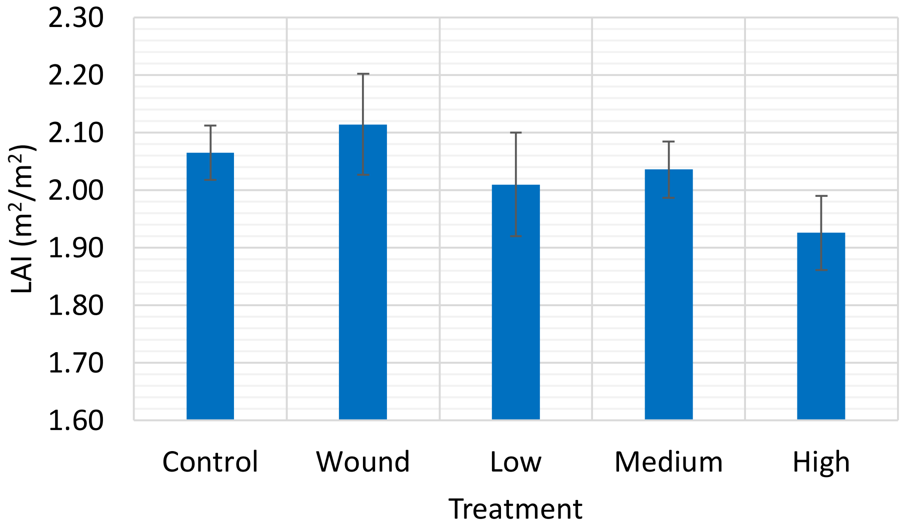
Inoculation Process

LAI Measurement associated with Root Disease

Leaf Area Index (LAI) was measured with a ceptometer

$L = [(1 – 1/2K) f_b – 1] *\ln\tau / (A (1 – 0.47f_b))$

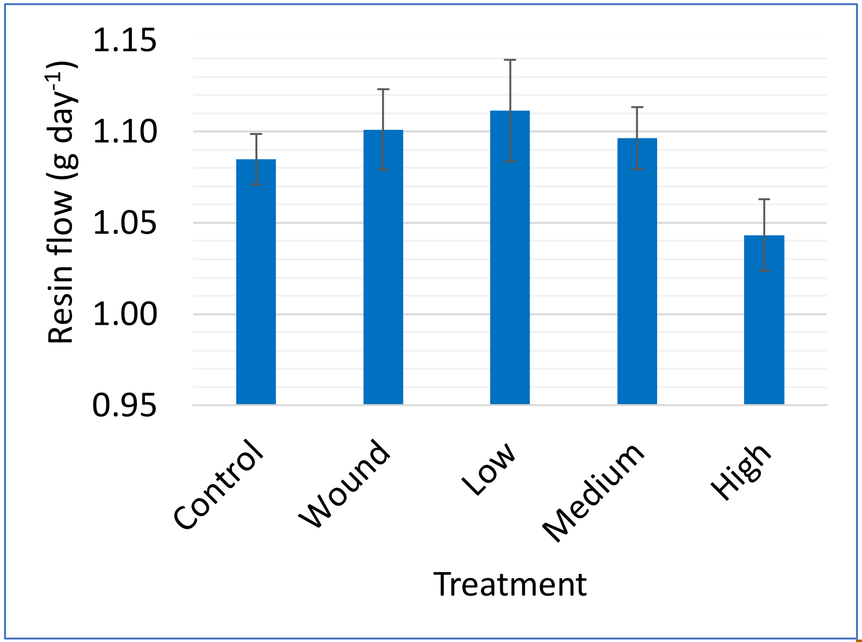
- L – Leaf area index
- τ – Ratio of PAR below to PAR above
- f_b – fraction of incident PAR
- K – Extinction coefficient for the canopy



John Mensah (PhD)

Resin Flow associated with Root Disease

- North-south sides of each tree were sampled by punching a hole with 1.9 cm diameter arch punch at DBH
- A plastic connector was screwed into the tree to direct resin into a pre-weighed plastic tube attached to the connector
- Tubes were removed after 24hrs and transported
- Average resin weights were determined

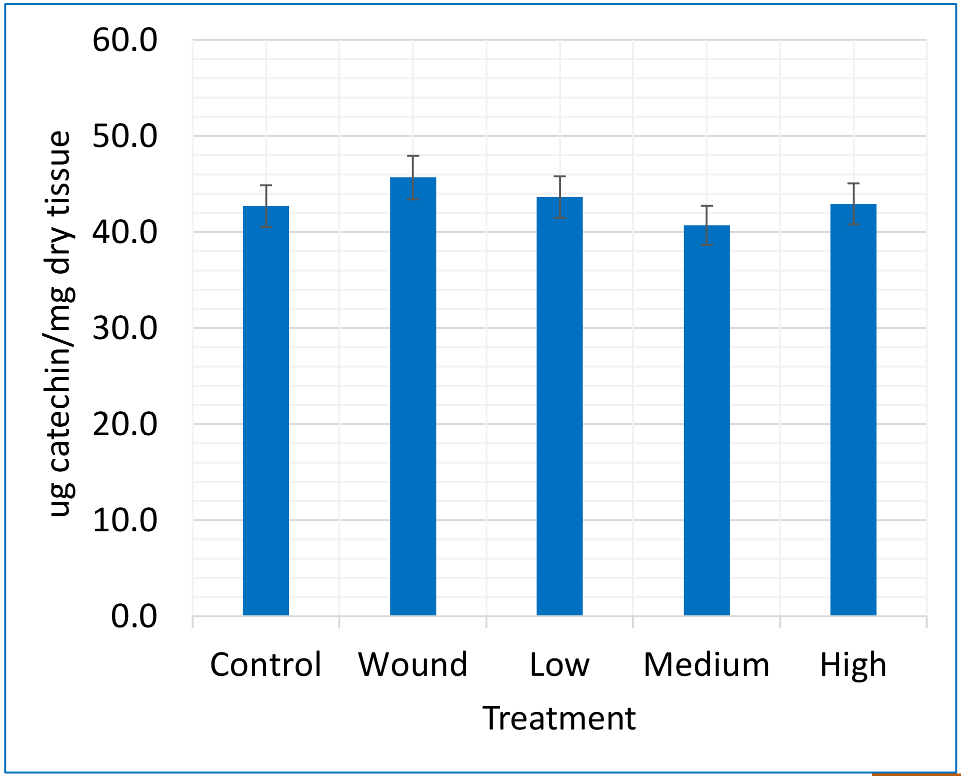


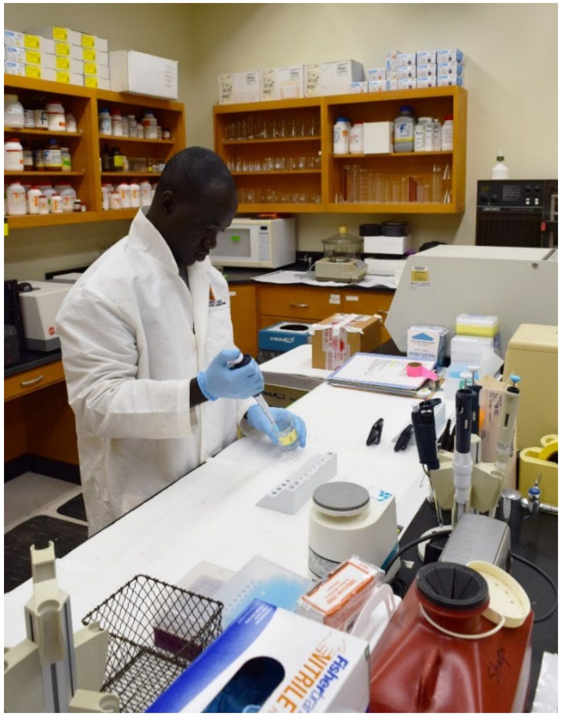
Phenolic Production associated with Root Disease

Extraction - 70% acetone

Development - Na_2CO_3

Absorbance - Spectrophotometry



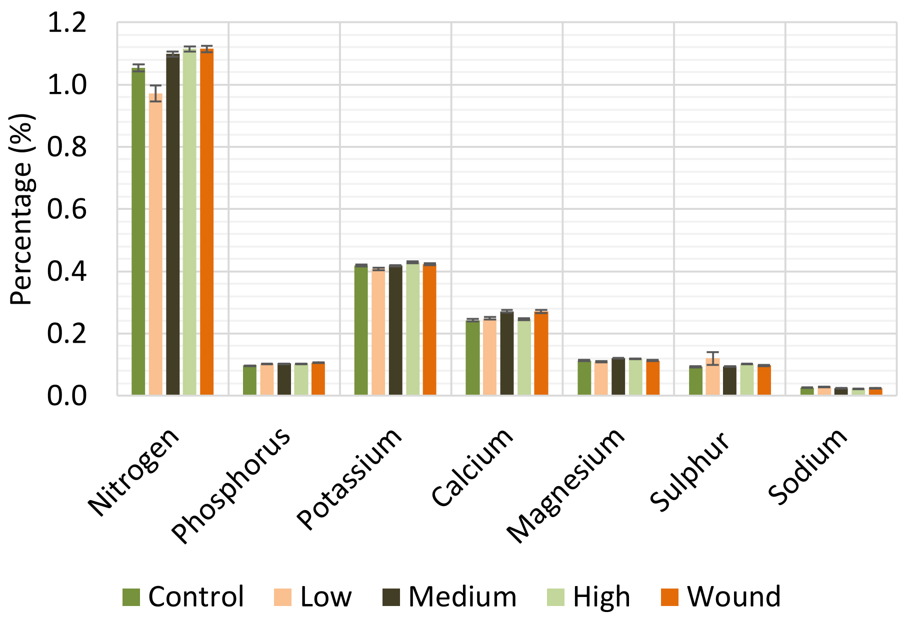


Foliar Nutrients associated with Root Disease

About 25 fascicles

Samples were forced-air oven dried at 70^{O}C

Foliar nutrients - Waypoint Analytical (Memphis, TN)



Fine Root Dynamics and Soil Microbial Biomass associated with Root Disease

RLD (Root length density)=R/A

Newman's equation: R= (π×N×A)/ (2×H)

R =root length (cm)

N=No. of root intersections with etched lines

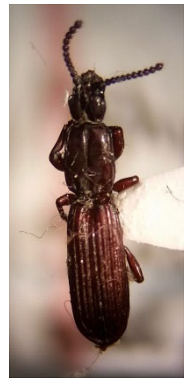
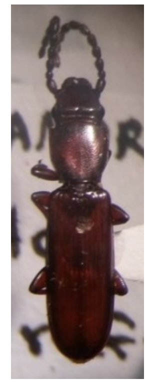
A=area of tube being accessed

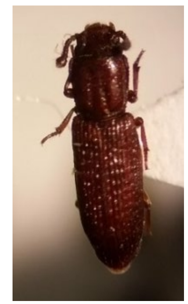
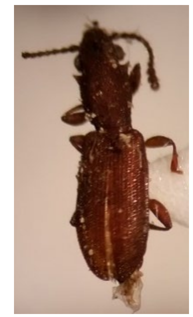
H=length of the etched line which is the tube circumference

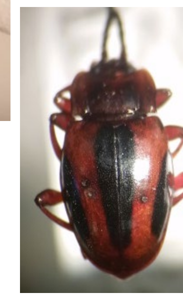
Shrijana Duwadii (MS)

Insect Diversity in a Loblolly Pine Stand associated with Root Disease



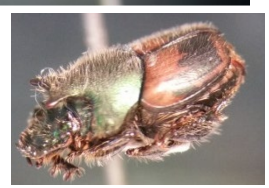
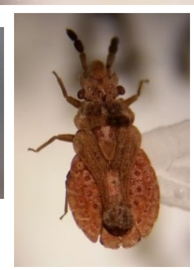




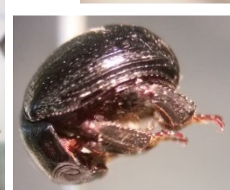






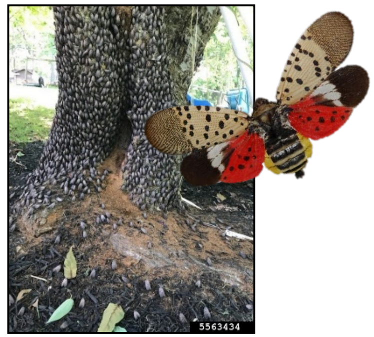




Jessica Ahl (MS)

Emerging Pests & Disease Problems

Spotted Lanternfly



Shot Hole Borer

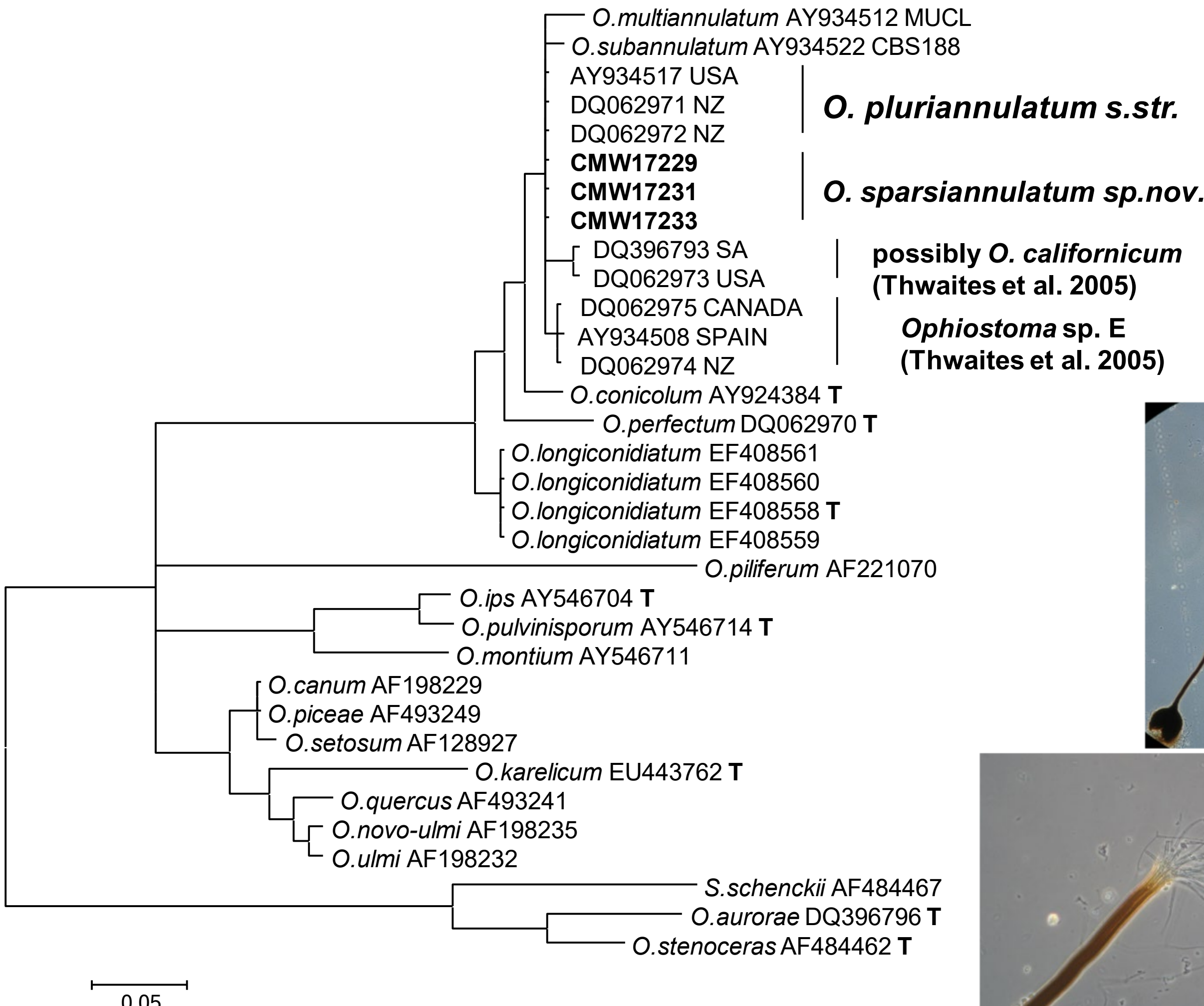
Thousand Cankers Disease

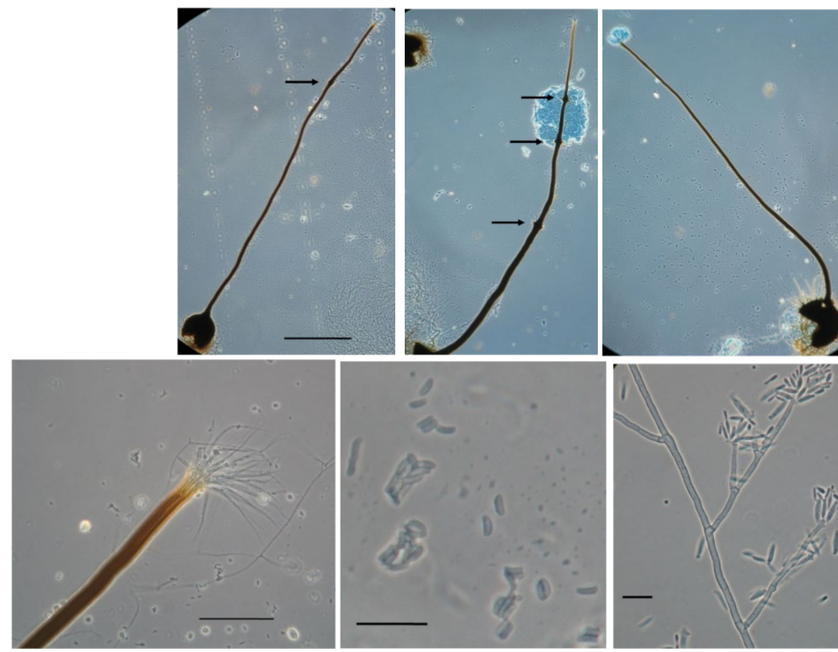
Sudden Oak Death

Needle Blight

Laurel Wilt

A new *Ophiostoma* species in the *O. pluriannulatum* complex from loblolly pine roots



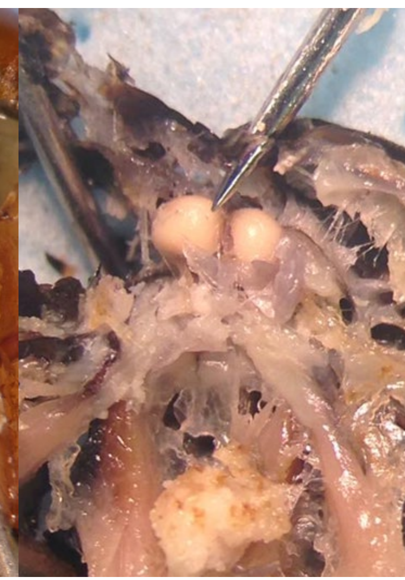


Zanzot*, J.W., de Beer, Z.W., Eckhardt, L.G., and Wingfield, M.J. 2010. A new *Ophiostoma* species from loblolly pine roots in the southeastern United States. Mycol Progress 9:447-457

Siricid Survey in Alabama

Conclusions:

- *S. nigricornis* was found to carry *A. areolatum* and *D. siricidicola*, normally associated with *S. noctilio*
- *T. columba* was found to be parasitized by *D. siricidicola*
- *D. siricidicola* was shown to be in association with both *A. chailletii* and *Cerrena unicolor* (*T. columba*)

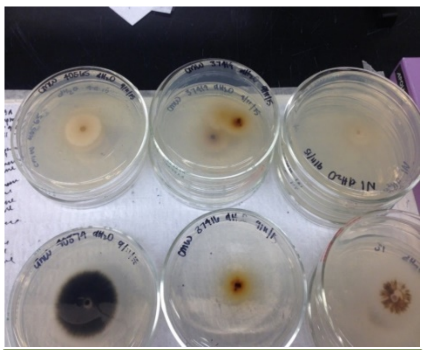


*Wahl, A.C., Nadel, R.L., *Fitza, K., Slippers, B. and Eckhardt, L.G. (*Submitted*) *Deladenus* species associated with native Siricid Woodwasps in Alabama. Agricultural and Forest Entomology

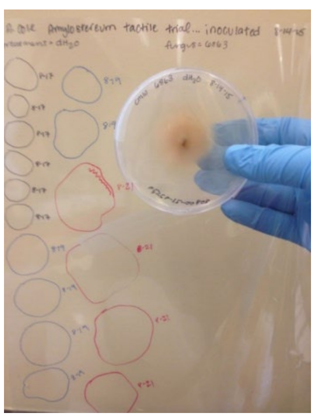
In cooperation with Dr. Slippers at FABI, South Africa

Effect of Growth Rate on *Amylostereum* spp. Fungi by Terpenes

Isolation



Inoculation and Growth



Measurements

Atmospheric Trial

Tactial Trial

Conclusions:

- The Northern Hemisphere collected isolates were slower growing compared to the fungal isolates from the Southern Hemisphere
- β-Myrcene significantly increased growth of *A. areolatum* isolates for the atmospheric trial, but not the tactile trial
- The compounds α-Phellandrene and 4AA resulted in nominal growth of *A. areolatum* isolates

*Wahl, A.C., Nadel, R.L., Slippers, B. and Eckhardt, L.G. (*In preparation*) Effects of growth rate on *Amylostereum* spp. Forest Pathology

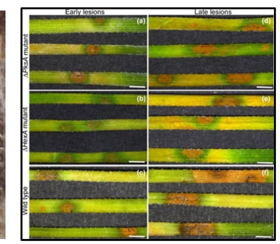
In cooperation with Dr. Slippers at FABI, South Africa

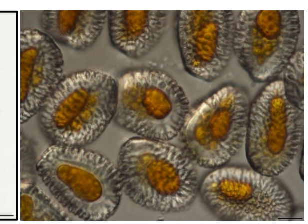
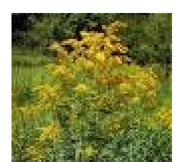
Needle Cast, Blight or Rust?




Which pathogen is causing the mortality in these stands?

Survey across Alabama, Mississippi and Georgia of infected stands with and without mortality.


Debit Datta (MS)

Identifying Fungal Communities associated with *Dendroctonus, Hylastes and Ips* spp.

Dendroctonus approximatus

Dendroctonus valens

Hylastes fulgidus

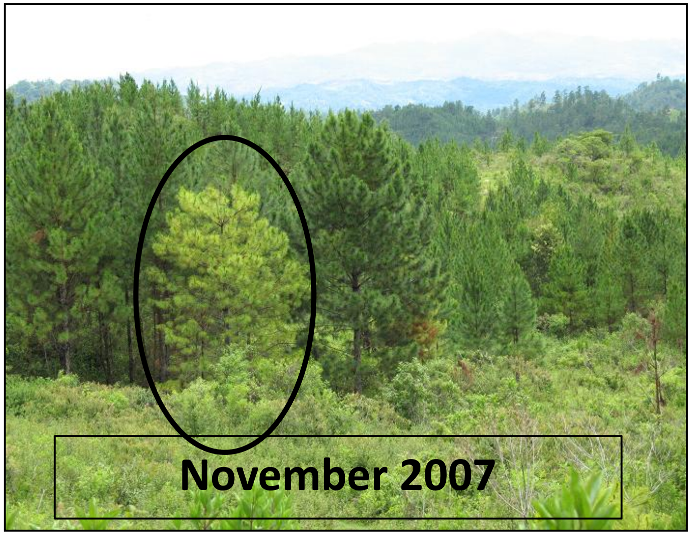
Ips apache

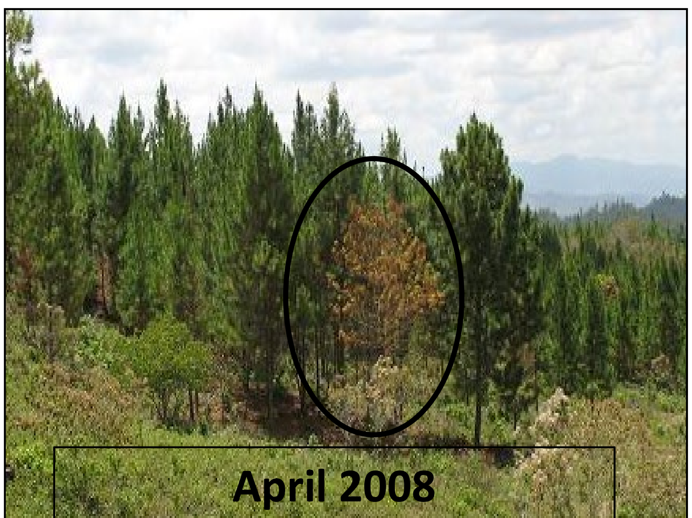
In cooperation with Alberto Sediles (Universidad Nacional Agraria, Nicaragua), Roger Menard (USFS-FHP), Wilhelm deBeer and Duong Tuan (FABi, South Africa)

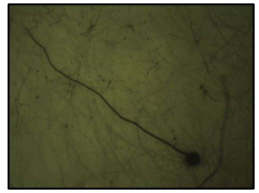
Tessa Bauman (PhD), Matthew Meyerpeter (MS), Roger Menard (MS)

Pinus oocarpa Decline in Nicaragua

Tessa Bauman (PhD), Matthew Meyerpeter (MS), Roger Menard (MS)







In cooperation with Alberto Sediles, Universidad Nacional Agraria, Nicaragua

Eckhardt, L.G., Menard, R.D., Meyerpeter, M.B., Bauman, T.A. and Sediles, A. (*In preparation*) Evaluation of pine mortality in the forests of Nicaragua. Southern Forests

Forest Health Research at SFWS

Forest Health Dynamics Laboratory

Dr. Lori Eckhardt
Co-director

Dr. Scott Enebak
Co-director

Alabama Cooperative Extension System

Disease Ecology

To examine the impact of forest health and manipulation on the health of surrounding wildlife and human communities.

Dr. Sarah Zohdy

Economic and Social Sustainability

To address linkages of forest ecosystem services to human well-being.

Dr. Yoaqi Zhang
Dr. Wayde Morse

Forest Products Development Center

Impact of abiotic and biotic factors that affect the final wood products physical and chemical properties.

Dr. Brian Via
Dr. Maria Peresin

Sudden Oak Death State Laboratory for Alabama & Mississippi

Dr. Lori Eckhardt - Director

Mission Statement

To provide for watershed sampling and laboratory detection of Sudden Oak Death causing pathogen in waterways outside of nurseries which have had infected nursery stock in Alabama and Mississippi

Staff

Luis Mendez
Jessica Ahl

Forest Health Cooperative

Dr. Lori Eckhardt - Director

Mission Statement

To address important, current and pertinent forest health issues (disease, insect, plants and invasive species) in a way that addresses real world management problems in the southern United States

Staff

Dr. Nancy Loewenstein
Luis Mendez
Angelica Baker

Southern Forest Nursery Management Cooperative

Dr. Scott Enebak - Director

Mission Statement

To develop and disseminate available cultural, biological and chemical technologies using an integrated system for the economical production and utilization of forest tree seedlings in the southern United States

Staff

Dr. Ryan Nadel
Nina Payne
Will Harges

GIS & Remote Sensing

Monitoring and detecting forest health by using remote sensing and GIS. Forecasting forest health change by using ecological models.

Dr. Shufan Pan

Forest Decline and Invasive Species Modeling

Multi-scale spatio-tempo modeling of invasive species and forest decline under changing climate and alternative forest management regimes.

Dr. Joseph Fan

Abiotic

To gain an understanding of the response of forest tree species and ecosystems in a changing climate to abiotic stressors such as ozone pollution and drought

Dr. Art Chappelka

Acknowledgements

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FABI Group: Tuan Duong, Wilhelm DeBeer, Mike Wingfield, Bernard Slippers, Katrin Fitz

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Industry Collaborators: Alan Wilson, Paul Padgett, Wilson Edwards, Bruce DeHann, Kris Bradley

Questions