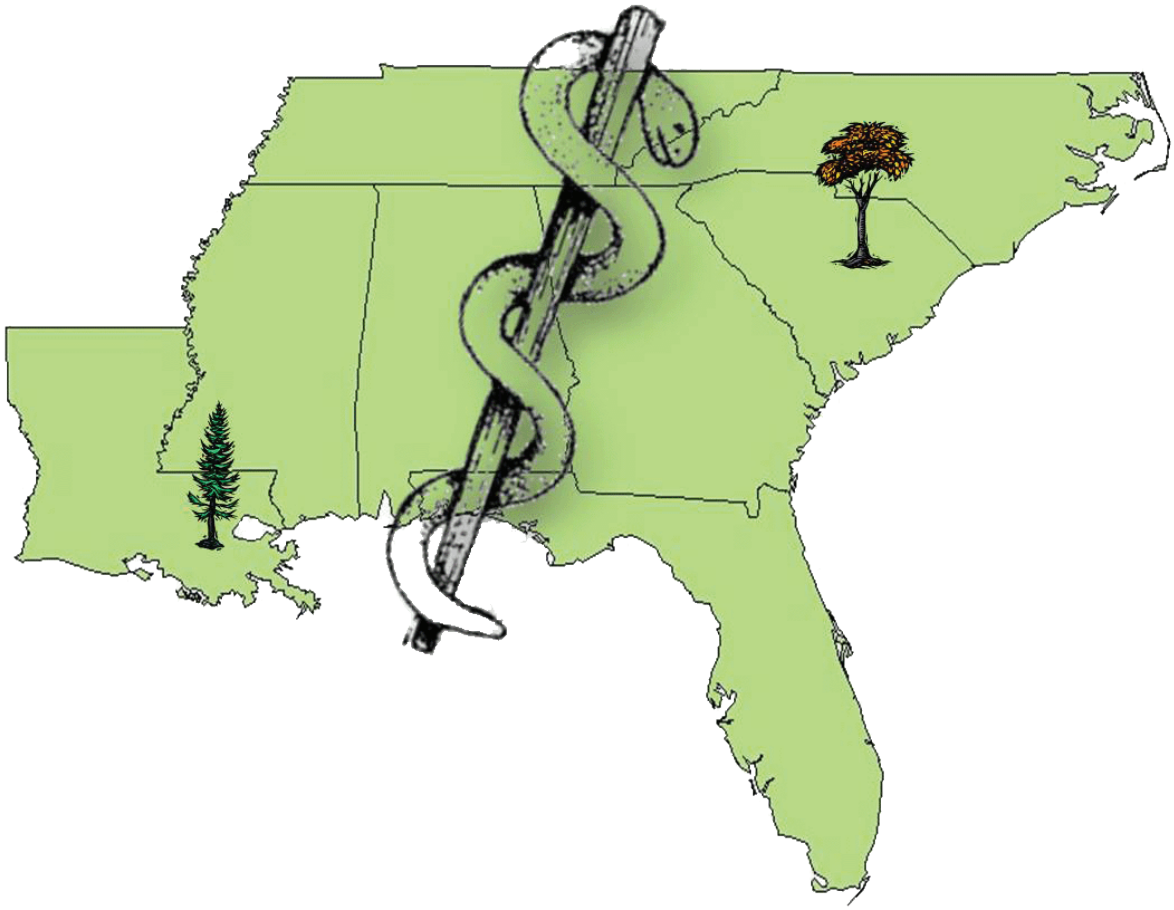
# Auburn University Forest Health Cooperative



# FY 2015 Annual Report

# EXECUTIVE SUMMARY

They FY17 meeting is set for June 29-30, 2016. It will begin after lunch on Wednesday and adjourn around noon on Thursday. Place those days on your calendar. More information will be available soon.

**RESEARCH**

- The RW-19 study found that insect numbers were greater in post treatment implementation. A significant interaction with *Hylastes* beetles and thinning regime was found with stands of 100 trees per acre (TPA) having a fewer number of individuals. This study has been extended to include analysis using tree growth data from the Productivity Cooperative.

- The preliminary results from the Mature Root Inoculation study showed the same level of family difference exists in mature as well as in premature stages of loblolly pine. This study will be repeated March – May 2016.

- We have currently tested 130 loblolly families and 11 slash families for tolerance to ophiostomatoid fungi. Year 5 screening is underway and the families for year 6 have been chosen.

- In Year 4 the average length of the lesion produced by both the fungal treatments was significantly different among the families. Families, L108 and L99 had shorter lesions and L81 and L91 had the longest lesions when treated with *L. terebrantis*. Whereas, L86 and L108 had the shortest lesions and L88 and L91 had the longer lesions when treated by *G. huntii*. The side by side experiment (Bareroot vs Container), no variation in tolerance was shown suggesting that the length of the lesion caused by the fungi is similar in seedling grown by either method.

- The "Quantifying Pine Decline" project plots were installed and data collection has begun.

- The Fire - Insect study found that insect pest numbers were highest in the symptomatic and burned areas. Pathogenic fungal species were recovered from all trees on the sites, regardless of management regime.

- Results from the Sirex study indicate that isolates from the Northern Hemisphere had a slower growth rate as compared to those from the Southern Hemisphere.

- Cogongrass does have an impact on pine mycorrhizzae which, in the long run, can affect pine health.

- The use of microbes to control diseases is becoming more common and is an environmentally friendly approach. Plant growth-promoting rhizobacteria (PGPR) have the potential as a biocontrol agent. The objective of this research was to study the effect of thirty PGPR strains that previously exhibited both broad-spectrum biocontrol activity against plant pathogens towards blue-stain fungi *in vitro*.

- In conjunction with the Nursery Cooperative, a speed screening method was developed and is capable of detecting a single *G. circinata* infected seed for all pine species. The results will assist in developing requirement protocols which must be accepted by the International Seed Testing Association.

- Wood quality is being questioned and forest health is under question. The combination of these two factors are problematic because a reduction in forest health reduces the quantity of material for harvest while a reduction in stiffness lowers the quality of the tree. A counter solution to this problem is to find genetic families that are resistant to disease.

**ASSOCIATED ACTIVITIES, GRADUATE STUDENTS, COOPERATIVE STAFF, MEMBERSHIP**

We gained a new sustaining member and lost a full member due to the merger of Weyerhaeuser/Plum Creek. The Forest Health Cooperative currently has 5 Full Members, 5 Associate Members, 1 Maintaining Member and 5 Sustaining Members. Graduate students' contributions to the program continue to be critical. We continue to organize workshops for members and colleagues at AU and around the southeast. Dalton Smith and Sarah Peaden started in July as replacements for Alyssa Rosenblum and Tessa Bauman.

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## DIRECTOR'S REPORT

Another successful year is in the books and I hope that this report finds everyone well. It has been a busier year than normal, both professionally and personally. As some of you may know I missed the annual meeting in St. Simon's Island, GA after having a brain tumor removed. Things are going great and after 10 years of non-stop headaches, I am now headache free. I was promoted to Full Professor in October and was appointed as the Coordinator, IUFRO Working Group WP 7.02.06 Disease/ Environment Interactions in Forest Decline, Research Group RG 7.02.00 Pathology, IUFRO Division 7. I also was elected as Sigma XI's (The Research Honor Society) Associate Directory of the Southeast Region. I look forward to seeing everyone at the meeting this upcoming year.

## MEMBERSHIP

I have been approaching several companies and consulting firms in the southern U.S. about joining the Forest Health Cooperative. We have shared our membership materials with them and answered a few questions concerning membership. The Forest Health Cooperative currently has 5 Full Members, 5 Associate Members, 1 Maintaining Member and 5 Sustaining Members.

## CONTACT LIST

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# MEMBERSHIP LIST

## FULL MEMBERS

**Federal**
United States Forest Service – NFS

**Forest Industry**
Hancock Forest Management
Plum Creek Timber Company
Rayonier
Westervelt
Weyerhaeuser

## ASSOCIATE MEMBERS

**Forest Industry**
Delaney Development
Molpus Timber Management
Scotch Lumber Company

**Federal**
United States Forest Service - SRS

**Non-Industrial – Private**
ArborGen, LLC

**Consulting Foresters**
F & W Forestry

## MAINTAINING MEMBERS

**Non-Industrial – Private**
Burgin Land

## SUSTAINING MEMBERS

**Non-Industrial – Private**
International Paper
Forestry & Land Resource Consultants

**Individual Foresters**
Beth Richardson
Ken Clark

**State**
Alabama Forestry Commission

# ADVISORY BOARD CHAIRMAN
## Service Rotation

| Fiscal Year† | Chairman* |
|---|---|
| 2011 | Westervelt |
| 2012 | Weyerhaeuser |
| 2013 | US Forest Service |
| 2014 | Hancock Forestry |
| 2015 | Plum Creek |
| 2016 | Rayonier |
| 2017 | Resource Management Service |
| 2018 | Westervelt |
| 2019 | Weyerhaeuser |
| 2020 | US Forest Service |
| 2021 | Hancock Forestry |
| 2022 | Plum Creek |
| 2023 | Rayonier |
| 2024 | Resource Management Service |

†Member will conduct the Cooperative business meeting held in that fiscal year.
*First Chairman randomly chosen for FY2011, subsequent Chairman will be alphabetical by company name.

# Rules and Policies
for
# Auburn University
# Forest Health Cooperative

## Re-Approved February 1, 2011

## MEMBERSHIP

1. Membership in the Forest Health Cooperative (FHC) is open to anyone in the southeastern region of the United States.

2. Members are required to pay annual dues which are as follows:

| | |
|---|---|
| Full Member | $10,000 |
| Associate Member | $ 5,000 |
| Maintaining Member | $ 2,500 |
| Sustaining Member | $ 500 |

3. Sustaining Members receive access to FHC Webpage, annual Newsletter, Priority Email and Telephone Consulting, and participation in Members Only Workshops and may participate at the Annual Advisory Meeting, but cannot serve on the Advisory Council. Maintaining Members receive the benefits of Sustaining Members, and Research and Technical Reports. Associate Members receive the benefits of the Maintaining Members, and Field Consulting and Laboratory Diagnostics. Full members receive all the benefits of Associate, Maintaining and Sustaining Members and serve on the Advisory Council and have full voting powers with respect to research program and budgetary decisions.

4. Membership is for one year beginning October 1. Membership may be terminated by either the member organization or by Auburn University by giving 60 days written notice before October 1.

5. Membership will be contingent on signing a memorandum of agreement with Auburn University.

6. After September 30, 2009, all new members at all levels will be required to contribute 1-3 x their annual membership dues in addition to their annual membership dues. The number of annual contributions will depend upon the year of membership beyond 2008.

| Year of Joining | Contributions to Forest Health Cooperative |
|---|---|
| 2008 | 1 Annual Membership |
| 2009 | 1 Annual Membership + 1 Annual Membership |
| 2010 | 1 Annual Membership + 2 Annual Membership |
| 2011 and beyond | 1 Annual Membership + 3 Annual Membership |

# ORGANIZATION

1. The Dean, School of Forestry and Wildlife Sciences, Associate Director Agricultural Experiment Station of Auburn University in consultation with the Forest Health Cooperative Executive Committee, will appoint the Forest Health Cooperative's Director.

   The Director will be responsible for:
   - A. Directing the activities of the Forest Health Cooperative;
   - B. Employing a competent staff;
   - C. Developing the Forest Health Cooperative's direction in conjunction with the Advisory Council;
   - D. Ensuring each member participates to a threshold level; and
   - E. Reporting research accomplishments to the Advisory Council

2. The Advisory Council will have an annual meeting in the first quarter of each fiscal year.

3. An Advisory Council consisting of one representative from each full member shall be established to:
   - A. Act as a liaison between the organization and the Director;
   - B. Develop Forest Health Cooperative policies;
   - C. Advise the Director on the Forest Health Cooperative's direction;
   - D. Approve the annual budget and membership fee.

4. An Executive Committee consisting of three Advisory Council members and the Director shall have the authority to meet and conduct routine business in the name of the Advisory Council. One Executive Committee member will be appointed annually according to a rotating schedule and will serve for 3 years. The Advisory Council chairman will be the senior member of the Executive Committee and will preside at the Executive Committee and Advisory meetings.

5. Contact representatives will be designated by each cooperating member/organization. This individual may or may not be the same person serving on the Advisory Council. Contact Representatives will be directly involved in research established with each member organization.

6. All information will be available to all members in the Forest Health Cooperative.

7. All members agree to keep confidential the data and information given to them for future publications and limit the spread of information to non-members that would benefit without paying annual FHC dues.

## DUES and BUDGET

1. Membership dues will be set by the Advisory Council at its annual meeting.

2. The Cooperative will operate on the fiscal year October 1 to September 30. Invoices for membership fees will be sent to all member organizations on October 1 of each year, or by special arrangement with the individual organization.

## RULES CHANGES

1. Changes in, deletions from, and additions to the membership rules may be adopted by a two-thirds vote of advisory members in attendance at regularly scheduled or special sessions of the Advisory Council.

## DIVISION OF RESPONSIBILITIES BETWEEN AUBURN UNIVERSITY AND MEMBER ORGANIZATIONS IN THE AUBURN UNIVERSITY FOREST HEALTH DYNAMICS LABORATORY COOPERATIVE

1. Study plans will be developed by Auburn University in conjunction with the Cooperative's Advisory Council. Responsibilities for cooperative research will be delineated in individual study plans.

2. Auburn will do data analysis and processing, as well as manuscript preparation, and will insure timely distribution of results to cooperators.

3. Auburn University graduate students will be utilized to work on specific forest health problems.

4. All cooperators will be responsible for adhering to the study plans.

5. Information will be disseminated at annual Advisory meeting and in an annual Newsletter and Research Reports to members. A web site dedicated to Forest Health with the Cooperatives' research will be maintained by School of Forestry & Wildlife Sciences.

6. Results will also be disseminated at local, regional and national forest related meetings.

7. Site visits for risk assessment and diagnostic evaluations will be conducted by Auburn University staff. Full members get 2 days/yr, Associate Members get 1 day/ yr. Additional days are $1000 per day for all membership classes.

8. Laboratory diagnostic evaluations will be conducted by Auburn University staff. Full members get 10 sent in samples per year, Associate Members get 5 sent in samples per year. Additional samples are $100 per sample for all membership classes.

**RW-19 STUDY, ANDREA COLE**

The RW-19 insect study was conducted by the Forest Health Dynamics Lab and assessed the impact that different thinning and fertilization regimes would have on pest insect populations. The objective of this study was to quantify the population dynamics of root and lower stem colonizing beetles (*Hylastes* spp.) and other pine bark beetles over a 3 year period. Insect populations on plots under ten various treatments (Thinning to 100 TPA, 200 TPA, 300 TPA, 500 TPA and with or without fertilization: 200 lbs N + 25 lbs P) were monitored, taking seasonal variation into consideration. Tree vigor following thinning and fertilization treatments were determined, with management and site characteristics to changes in insect populations monitored for changes in forest health condition so as to relate back to treatment.

The larger scope of this project includes eight industrial study sites which were established across different physiographic regions across the southeastern United States. This project focused on the insect data collected at one of these sites established near Hilliard, Florida. Insects were collected and monitored from November 2012 until February 2015, which encompassed pre thinning monitoring November 2012 to May 2013 and post thinning monitoring from February 2014 until February 2015.

The study found that insect numbers were found to be greater post treatment implementation. A significant interaction with *Hylastes* beetles and thinning regime was found with stands of 100 trees per acre (TPA) having a fewer number of individuals (Figs. 1-2). Although significant interactions with treatments and ambrosia beetle populations were present prior to treatment implementation, an interaction with thinning was still present post treatment implementation (Figs. 3-4).

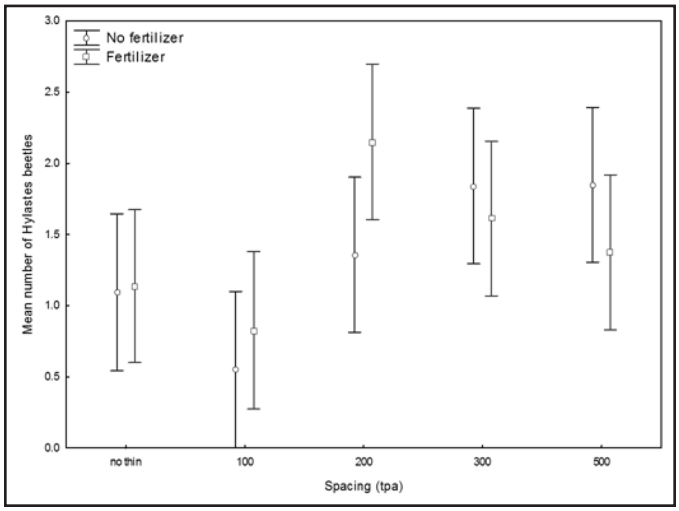



**Figure 1.** Average number of Hylastes beetles per site, pretreatment.

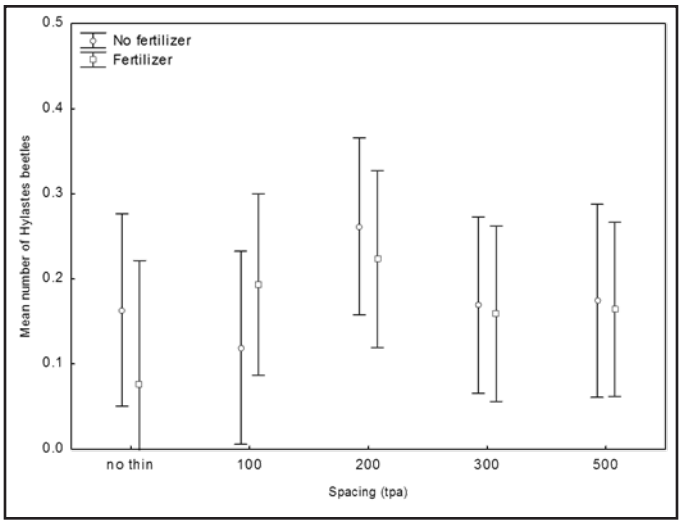



**Figure 2.** Average number of *Hylastes* beetles per site, post treatment.

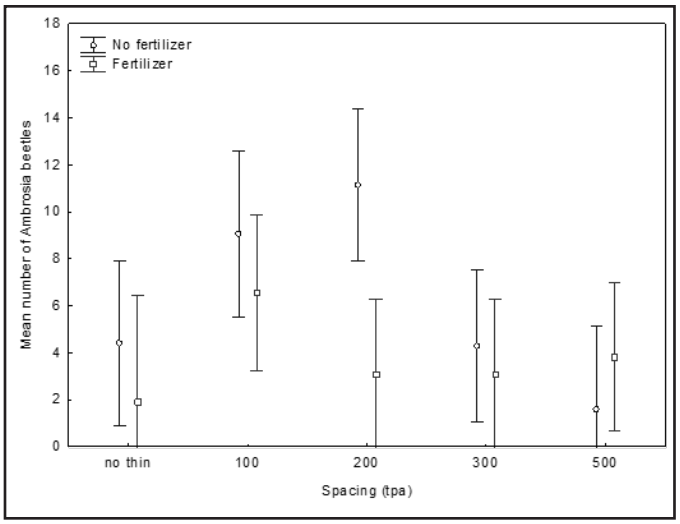



**Figure 3.** Average number of Ambrosia beetles per site, pre-treatment.

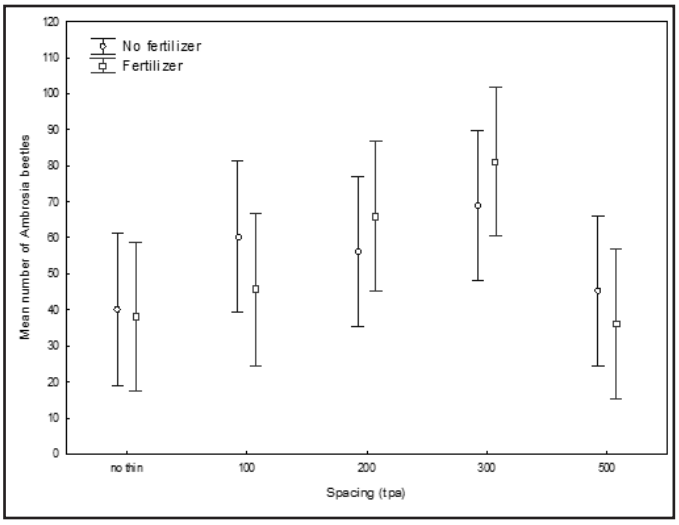



**Figure 4.** Average number of Ambrosia beetles per site, post treatment.

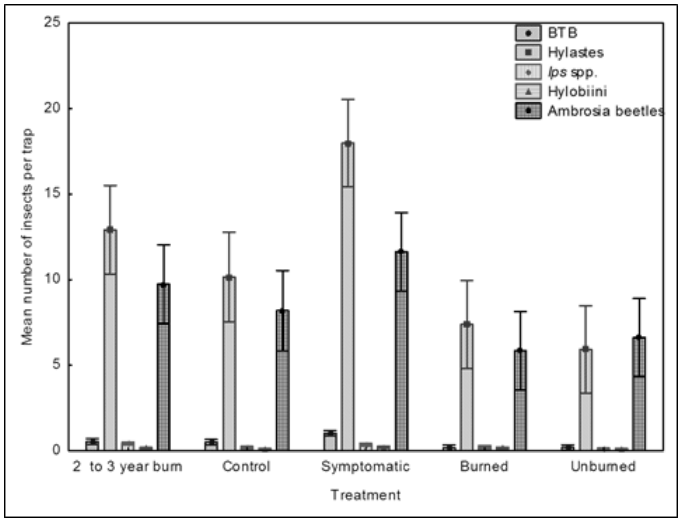



**Figure 1.** Average number of groups of insects of concern per treatment site over the course of the entire trapping survey.

## FIRE – INSECT STUDY, ANDREA COLE

This study to determine the effects of fire on insect populations was carried out on Scotch land in Clark and Marengo Counties in Alabama. Five treatments were implemented: a 2-3 year burn, symptomatic area not burned, unmanaged control, burned asymptomatic, and unburned asymptomatic. The objectives of this study included quantifying the populations of root and lower stem colonizing beetles and other pine bark beetles across different burning regimes, comparing populations among sites under various treatments, and relating management methods to changes in insect populations.

Insect trapping spanned from February 2014 to March 2015. In the duration of this year, thousands of insects were collected and brought back to the lab to identify to species (Fig 1.). *Hylastes* spp. and ambrosia beetles were captured in the highest concentrations throughout the duration of the study. Pest insect numbers were highest in the symptomatic and burned areas. Pest insect numbers were lowest in the unburned area (Fig. 2).

Roots from three trees from each site were excavated in September 2015. Pieces of these roots were surface sterilized and plated on media so that any isolates of fungi inside the root would grow out to be identified. Seven pathogenic fungal species were isolated from the roots of trees on these sites. Pathogenic fungal samples were recovered from all trees on all sites, regardless of management regime (Fig. 3). The unburned and unmanaged control sites more commonly hosted *Grosmannia* spp., the most severe and virulent pathogens. Currently, the most severe pathogen species are found on the sites with the lowest insect infestation levels.

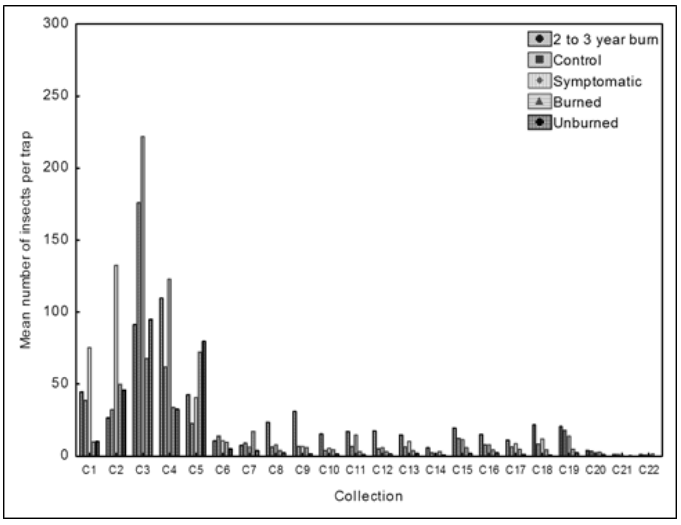



**Figure 2.** Average number of total insects of concern by treatment over the course of the trapping survey.

| Plot | Treatment | Fungal Species |
|---|---|---|
| 1 | Asymptomatic 2-3 year burn rotation | *Grosmannia huntii, Ophiostoma minus* –like sp., *O. ips*, ***Leptographium procerum, L. terebrantis, Graphium* sp.** |
| 2 | Asymptomatic 2-3 year burn rotation | *G. alacris, O. minus* –like sp., *O. ips*, ***L. terebrantis, L. procerum, Graphium* sp.** |
| 3 | Asymptomatic 2-3 year burn rotation | *G. alacris, O. minus* –like sp., *O. ips*, ***L. terebrantis, L. procerum, Graphium* sp.** |
| 4 | Unmanaged control (Hwd/Pine Mix) | *O. minus* –like sp., ***L. terebrantis, L. procerum*** |
| 5 | Unmanaged control (Hwd/Pine Mix) | *G. alacris, O. minus* –like sp., ***L. terebrantis, L. procerum, Graphium* sp.** |
| 6 | Unmanaged control (Hwd/Pine Mix) | *G. alacris, O. minus* –like sp., ***L. terebrantis, L. procerum, Graphium* sp.** |
| 7 | Symptomatic non burned | *O. minus* –like sp., *O. ips*, ***L. procerum*** |
| 8 | Symptomatic non burned | *O. minus* –like sp., *O. ips*, ***L. procerum*** |
| 9 | Symptomatic non burned | *O. minus* –like sp., *O. ips*, ***L. terebrantis, L. procerum*** |
| 10 | Asymptomatic Burned | *O. minus* –like sp., *O. ips*, ***L. terebrantis, L. procerum*** |
| 11 | Asymptomatic Burned | *O. minus* –like sp., *O. ips*, ***L. terebrantis, L. procerum*** |
| 12 | Asymptomatic Burned | *O. minus* –like sp., *O. ips*, ***L. terebrantis, L. procerum*** |
| 13 | Asymptomatic Not Burned | *G. alacris, G. huntii, O. minus* –like sp., *O. ips*, ***L. terebrantis, L. procerum*** |
| 14 | Asymptomatic Not Burned | *O. minus* –like sp., *O. ips*, ***L. procerum*** |
| 15 | Asymptomatic Not Burned | *G. alacris, G. huntii, O. minus* –like sp., ***L. terebrantis, L. procerum*** |

**Figure 3.** Fungal species isolated from roots on each site.

## SIREX, ANDREA COLE

*Sirex* woodwasps are a group of insects that can cause great damage by depositing eggs and fungal spores into xylem tissue of pine trees. In their native areas, Siricids are attracted to dead and dying trees, but in non-native areas they have been documented colonizing healthy tree stands. Once a tree has been attacked by a *Sirex* wasp, the tree begins to exhibit defensive behavior. This defense is made up of chemicals given off, some of which have been shown to serve as attractants to secondary pests and some of which are hypothesized to affect the growth rates of *Sirex* associated fungal species (Fig. 1).

For the past year, a survey has been conducted throughout the state of Alabama to gain a clearer understanding as to what native or non-native woodwasp populations exist. Insect panel traps were checked every other week for the duration of the year in Talladega National Forest (Oakmulgee District), Tuskegee National Forest, and Auburn University's Solon Dixon Center. Currently, only native species of woodwasps have been captured and identified. Later this year, all wasps collected and the fungi isolated from those wasps will be taken to the Forestry and Agricultural Biotechnology Institute (FABI) at the University of Pretoria, South Africa, for molecular analyses. These molecular analyses will provide insight as to how closely related populations of woodwasps from different areas of the state are, in addition to understanding what species of associated fungi are carried by them.

During the summer, a plate study was undertaken to identify the effect that different terpenes emitted by *Pinus* spp. have on the growth rates of *Amylostereum areolatum* fungal isolates from around the world. The study yielded results showing the compounds α-Phellandrene and 4AA resulted in nominal growth of the *A. areolatum*. Chemical treatments 4AA, (+) Camphene, (-) Limonene, and α- Phellandrene significantly reduced the growth of isolates (Figs. 2-3). The chemicals (+) α- Pinene and β- Myrcene resulted in the highest percentage of fungal growth compared to that of the control in all tested fungal isolates in atmospheric conditions (Figs. 4-5). Overall, Northern Hemisphere collected isolates were slower growing compared to the fungal isolates collected from the Southern Hemisphere.

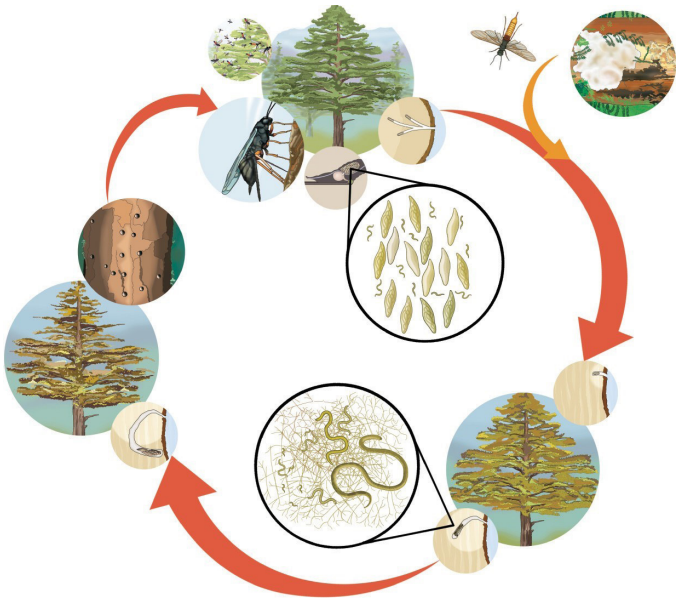


**Figure 1.** *Sirex* lifecycle from Slippers et. al 2015.

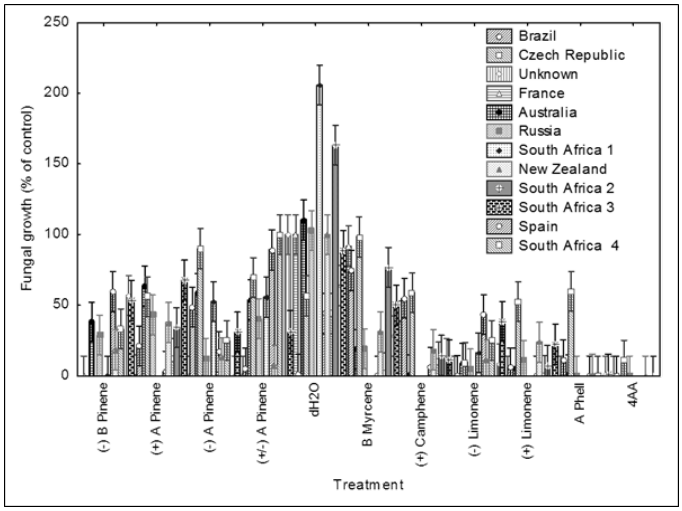



**Figure 2.** Overall effects of terpenes when directly in contact with isolates of *Amylostereum areolatum* from the Southern Hemisphere.

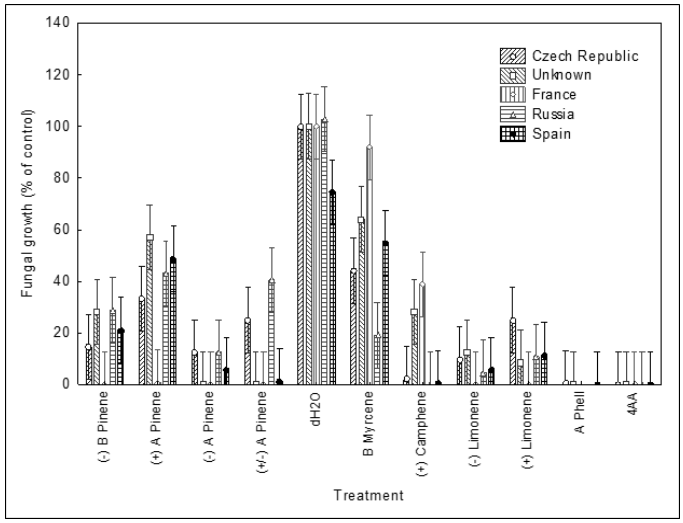



**Figure 3.** Overall effects of terpenes when directly in contact with isolates of *Amylostereum areolatum* from the Northern Hemisphere.

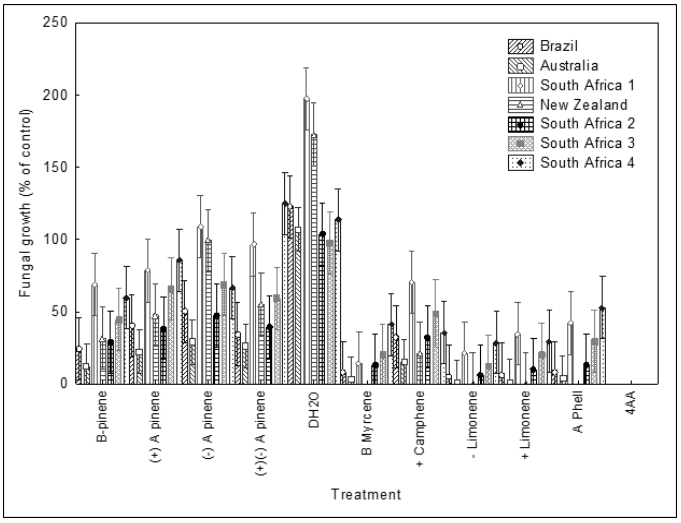



**Figure 4.** Overall effects of terpenes when directly in atmospheric conditions with isolates of *Amylostereum areolatum* from the Southern Hemisphere.

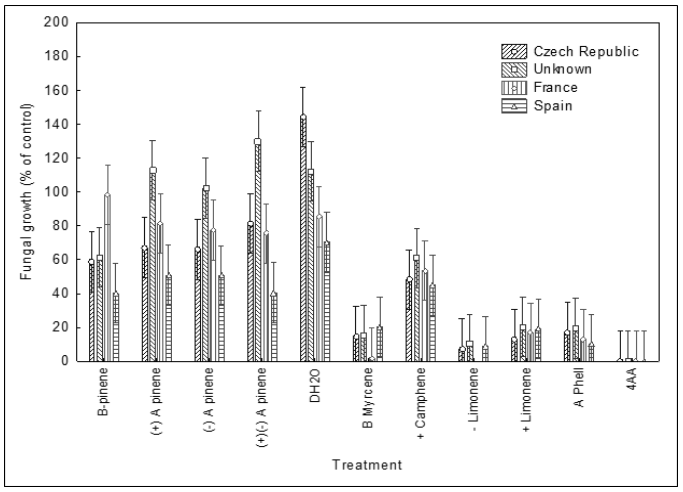



**Figure 5.** Overall effects of terpenes when in atmospheric conditions with isolates of *Amylostereum areolatum* from the Northern Hemisphere.

## MATURE ROOT INOCULATIONS, PRATIMA DEVKOTA

Pine decline is an emerging problem in the southern United States. Root feeding bark beetles and their fungal associates *Leptographium terebrantis* (native) and *Grosmannia huntii* (non-native) are the biotic factors. This study was conducted to understand the susceptibility of four mature loblolly pine (*Pinus taeda* L.) tree families to these root infecting fungi and correlate results with the same pre-screened seedling families. Two mature families which were susceptible (L56 and L57) and two families which were tolerant (L05 and L8) in the previous seedling screening study were studied. In the study, two primary lateral roots were excavated from each tree. Each of the roots were artificially inoculated with either *L. terebrantis* or *G. huntii* along with a control. Eight weeks following inoculation, host responses were recorded as the length of the lesion and vascular occlusion.

Both fungi caused lesions and occlusions upward and downward radiating from the point of initial inoculation. The lesion caused by the fungal treatments were significantly higher than those caused by fungal treatments Table 1.

The average lesion length produced by the fungal treatment was significantly different among the families. Family L56, which was the susceptible family in the seedling screening study, had the highest average lesion length in this study as well. The average length of the lesion produced in tolerant families L8 and L05 was significantly shorter than

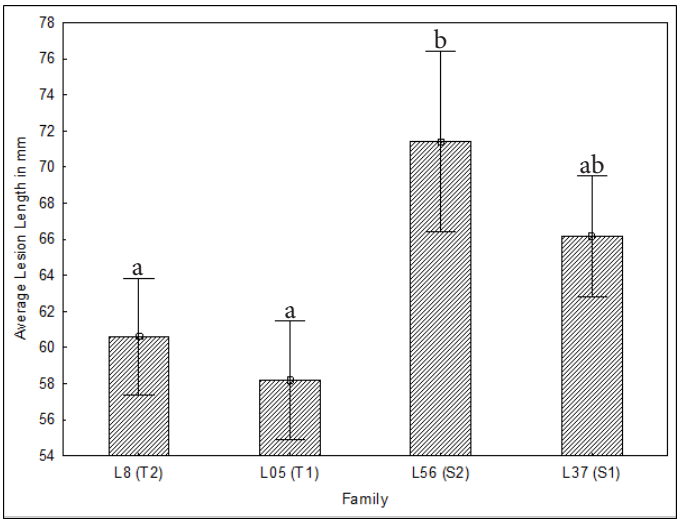



**Figure 1.** Average lesion length produced in four families when tretated with *G. huntii* and *L. terebrantis*. Current effect: $F_{(3,184)}$=3.23, $p$=0.024. Different letters indicate significant difference at 95% confidence level.

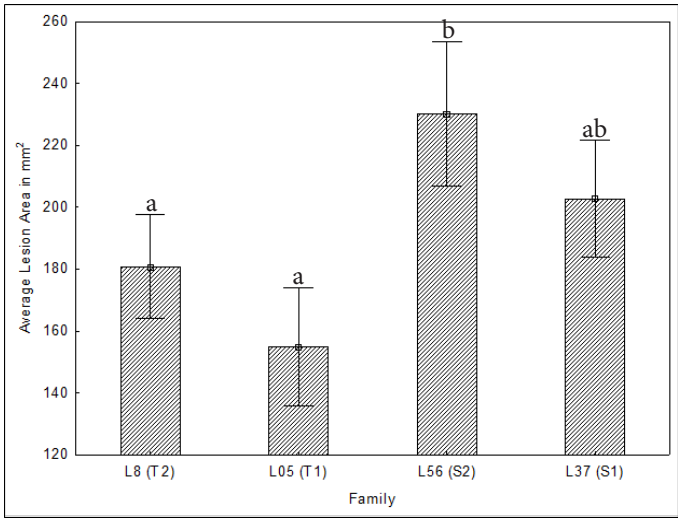



**Figure 2.** Average lesion area in four families following inoculation with *L. terebrantis* and *G. huntii*. Current effect: $F_{(3,\ 182)}$=3.0429, $p$=0.030. Different letters indicate significant difference at 95% confidence level.

**Table 1.** Pairwise comparisons of different treatments on different families.

| Treatments | L8 | L05 | L56 | L37 |
|---|---|---|---|---|
| GH vs WM | 0.0001 | 0.0008 | 0.00014 | 0.0001 |
| LT vs WM | 0.002 | 0.160 | 0.028 | 0.001 |
| WM vs W | 0.939 | 0.787 | 0.73 | 0.29 |
| GH vs W | 0.0001 | 0.002 | 0.005 | <0.0001 |
| LT vs W | 0.002 | 0.26 | 0.064 | <0.0001 |
| GH vs LT | 0.50 | 0.07 | 0.126 | 0.341 |

that of L56 (Figure 1). Similarly, different families produced significantly different average lesion area. Family L56 had bigger average lesion area and family L05 had smaller average lesion area (Figure 2).

Families screened showed different levels of susceptibility to the fungal species tested, as indicated by their average lesion length and lesion area.The pattern of susceptibility and tolerance in the large mature tree families and seedling families was similar. The results supported seedling screening study. In summary, the same level of family difference exists in mature as well as in premature stages of loblolly pine.


**A:** Mature loblolly pine tree lateral roots inoculated with fungi and controls; **B and C:** Lesion caused by *Grosmannia huntii* and *Leptographium terebrantis* respectively on the inoculated roots

## YEAR 4 SEEDLING UPDATE, PRATIMA DEVKOTA

Pine decline is a serious threat to forest production sustainability in the southern United States and involves complex interactions between biotic and abiotic factors. Biotic factors like *Leptographium* and *Grosmannia* species vectored by the root-feeding bark beetles are the major contributing factors of this decline. The symptoms associated with southern pine decline are thin crowns, sparse and chlorotic needles, deterioration of fine and lateral roots, premature mortality and decline of pine trees.

The objective of this study was to determine the variability in tolerance of different loblolly pine families to these ophiostomatoid fungi. In 2014, the study was conducted in 38 containerized loblolly pine seedling families and 4 bare root loblolly pine families which were similar to 4 of the containerized families. These seedlings were artificially inoculated with *Leptographium terebrantis* (native) and *Grosmannia huntii* (non-native). Seedling responses (seedling survival, lesion presence, lesion length and occlusion of vascular tissues) were measured eight weeks following inoculations.

Both the fungal treatments caused dark brown lesions in all of the families tested as shown in Figure 1. The length of the lesion caused by both the fungal

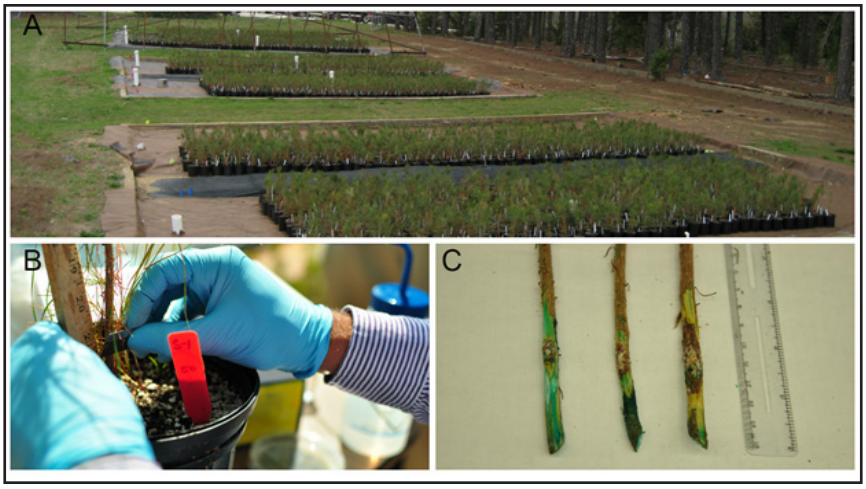



**Figure 1: A:** Seedlings of loblolly pine families planted in Randomized Complete Block Design; **B:** Artificial fungal inoculation method; **C:** Lesions in seedlings eight week following inoculation

The average length of the lesion produced by both the fungal treatments was significantly different among the families. Families L108 and L99 had shorter lesions and L81 and L91 had longest lesions when treated with *L. terebrantis*. Whereas, L86 and L108 had the shortest lesions and L88 and L91 had longer lesions when treated by *G. huntii* (Figure 5 and 6).

There was variation in susceptibility or tolerance of loblolly pine families to ophiostomatoid fungi associated with pine decline in 2014 seedling screening study which is consistent with the results of previous seedling screening studies. The same bare root or container grown families study did not show any variation in tolerance. This suggests that the length of the lesion caused by the fungi is similar in seedling grown by either method. In conclusion, family difference exists and specific tolerant families can perform better in pine decline risk sites.

treatments was significantly longer than those caused by the control treatments as shown by pairwise comparisons test. *Grosmannia huntii* produced significantly longer lesion length than *L. terebrantis* ($p<0.0001$). Similarly, the length of occlusion caused by *G. huntii* was significantly longer than that caused by L. terebrantis ($p<0.0001$). There was no significant difference in the length of the lesion between the bare-root and the container grown connector families when treated with both *L. terebrantis* and *G. hunti* as shown in Figure 2 and 3 respectively. Although the difference was seen among the different families, none of the same two families had significantly different lesion length.

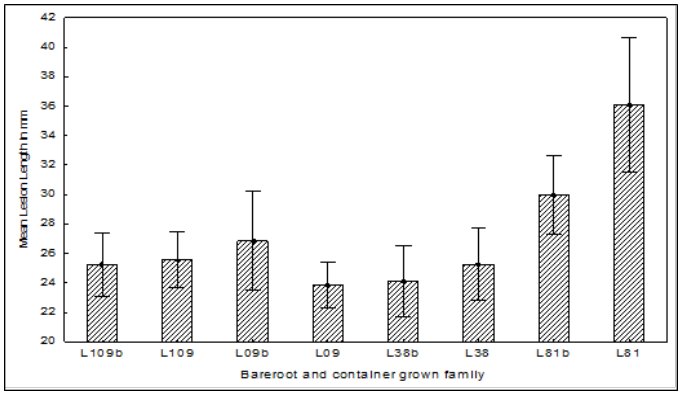



**Figure 2.** Mean lesion length caused by *L. terebrantis* on bare root and container grown connector families. Current effect Current effect: $F_{(7, 241)}=2.3885$, $p=0.02226$

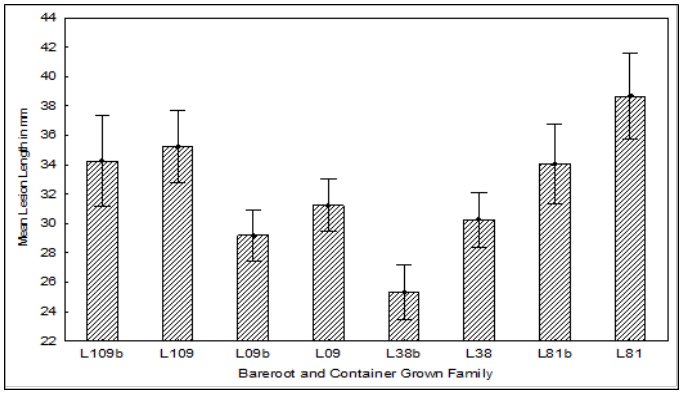



**Figure 3.** Overall mean lesion length produced by *G. huntii* on bare root and container grown connector families. Current effect: $F_{(7, 258)}=2.5042$, $p=0.01662$

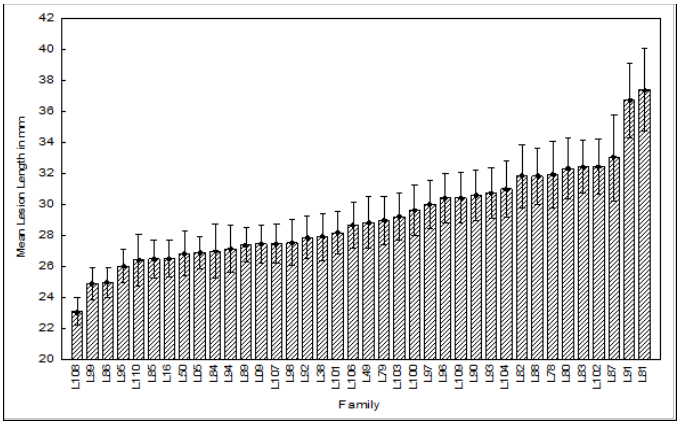



**Figure 4.** Overall mean lesion length caused by both the fungal treatments on families. Current effect. $F_{(37, 2910)}=3.4841$, $p=<0.0001$

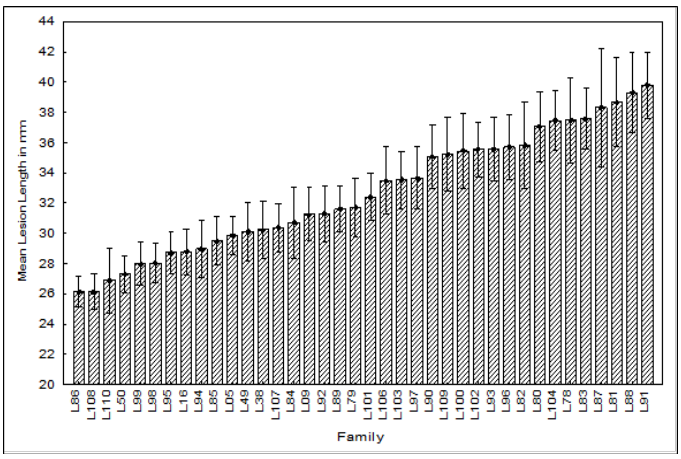



**Figure 5.** Mean lesion length by *G. huntii* on different family (Current effect: $F_{(37, 1446)}$=3.8184, $p$=0.00000)

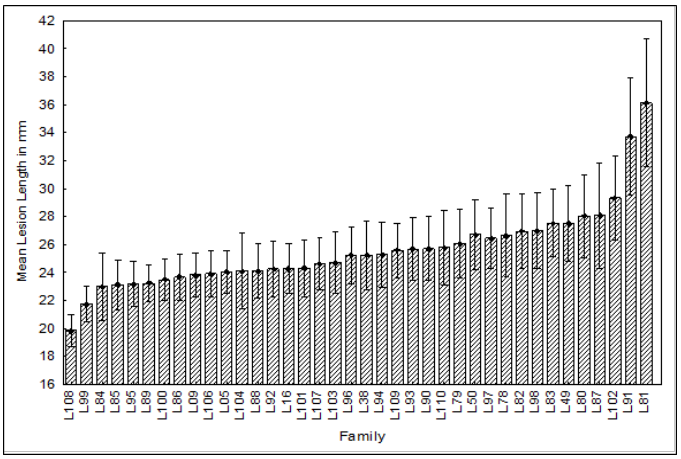



**Figure 6.** Mean Lesion length caused by *L. terebrantis* on different families. Current effect: $F_{(37, 1428)}$=1.4567, $p$=0.03840

## COGONGRASS – PINE MYCORRHIZZAE RELATIONSHIPS, ADAM TRAUTWIG

Cogongrass (*Imperata cylindrica* (L.) Beauv.) is a rhizome producing, C4, perennial grass with a multifaceted and dynamic invasion process. *Imperata cylindrica* is a prolific seed producer and reproduces vegetatively from established plants, which makes it an effective disperser that thrives on disturbance. Once present, *I. cylindrica* can outcompete native vegetation through several strategies such as shading out, altered fire regimes, and production of potentially allelopathic compounds. These compounds were enumerated by Hagen et al. (2013) and demonstrated to be present in the soil in higher concentrations in *I. cylindrica* present plots than *I. cylindrica* absent plots in loblolly pine (*Pinus taeda* L.) stands. We measured the effect these compounds had on common pine mycorrhizal fungi, a group of organisms vital to healthy plant growth and development.

The objective of this study was to measure the effect of invasion by *I. cylindrica* on individual species of mycorrhizal fungi without confounding factors. We designed and implemented a study to measure the effect of individual components of *I. cylindrica* exudate on individual species of mycorrhizal fungi in culture. We expected these compounds to have varying effects on the growth of species of mycorrhizal fungi. The severity and ubiquity of effect on growth will be useful in determining the mechanism of *I. cylindrica* invasion responsible for reduced colonization of mycorrhizal fungi on *P. taeda* fine feeder roots observed in earlier studies. In addition we expected compounds to have similar effects on different isolates belonging to the same species. This study measured six components of *I. cylindrica* exudate on nine fungal isolates representing five unique species. Each combination of exudate component and mycorrhizal fungi was replicated 25 times and measured once every two weeks.

*Amanita muscaria* demonstrated a significant time by treatment interaction ($F_{(6,608)}$=13.12, $p$<0.0001) (Table 1A). Sinapinic acid elicited an increase in growth compared to control treatments in pairwise comparisons. *Laccaria*

**Table 1.** Growth rate ($cm^2$) of mycorrhizal fungi in culture with cogongrass exudate component. Individual mycorrhizal fungal isolates are denoted by letters (A-I), red cells denote significant increased growth, yellow cells denote significant decreased growth.

| | Gallic acid | Caffeic acid | Salicylic acid | Sinapinic acid | Cinnamic acid | Emodin | Control |
|---|---|---|---|---|---|---|---|
| A) *Amanita muscaria* | 0.3959 | 0.3789 | 0.3897 | 0.5048 | 0.4389 | 0.3514 | 0.4277 |
| B) *Laccaria laccata* | 0.4217 | 0.2675 | 0.2798 | 0.1951 | 0.2610 | 0.2542 | 0.2771 |
| C) *Lactarius paradoxus* | 0.1200 | 0.0664 | 0.0699 | 0.0825 | 0.0894 | 0.0709 | 0.1131 |
| D) *Rhizopogon roseolus* | 0.1505 | 0.1167 | 0.1015 | 0.1857 | 0.1697 | 0.1969 | 0.1426 |
| E) *Suillus brevipes* | 0.5950 | 0.5955 | 0.6752 | 0.5750 | 0.6109 | 0.5835 | 0.7197 |
| F) *Suillus hirtellus A* | 0.4531 | 0.4791 | 0.4719 | 0.4670 | 0.4842 | 0.4829 | 0.4438 |
| G) *Suillus hirtellus B* | 0.4397 | 0.4591 | 0.5070 | 0.4805 | 0.4102 | 0.3907 | 0.3797 |
| H) *Suillus salmonicolor A* | 0.6195 | 0.5865 | 0.5662 | 0.6119 | 0.4075 | 0.5925 | 0.8519 |
| I) *Suillus salmonicolor B* | 0.5138 | 0.3013 | 0.2942 | 0.8059 | 0.3635 | 0.4609 | 0.7827 |

*laccata* also demonstrated a significant time by treatment interaction ($F_{(6,627)}$=11.35, $p$<0.0001) (Table 1B). In *L. laccata* cultures treatment with gallic acid resulted increased growth, while treatment with sinapinic acid resulted in significantly decreased growth in pairwise comparison. *Lactarius paradoxus* demonstrated a significant time by treatment interaction ($F_{(6,630)}$=11.34, $p$<0.0001) (Table 1C).

In *L. paradoxus* cultures treatment with caffeic acid, salicylic acid, sinapinic acid and emodin all resulted in negative growth according to pairwise comparisons. *Rhizopogon roseolus* likewise yielded a time by treatment interaction ($F_{(2,639)}$=11.63, $p$<0.0001) (Table 1D), although no treatment differed significantly from the control. *Suillus brevipes* demonstrated a time by treatment interaction ($F_{(6,629)}$=5.19, $p$<0.0001) (Table 1E). Gallic acid, sinapinic acid, cinnamic acid and emodin were correlated with decreased growth in pairwise comparisons. Two isolates of *Suillus hirtellus* were examined. Specimen A (*S. hirtellus* A) didn't demonstrated a significant time by treatment interaction ($F_{(6,620)}$=1.20, $p$=0.307) (Table 1F). No treatment decreased growth of *S. hirtellus* A but caffeic acid was consistent with increased growth. Specimen B (*S. hirtellus* B) had a significant time by treatment interaction ($F_{(6,625)}$=6.81, $p$<0.0001) (Table 1G).

No treatment was consistent with decreased growth but salicylic acid was consistent with increased growth. Final growth of *S. hirtellus* A and *S. hirtellus* B were compared and it was determined that a significant difference existed between isolate growth ($F_{(6,292)}$=4.29, $p$=0.0004) (Figure 1). Specifically, a difference was observed in *S. hirtellus* response to cinnamic acid ($p$=0.048) and emodin ($p$=0.006).

Two isolates of *Suillus salmonicolor* were also incorporated. Specimen A (*S. salmonicolor* A) displayed significant time by treatment interaction ($F_{(6,460)}$=11.21, $p$<0.0001) (Table 1H). In this specimen, all treatments resulted in significantly decreased growth: gallic acid, caffeic acid, salicylic acid, cinnamic acid and emodin. Specimen B (*S. salmonicolor* B) had a time by treatment interaction ($F_{(6,476)}$=49.46, $p$<0.0001) (Table 1I). Gallic acid, caffeic acid, salicylic acid, cinnamic acid and emodin treatments all resulted in decreased growth relative to the control. Final growth of *S. salmonicolor* A and *S. salmonicolor* B was compared and a significant difference was present between similar treatments of different isolates ($F_{(6,286)}$=5.42, $p$<0.0001) (Figure 2). *Suillus salmonicolor* had two treatments that were significantly different between specimens of the same species: caffeic acid ($p$=0.003) and salicylic acid ($p$=0.010).

Emodin most frequently resulted in reduced growth when applied to plates on which mycorrhizal fungi were grown (4 out of 9). Emodin is found across 17 families in a diversity of growth forms worldwide. In experiments on a variety of media and taxa, emodin has been found to reduce the growth of several plant species and soil bacteria, in some cases at minimal concentrations. Emodin has also been recorded to decrease availability of $Mn^{2+}$ and increase the availability of $Na^{+}$ and $K^{+}$. The preponderance of these findings was consistent with conditions observed in earlier studies. Contrary to our predictions, however, isolates of the same species performed similarly but not identically, so further testing may be warranted.

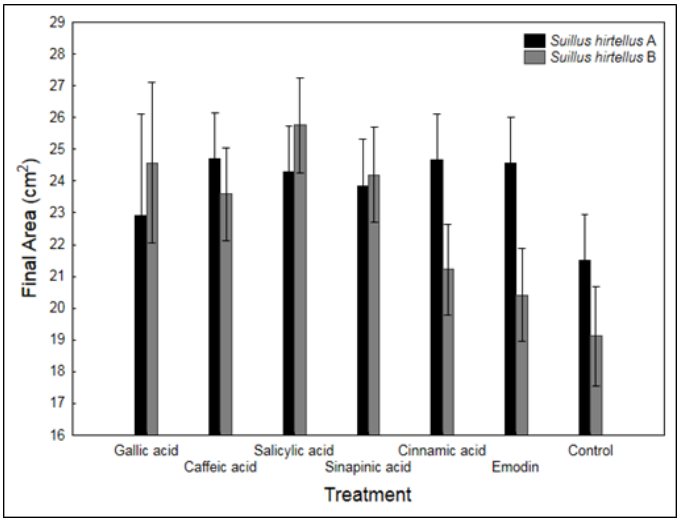



**Figure 1.** Mean final area of fungal colonies is compared across like treatments of different specimens of the same fungal species *Suillus hirtellus*. Significant differences (α=0.05) are denoted with asterisks.

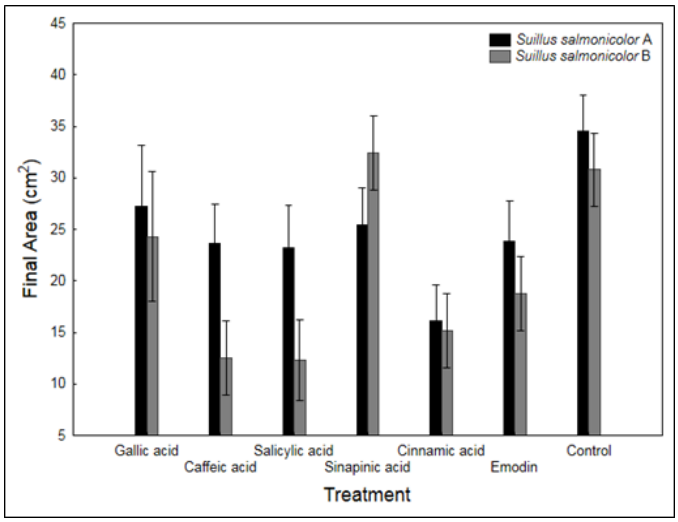



**Figure 2.** Mean final area of fungal colonies is compared across like treatments of different specimens of the same fungal species *Suillus salmonicolor*. Significant differences (α=0.05) are denoted with asterisks.

## ANTIBIOSIS STUDY, PRATIMA DEVKOTA

The use of microbes to control diseases is becoming more common and is an environmentally friendly approach. Plant growth-promoting rhizobacteria (PGPR) have the potential as a biocontrol agent. Blue-stain fungi *Leptographium terebrantis*, *Leptographium procerum*, *Grosmannia huntii* and *Grosmannia alacris* are most commonly isolated from roots of loblolly pine trees showing decline symptoms in the southern United States.

The objective of this research was to study the effect of thirty PGPR strains that previously exhibited both broad-spectrum biocontrol activity against plant pathogens towards blue-stain fungi *in vitro*. It was hypothesized that some of the well characterized PGPR strains would exhibit *in vitro* antibiosis against the blue stain fungi. All PGPR strains used in the study were pre-identified using 16S rDNA sequencing with a comparison to sequences of type strains. Then antibiosis test was performed to determine the inhibitory action of each PGPR in comparison with the control.

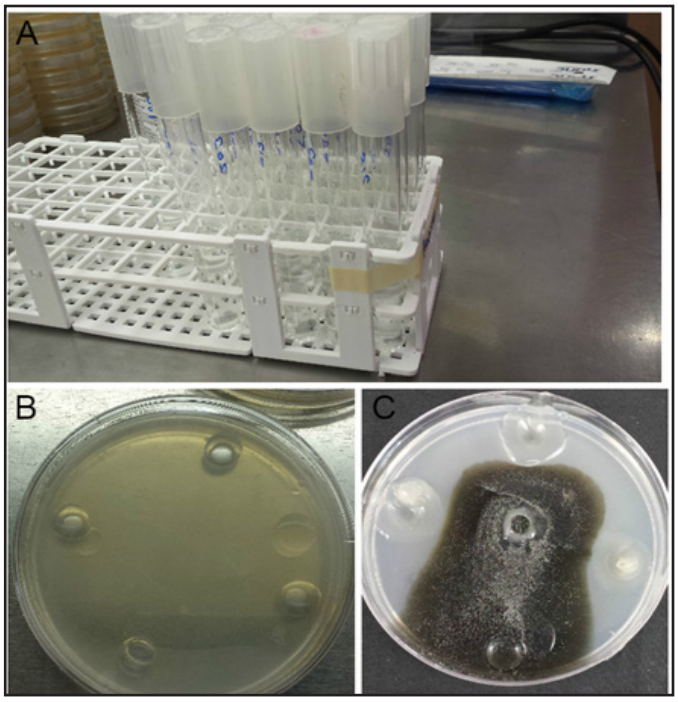



**Figure 1: A:** Rhizobacterial inoculum; **B:** Agar plate with four inoculation holes; **C:** Fungi being inhibited by the rhizobacteria on three side and growing properly on control side

Out of 30 tested strains of PGPR 26, 11, 26 and 10 strains significantly inhibited the growth of *L. procerum*, *L. terebrantis*, *G. alacris* and *G. huntii* respectively. Only light growth near the inhibition zone was observed. There was no inhibition zone towards control in all plates as shown in **Figure1**. This in vitro study demonstrates that the tested PGPR strains produce metabolites that stop the growth of blue-stain fungi. These strains will be evaluated for their biocontrol potential in *planta*.

## PITCH CANKER, DR. RYAN NADEL

Pitch canker is a serious disease caused by the fungal pathogen *Fusarium circinatum* (*Gibberella circinata*). This disease affects numerous pine species and is characterized by large resinous cankers that develop on roots, trunks, branches and reproductive organs of mature pine tree hosts. On pine seedlings, the pathogen mainly causes root and collar rots.

Pitch canker is readily transported in and on pine seed and cuttings. As a result, seed certification indicating the absence of the pathogen is required for international seed importation. Currently the International Seed Testing Association (ISTA) seed screening blotter paper method is used by the USDA Forest Service Resistance Screening Center to screen for the pathogen. This method relies on culturing the pathogen from seed on blotter paper infused with PCNB broth medium and identifying suspected colonies morphologically. Unfortunately this method does not allow for the reliable identification of suspected colonies to the species level. In addition, the blotter paper method can also lead to false negative results as a result of numerous fungi that may grow from the pine seed, covering *G. circinata* colonies.

To date, with our collaborators, we have developed a faster more accurate method through bulk DNA extraction and molecular PCR procedures that are used to screen seed for the presence of *G. circinata*. Numerous seed lots, representing several of the most commonly planted pine species in the southeastern US, were sourced and screened with the refined DNA extraction and PCR amplification. We have demonstrated the ability to quickly and positively identify the pathogen in seed lots and planting material. Since our last newsletter article we have compared contamination rates in a large number of seed lots across several pine species. Using this technique, results indicate the detection of the pathogen in 14% of Loblolly, 10% of Slash, 17% of Shortleaf and 72% of Longleaf screened seed lots (Figure 1).

To ascertain the detection limit for *G. circinata* using the protocol, several seed lots were sterilized and then intentionally infected with a specific number of seed infected with the pathogen. Seed lots were infected with seed, ranging from 1 – 13 seeds per sample of

400 seeds. Results from this study indicate that the developed method was capable of detecting a single *G. circinata* infected seed for all pine species tested (Figure 2). These results will assist in developing requirements for a screening protocol which must be accepted by the International Seed Testing Association (ISTA).

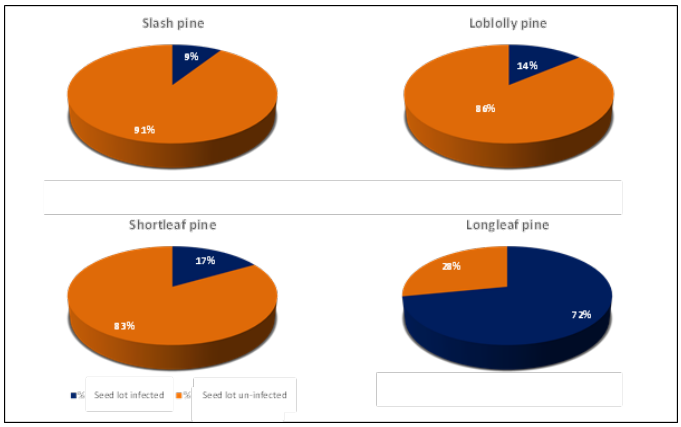



**Figure 1.** The percentage of seed lots screened, for several southern pine species, which were found to be infected with *G. circinata* using the developed molecular protocol.

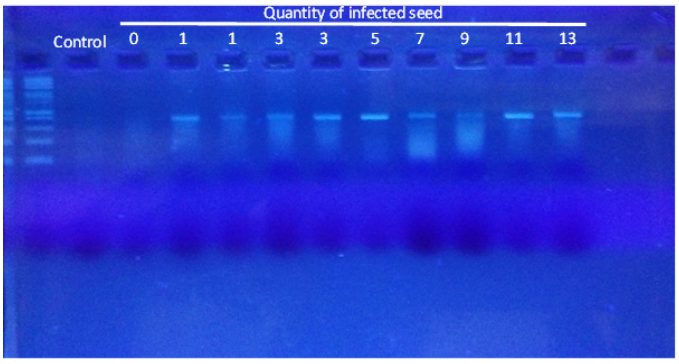



**Figure 2.** PCR amplification for the presence of *G. circinata* from pine seed lots infected with 1 – 13 seeds per 400 seed. A 2% agarose gel shows either the presence or absence of a band after PCR.

## QUANTIFYING PINE DECLINE UPDATE, DR. RYAN NADEL

The Forest health Coop funded project that aims to quantifying the impact of pine decline (QPD) was finally initiated in December 2015. Experimental plots were installed at the study site, located in Eufaula Alabama, with initial tree and soil measurements undertaken. For a one year period, prior to fungal treatments being imposed, all installed plots will regularly have tree growth and physiological measurements undertaken.

These measurements will aid in addressing the main objectives of the project which are to:

- Quantify the impact of fungal root infection on tree and plantation productivity and investigate the early detection potential of a subset of variables.
- Determine the threshold level of fungal root infection required to cause growth reductions and mortality of plantation trees.
- Examine the role of fungal root infection and its interaction with water, nutrient and carbon relations of plantation trees to determine the causes of tree mortality and growth losses by the pine decline process.
- Determine the impact of fungal root infection on the behavior of bark beetles and other pests within affected stands.

By addressing the objectives of the project we envisage that the main contribution of the work, once completed, will finally allow foresters to actually quantify the impact that certain pests and pathogens have on the growth of their trees and thus productivity at a particular site. This research shall improve our understanding of the interactive effect among fungal infection, stand environment and tree physiology of loblolly sustainability required for developing remedial actions, reducing productivity losses, for trees and stands already affected with decline.

The QPD project will be undertaken by two new graduate students namely John Mensah and Shrijana Duwadi who recently joined the forest health dynamics laboratory. These students will both be researching various aspects of this project as part of their PhD and MS degrees.

# GRANTS

**NEW GRANTS**

Via and Eckhardt. 2015. Novel analytical tools for the selection of superior loblolly pine genotypes for improved plant health, fuels, and chemicals – SFWS, Forest Products Development Center and AU-IGP (Good to Great Grant). $150,000. 2 years.

**CONTINUING GRANTS**

Hoeksema and Eckhardt. 2015. Identification of climate effects on microbial symbionts of longleaf pine - ERDC-SERL - $50,000. *Year 2 of 2

Enebak and Eckhardt. 2014. Seedling production and forest health in the Southeastern United States – NSF-CAFS - $300,000 ($150,000 to FHC). *Year 2 of 5

Enebak and Eckhardt. 2014. Testing of a rapid PCR Screening test for the presence of Fusarium circinatum, the causal agent of pitch canker on pine planting material – FHM - $150,000. *Year 3 of 3

Hoeksema and Eckhardt. 2015. Identification of climate effects on microbial symbionts of longleaf pine - ERDC-SERL - $50,000. *Year 3 of 3

Eckhardt and Enebak. 2015. Sudden Oak Death – Phytophpora ramorum surveys - $180,000. *Year 5. Funding for 2017 expected.

Via and Eckhardt. 2014. Wood chemistry and disease resistance. SFWS - $25,000. *Year 3 of 5

Hoeksema and Eckhardt. 2014. Mycorrhizal fungal colonization and disease resistance – SFWS and University of Mississippi - $25,000. *Year 3 of 3

Eckhardt and Wingfield. 2015 Pinus related diseases and molecular aspects. SFWS and FABI – University of Pretoria South Africa for travel and supplies and a graduate student stipend at UP - $30,000. *Year 3. Extended for 3 more years until 2019.

Via and Eckhardt. 2014. Rapid assessment tools for the genetic improvement of forest products and bioenergy – HATCH - $50,000. *Year 2 of 2

# ASSOCIATED ACTIVITIES

(Meeting, Workshops, Short Courses, Disease Clinic)

## ADVISORY MEETING

The Advisory meeting was held July 28-30, 2015 in St. Simon's Island, GA with Plum Creek hosting a nursery tour in Jesup, GA. This was the first joint meeting of the Forest Health Cooperative and the Southern Forest Nursery Management Cooperative, both of which operate out of the Forest Health Dynamics Laboratory at Auburn University. Our attempt at this joint meeting was to allow the members of each research cooperative to see what the other research cooperative was working on and the issues each group (nursery and reforestation) faces. The meeting was attended by 30 Nursery Cooperative members and 20 Forest Health Cooperative members. Forest Health Cooperative staff presented information of the virulence of the fungi associated with Pine Decline, the emerging threats of non-native invasive weeds and the potential effects of Sirex Wood Wasp. Nursery Cooperative staff presented information to the entire group on new soil fumigant chemistries, weed control in native plant production systems, a rapid pitch canker identification tool and the exciting results of using Near Infrared (NIR) scanning to identify freeze injury in seedlings. The field trips at this meeting included a tour of the Jesup Plum Creek Nursery that had a MBR alternative fumigation trial installed with some new compounds, herbicide trials containing Marengo and PAC and a new irrigation system. In addition, Plum Creek's McKinnon Seed Orchard was toured along with the silvicultural demonstration trials. Special thanks to Doug Sharp and Plum Creek for hosting the social each night at the conference center. To review any of the presentations again, I encourage you to access them on the member page. The end-of-meeting poll results were mixed with each group (cooperative) indicating that the other's research group was not relevant to them.

They FY17 meeting is set for June 29-30, 2016. It will begin after lunch on Wednesday and adjourn around noon on Thursday. Place those days on your calendar and more information will be available soon.

## BUSINESS MEETING

The Business meeting was held on December 3, 2015 at the School of Forestry and Wildlife Building at 602 Duncan Drive. The Forest Health Cooperative Staff presented the Accomplishments, Budget and next year's Work Plan. The work plan and budget were approved.

## CENTER FOR ADVANCED FORESTRY SYSTEMS (CAFS)

Staff from both Cooperatives attended the CAFS Annual meeting in Asheville North Carolina May 19-21, 2015. Adam Trautwig, a MS student, won a graduate student travel scholarship to the meeting. The Forest Health Dynamics Laboratory at Auburn's School of Forestry and Wildlife Sciences was awarded the second year of the 5-yr grant as part of the research center of the National Science Foundation, as part of the Center for Advanced Forestry Systems (CAFS). The Auburn site addresses forest health in the region via the two research Cooperatives. This $60,000 grant will be used to fund research in the Nursery and Forest Health Cooperative.

## WORKSHOPS, TRAINING AND FIELD VISITS

We conducted a Pine Decline Workshop and Tour in Leesville South Carolina entitled "Pine Decline: Is it real? If so, what are its effects?". There were over 120 landowners in attendance and the workshop and field trip got good reviews. We also completed various forest health trainings and field visits for members. In addition we worked with the 4-H Forestry county teams in Alabama with insect and disease identification and were involved in several FFA (Future Farmers of America) teacher workshops on forest insect and disease as well as the student competitions. Training the youth of Alabama about forestry is important to the industry.

## DISEASE CLINIC

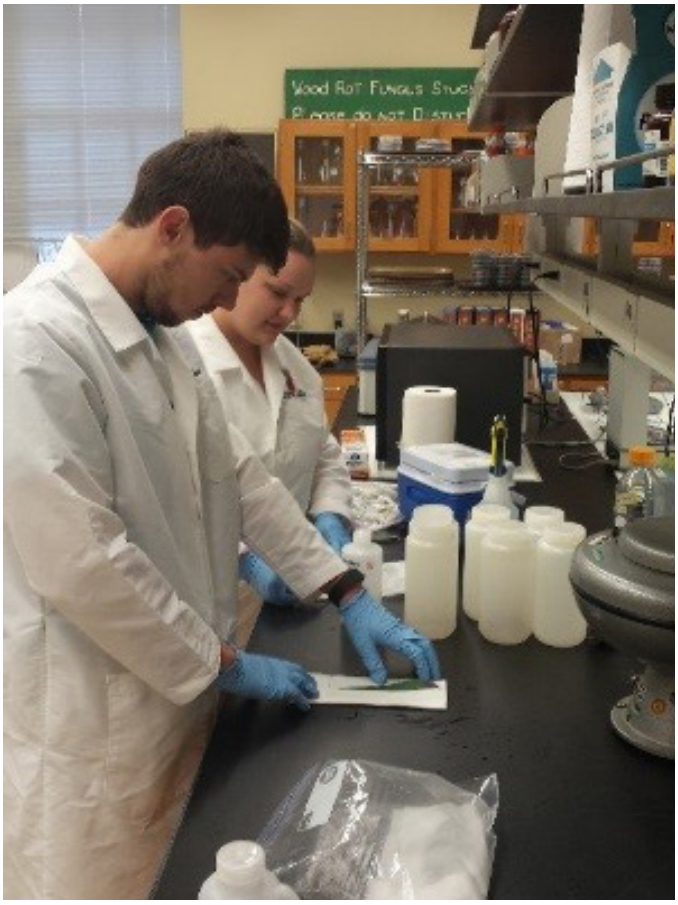
We have instituted some new procedures for the Disease Clinic. There is a new link on the webpage explaining sampling procedures and a form to send in with your samples. This will make the process and information received more uniform and easier for us to track, process and report. Dalton Smith and Sarah Peaden are the new contacts for diagnostics for the Cooperative. Their contact information is at the beginning of this report and on the website. Please feel free to contact them with any questions.

The Forest Health Cooperative Staff saw a variety of issues this past year in the laboratory. The most frequent repeat occurrence was blue-stain fungi and root-feeding insect damage in loblolly pine roots. If you have any questions about the identification and management of these issues, be sure to check the

Forest Health Cooperative web page or just give us a call.

Here is a list of the problems we were involved in during 2012:

1. Pine decline – blue-stain fungi and *Hylastes* feeding in loblolly pine roots
2. Pine decline – blue-stain and *Hylastes* feeding in longleaf pine roots
3. Annosus Root Disease
4. Tip Moth
5. Pine Sawfly
6. Pine Shoot Borer
7. Seiridium Canker of Leyland Cypress
8. *Neoclytus scutellaris*
9. Slim flux
10. Hickory Borer
11. Horned Oak Gall
12. *Diplodia* on pine



*Dalton Smith and Sarah Peaden processing the "Bottle of Bait", Sudden Oak Death samples.*

**SUDDEN OAK DEATH (SOD) STATE LABORATORY**

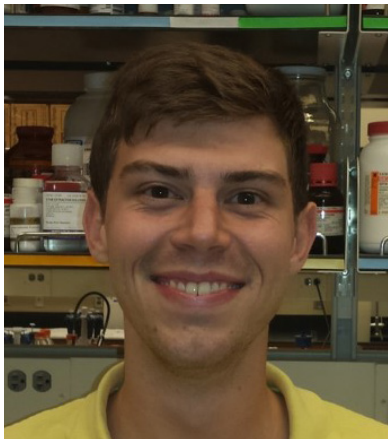
The Forest Health Cooperative (FHC) continued to be involved in the national 2015/2016 Sudden Oak Death (SOD) surveys and responsible for Alabama and Mississippi monitoring. During both fall and spring the Forest Health Cooperative conducted its survey using the "bottle of bait" protocol to monitor for the presence of *Phytophthora ramorum*, the pathogen responsible for Sudden Oak Death. Surveys were conducted at a total of 9 sites in Alabama and 5 sites in Mississippi. Early detection of this pathogen is essential to prevent an infection from becoming fully established. Water supplies at specific locations were monitored for the presence of the pathogen, with site selection based on stream drainage from nurseries considered at risk or known to have received plant material contaminated with the pathogen.

Sampling occurs only in fall and spring as water temperatures are then optimal for *Phytophthora ramorum* detection. Detection of the pathogen is determined using both morphologically and molecular identification techniques and carried out by the Department of Agriculture, Plant Disease Diagnostic lab. The 2016 sampling is scheduled to commence in March – April.

# STAFF

**STAFF**

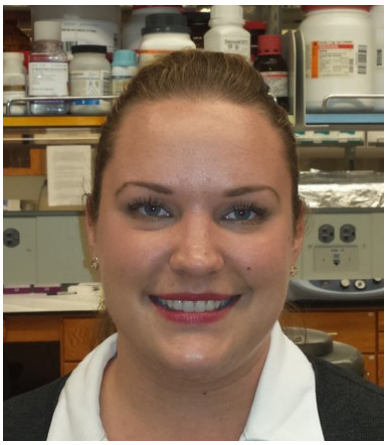
The Forest Health Cooperative has had some changes in staff. Tessa Bauman returned to Louisiana to finish her PhD and we have gained two new Research Assistants, Dalton Smith and Sarah Peaden.



**Dalton Smith – Research Assistant (Fall 2015)**

Dalton Smith joined the Forest Health Dynamics Laboratory this past September as a Research Assistant, replacing Tessa Bauman. He is from St. Petersburg, Florida and a graduate from the University of Florida where he studied Natural Resource and Forest Conservation. He is interested in the field of forest health and mycology as well as the economic side of forestry. He wishes to continue his learning, gain valuable experience and possibly attend graduate school in the future. In the Forest Health Dynamics Laboratory he assists Dr. Lori Eckhardt with the work being done in the laboratory on Southern Pine Decline as well as works with the graduate students offering them any assistance they require. He and Sarah Peaden work together on the Sudden Oak Death (*Phytophthora ramorum*) survey, where they take water samples in Alabama and Mississippi. They test different nurseries for the presence of the pathogen *Phytophthora ramorum* and, in conjunction with APHIS, monitor the pathogen in the southeast. He is excited to work in the Forest Health Dynamics Laboratory, meet individuals involved in industry and contribute to the research in the laboratory.

**Sarah Peaden – Research Assistant (Fall 2015)**



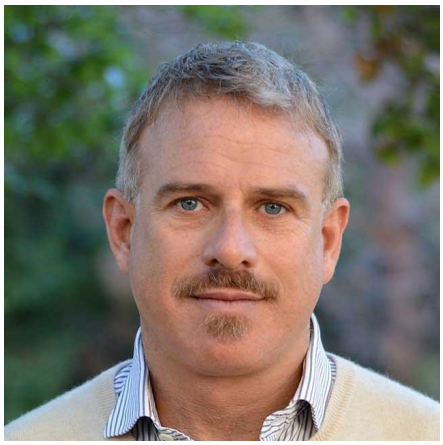
Sarah Peaden joined the Forest Health Dynamics Laboratory in September of 2015 as a Research Assistant, replacing Alyssa Rosenblum. From Orange Beach, Alabama, she is a recent graduate of Auburn University receiving her Bachelor's degree in Microbiology. With a background predominantly in bacteriology, she has a passion for laboratory work and a great interest in forest health related pathology. She assists the graduate students in their research projects while also contributing to Dr. Lori Eckhardt's current research regarding the various *Leptographium* species of fungi and their vectors associated with Southern Pine Decline and mortality. Sarah also is currently working with swab samples obtained from deer antlers detecting the presence of fungi in concurrence with Dr. Stephen Ditchkoff's Deer Lab. Along with Dalton Smith, Sarah partakes in the 1,000 mile Sudden Oak Death survey across Alabama and Mississippi three times in both the spring and fall collecting and processing stream water samples from runoff nursery water to monitor and detect the presence of *Phytophthora ramorum*, a serious pathogen associated with forestry. She is enthusiastic about this new position and looks forward to serving the forestry industry.

**Dr. Ryan Nadel – Postdoctoral Fellow (Spring 2014)**

Dr. Ryan Nadel joined the Forest Health Dynamics Laboratory as a Post Doctoral Fellow. His current research focus is on tree health. His current research project focusses on testing pine seed for the presence of *Fusarium circinatum* using a newly developed rapid molecular screening technique compared to the blotter paper method currently used by the International Seed Testing Association (ISTA). Ryan is from South Africa where he was employed as a Senior Research Scientist and Project Leader for Integrated Pest Management (IPM) Research at the Institute for Commercial Forestry Research (ICFR). Ryan has worked on numerous pests and pathogens (including *Fusarium circinatum*) that impacted the growth and survival of non-native Eucalypt, Pine and Wattle tree species grown in commercial forestry plantations. He is a graduate of the University of the Witwatersrand where he was awarded a BSc, BSc (Hons) in Ecology, Environment and Conservation and an MSc in the School of Animal, Plant and Environmental Sciences. In 2010, he was awarded a PhD degree from the University of Pretoria in the Department of Genetics

after conducting research at the Forestry and Agricultural Biotechnology Institute (FABI). He has published several articles in international scientific journals and presented at several National and International conferences.

## VISITORS



Dr. Garbelotto, an Extension Specialist and Adjunct Professor at University of California Berkley visited us in October 2015. He received a BS & MS in Forestry from the University of Padua Italy and a MS and Ph.D. in Plant Pathology at the University of California Berkley. He serves as an advisor for the European Plant Protection Organization and European Food Safety Authority and is the world coordinator of the root rot (*Heterobasidion annosum*) working group and the co-coordinator of *Phytophthora* in natural ecosystems working group for IUFRO. He was even proclaimed by the California State Assembly as the Oak Savior. He has taught public "sudden oak death" training sessions and has forged numerous interdisciplinary collaborations to develop innovative approaches to diagnosing and modeling diseases in natural forests and nurseries. He spearheaded the move to accept molecular-based diagnostics for *P. ramorum* within a federal regulatory agency, and is currently serving on an advisory panel to implement molecular diagnostics as a critical tool for diagnosing other dangerous plant diseases at the national level. He presented a seminar to the university on "Fungal invasions: beyond the lack of coevolution theory" and spent time with the cooperative graduate students and staff.

## TEACHING

Each year the faculty associated with the Cooperative teach various courses at both the graduate and undergraduate level. Lori Eckhardt and Scott Enebak co-teach FORY 5150/6150 (Forest Health) and FORY 5151/6151 (Forest Health Lab). Scott Enebak teaches FORY 3020 (Introduction to Forest Biology) at Summer Practicum at the Solon Dixon Center in Andalusia Alabama. Lori Eckhardt teaches FORY 7950 (Graduate Seminar) which teaches students how to give a research presentation. Nancy Loewenstein teaches FORY 3100 (Dendrology) and Brian Via teaches FORY 3390 (Introduction to Wood Science).

## GRADUATE STUDENTS

Graduate students' contributions to the program continue to be critical. Forest Health students have had a great year winning over 15 awards which include Best Presentation, Outstanding MS Student, Travel Scholarships, Research Scholarships, Top International Student, and Master's Thesis Awards. A big congratulations to them for their hard work and efforts on their projects!

Forest Health student Jeff Chieppa defended in October 2014 and received his master's degree in December. Congratulations to Jeff for completing his MS thesis entitled "Interactions of future climate change scenarios of elevated tropospheric ozone and altered rainfall on loblolly pine seedlings inoculated with ophiostomatoid fungi."

*Pictured, from left to right: Andrea Cole, Pratima Devkota, John Mensah, and Shrijana Duwadi.*

Forest Health student Adam Trautwig defended in June 2015 and received his master's degree in August. Congratulations to Adam for completing his MS thesis entitled "Microbial Communities in Cogongrass (*Imperata cylindrica* (L.) Beauv.) Invaded Commercial Loblolly Pine (*Pinus taeda* L.) Stands".

We additionally welcomed both a masters and PhD student, Shrijana Duwadi and John Mensah, this year to work on the "Quantifying Pine Decline" project. Listed below are the current students and a little bit about them and their project.

**Andrea Cole –Masters Student (Fall 2014)**

Andrea Cole joined the Forest Health Dynamics laboratory as an MS student. From Tucker, Georgia, Andrea undertook her undergraduate degree in Environmental Science at Berry College in Rome, Georgia. At Auburn her MSc will focus on *Sirex* woodwasps. This experiment is to assess what pest insects were found in the area, specifically targeting native and invasive *Sirex* wood wasp species. Of particular interest is *Sirex noctilio*, a species of wood wasp native to Europe that has been identified as an invasive species in Australia, South Africa, and a few states in the Northeastern United States. This study will discern major forest pest population and abundance in eastern Alabama, and what needs to be done in order to control pests found in Alabama forests. After specimens are collected, the wasps will be keyed to species, then will be dissected in order to sample symbiotic fungal arthrospores and nematodes carried in their abdomens. This survey to determine if *S. noctilio* has reached Alabama is necessary because southern Alabama is at risk of invasion via the port of Mobile, where species have the potential to do economic damage to natural and commercial forests.

**Shrijana Duwadi –Masters Student (Spring 2016)**

My name is Shrijana Duwadi. I joined the Forest Health Dynamics Laboratory, Auburn University in January 2016 for MS program. I earned my undergraduate degree from Tribhuwan University, Nepal. As an undergraduate, I had involvement in a project that focused on evaluating the drought resistance property of wheat genotypes in different soil and climatic conditions. Soil Science, Pathology and Genetics being my areas of interest; my MS at Auburn University will focus on quantifying the impact of root disease, associated with root-feeding bark beetles and ophiosomatoid fungi in pine tree function. For this, experiments will be carried out on the soil portion looking at physical and chemical composition, soil nutrients, microbial biomass function, mycorrhizae and how all these relate to disease progression. I am hopeful that my study will contribute to the economic well-being of forests in the southeastern U.S. to some extent. Reading is what I love and travelling is my greatest passion; these are the reasons why I am here in the U.S. to pursue my higher education. I am more than happy to be a part of the Auburn family.

**Pratima Devkota –PhD Student (Fall 2014)**

My name is Pratima Devkota. I am a PhD student at Forest Health Dynamics Laboratory, Auburn University. I started my program in August, 2014. I completed my B.S and M.S in Microbiology from Tribhuvan University in Nepal. My research interests include the mechanisms of host- fungal interactions and disease resistance, as well as genetics. Currently, I am studying the variance and resistance of different loblolly and slash pine families towards different ophistomatoid fungi like *Leptographium terebrantis* and *Grosmannia huntii*. My study will help land managers make informed decisions regarding planting tolerant pine families. I am happy to be a part of this lab and Auburn University. Some of my hobbies are traveling and playing sports.

**John Mensah –PhD Student (Spring 2016)**

My name is John Mensah and I joined Forest Health Dynamics Laboratory, Auburn University as a PhD student from the Forestry Research Institute of Ghana. I started my program in January, 2016. I obtained my BSc and MPhil degrees in Botany from the University of Ghana, Legon. My research interests include fungal host interactions, biological control of pest and diseases and cultivation of edible mushrooms and molecular biology. Currently I am working on "The impact of *Leptographium terebrantis* on *Pinus taeda* growth in southeastern United States". This study seeks to quantify the impact of fungal root infection on tree and plantation productivity and investigate the early detection potential of tree variables. Ultimately, it will enable forest managers and practitioners to take appropriate decisions concerning commercial stands that are affected by certain pests and pathogens. I am glad to be part of the Forest Health Dynamics Lab at Auburn University and I like watching soccer.

# PUBLICATIONS
OF SPECIAL INTEREST TO MEMBERS (2012-2015)

From our inception in 2008, there have been over 24 publications written by Cooperative scientists, students, and associates. Below is a list of publications from the last 3 years. The entire list is available on our website. (* indicates student)

**2015**

*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.

Beach, J., Uertz, J., and Eckhardt, L. 2015. Hyperspectral interferometry: sizing micro-scale surface features in the pine bark beetle. Microscopy Research and Techniques Published online first: DOI: 10.1002/jemt22550.

*Acquah, G.E., Via, B.K., Fasina, O. and Eckhardt, L.G. 2015. Nondestructive estimation of forest biomass properties for bioenergy, fuels and chemical applications using near infrared spectroscopy (NIRS). J. Near Infr. Spec. Published online first: doi: 10.1255/jnirs.1153.

*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.

**2014**

Via, B.K., Zhou, C., Acquah, G., Jiang, W., and Eckhardt, L. 2014. Near infrared spectroscopy calibration for wood chemistry: which chemometric technique is best for prediction and interpretation? Sensors. 14:13532-13547.

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.

*Duong, T.A., de Beer, Z.W., Wingfield, B.D., Eckhardt, L.G., and Wingfield, M.J. 2014. Microsatellite and mating-type markers reveal unexpected patterns of genetic diversity in the pine root-infecting fungus *Grosmannia alacris*. Phytopathology 64:235-242.

*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.

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. Invasive Plant Science and Management. 6:536-544.

**2013**

*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.

*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. Florida Entomologist. March: 238-241.

**2012**

*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.

# RESEARCH PRESENTATIONS
OF SPECIAL INTEREST TO MEMBERS (2014-2015)

From our inception in 2008, there have been over 200 presentations, seminars and trainings by Cooperative Scientists, Students, and Associates. Below is a list of presentations from the last year. The entire list is available at our website.

**2015**

***Talks:***

*Acquah G. E., Via B.K., Eckhardt L.G., Fasina O. O. and Billor N. 2015. Application of near infrared spectroscopy in the screening of disease tolerant *Pinus taeda* (Loblolly Pine) families for chemistry, strength and bioenergy. 19th International Nondestructive Testing and Evaluation of Wood Symposium, Rio de Janeiro, Brazil.

Eckhardt, L.G. 2015. *Leptographium* species: Tree pathogens and agents of blue stain, and their bark beetle associates [Pine Decline: Is it real? If so, what are its effects?] Clemson Cooperative Extension Landowners Workshop and Field Trip, T & S Farms, Leesville, SC

Eckhardt, L.G. 2015. An overview of forest health research at the forest health cooperative Auburn University. Entomology and Plant Pathology Departmental Seminar, Auburn University, Auburn, AL

Eckhardt, L.G., Ditchkoff, S.S. , Duong, T.A. , De Beer, Z.W. , and Wingfield, M.J. 2014. Two new ophiostomatoid species isolated from soil on snouts of feral hogs damaging pine roots in Georgia, USA. International Wild Pig Conference Science & Management, Montgomery, AL

Clay, N.A., Little, N., Eckhardt, L.G. and Riggins, J.J. 2015. Widespread and complex interactions among bark beetle vectored blue stain (ophiostomatoid) fungi and subterranean termites. Ecological Society of America Annual Meeting, Baltimore, MD

*Piculell, B.J. Nelson, C.D., Roberds, J., Eckhardt, L.G., and Hoeksema, J.D. 2015. Examining the evolutionary interactions of loblolly pine with both beneficial and pathogenic fungi. Ecological Society of America Annual Meeting, Baltimore, MD

*Trautwig, A., Eckhardt, L., Hoeksema, J., and Carter, E. 2015. Cogongrass (*Imperata cylindrica*) reduces colonization of mycorrhizal fungi on loblolly pine (*Pinus taeda*) in commercial stands. Ecological Society of America Annual Meeting, Baltimore, MD

Via, B.K. and Eckhardt, L.G. 2015. Near infrared reflectance (NIR) spectroscopy: dialing stem chemistry for optimal root disease resistance and forest products. Joint Auburn University Southern Forest Nursery Management & Forest Health Cooperatives 2015 Contact Meeting. St, Simons, GA

Nadel, R.L., Matusick, G., and Eckhardt, L.G. 2015. Quantifying the impact of pine decline in the southeastern United States. Joint Auburn University Southern Forest Nursery Management & Forest Health Cooperatives 2015 Contact Meeting. St, Simons, GA

*Trautwig, A., Eckhardt, L., Hoeksema, J., and Carter, E. 2015. Mycorrhizal communities in *Imperata cylindrica* invaded and non-invated commercial Pinus taeda stands. Joint Auburn University Southern Forest Nursery Management & Forest Health Cooperatives 2015 Contact Meeting. St, Simons, GA

*Chieppa, J.J., Chappelka, A.H., and Eckhardt, L.G. 2015. Effects of elevated tropospheric ozone and altered irrigation regimes on loblolly pine seedlings inoculated with ophiostomatoid fungi. Joint Auburn University Southern Forest Nursery Management & Forest Health Cooperatives 2015 Contact Meeting. St, Simons, GA

*Devkota, P. and Eckhardt, L.G. 2015. Variation In tolerance of *Pinus taeda* Families to root infesting fungi *Grosmannia huntii* and *Leptographium terebrantis*. Joint Auburn University Southern Forest Nursery Management & Forest Health Cooperatives 2015 Contact Meeting. St, Simons, GA

*Cole, A., Eckhardt, L., Liebold, A., and Slippers, B. 2015. A survey for *Sirex noctilio* and native woodwasps in Alabama. Joint Auburn University Southern Forest Nursery Management & Forest Health Cooperatives 2015 Contact Meeting. St, Simons, GA

Via, B.K. and Eckhardt, L.G. 2015. Near infrared reflectance (NIR) spectroscopy: dialing stem chemistry for optimal root disease resistance and forest products. Center for Advanced Forestry Systems 2015 Industrial Advisory Board Meeting, Asheville, NC

Nadel, R.L., Matusick, G., and Eckhardt, L.G. 2015. Quantifying the impact of pine decline in the southeastern United States. Center for Advanced Forestry Systems 2015 Industrial Advisory Board Meeting, Asheville, NC

*Acquah, G., Via, B.K., and Eckhardt, L.G. 2015. Nondestructive estimation of the chemical and thermal properties of forest biomass using vibrational spectroscopy and thermogravimetric analysis. This is Research: Student Symposium 2015. Auburn University, Auburn, AL

*Chieppa, J.J., Chappelka, A.H., and Eckhardt, L.G. 2015. Effects of elevated tropospheric ozone and altered irrigation regimes on loblolly pine seedlings inoculated with ophiostomatoid fungi. This is Research: Student Symposium 2015. Auburn University, Auburn, AL

*Trautwig, A., Eckhardt, L., Hoeksema, J., and Carter, E. 2015. Mycorrhizal communities in *Imperata cylindrica* invaded and non-invated commercial *Pinus taeda* stands. This is Research: Student Symposium 2015. Auburn University, Auburn, AL

*Devkota, P. and Eckhardt, L.G. 2015. Variation In tolerance of *Pinus taeda* families to root infesting fungi *Grosmannia huntii* and *Leptographium terebrantis*. This is Research: Student Symposium 2015. Auburn University, Auburn, AL

*Trautwig, A., Eckhardt, L., Hoeksema, J., and Carter, E. 2015. Mycorrhizal communities in *Imperata cylindrica* invaded and non-invated commercial Pinus taeda stands. Southeastern Ecology and Evolution Conference, Athens, GA

Eckhardt, L.G., Ditchkoff, S.S., Duong, T.A., DeBeer, Z.W, and Wingfield, M.J. 2015. Two new ophiostomatoid species isolated from soil on snouts of wild pigs damaging pine roots in Georgia. 18th Annual Biennial Southern Silvicultural Research Conference, Knoxville, TN

*Chieppa, J.J., Chappelka, A.H., and Eckhardt, L.G. 2015. Effects of elevated tropospheric ozone and altered irrigation regimes on loblolly pine seedlings inoculated with ophiostomatoid fungi. 18th Annual Biennial Southern Silvicultural Research Conference, Knoxville, TN

*Trautwig, A., Eckhardt, L., Hoeksema, J., and Carter, E. 2015. Mycorrhizal communities in *Imperata cylindrica* invaded and non-invated commercial Pinus taeda stands. 18th Annual Biennial Southern Silvicultural Research Conference, Knoxville, TN

Carter, E.A., Brunson, B.A., and Eckhardt, L.G. 2015. Soil properties associated with cogongrass infested and non-infested loblolly pine stands in Mississippi. 18th Annual Biennial Southern Silvicultural Research Conference, Knoxville, TN

***Posters:***

Nadel, R.L., Eckhardt, L.G., and Enebak, S.A. 2015. A rapid PCR screening test for the presence of *Fusarium circinatum* on pine seed and planting material. Society of American Foresters National Convention, Baton Rouge, LA

*Acquah G. E., Via B.K., Eckhardt L.G., Fasina O. O. and Billor N. 2015. Rapid assessment of disease tolerant Pinus taeda families for strength, chemical and bioenergy applications using near infrared spectroscopy. Sigma Xi's Annual Meeting and Student Research Conference, Kansas City, MO

*Cole, A.B., and Eckhardt, L.G. 2015. Effect of Growth Rate on *Amylostereum* spp. Fungus by Terpenes. Society of

American Foresters National Convention, Baton Rouge, LA

*Essien, C., Via, B.K., Eckhardt, L., Cheng, Q., Gallagher, T., McDonald, T., and Wang, X. 2015. Acouto-mechanical response of fourteen year old suppressed loblolly pine (*Pinus taeda*) to variation in cellulose, hemicelluloses, lignin, microfibril angel and density. Society of American Foresters National Convention, Baton Rouge, LA

*Cole, A.B., Eckhardt, L.G., Liebhold, A., Slippers, B. 2015. Prevalence of *Sirex noctilio* F. in Alabama Forests. Society of American Foresters National Convention, Baton Rouge, LA

*Acquah G.E., Via B.K., Eckhardt L.G., Fasina O. and Billor N. 2015. Application of NIRS in the screening of disease tolerant *Pinus taeda* families for chemistry, strength and bioenergy. Society of American Foresters National Convention, Baton Rouge, LA

*Trautwig, A., Eckhardt, L., Loewenstein, N.J., Hoeksema, J., and Carter, E. 2015. *Imperata cylindrica* reduces colonization by mycorrhizal fungi on *Pinus taeda* in commercial stands. Society of American Foresters National Convention, Baton Rouge, LA

*Devkota, P., Eckhardt, L., Liu, K. and Kloepper, J. 2015. Biological control of blue stain fungi by plant root growth promoting rhizobacteria (PGPR). Society of American Foresters National Convention, Baton Rouge, LA

*Devkota, P., Eckhardt, L., and Singh, A. 2015. Relative susceptibility of several loblolly pine (*Pinus taeda* L.) families to ophiostomatoid fungi. Society of American Foresters National Convention, Baton Rouge, LA

*Devkota, P. and Eckhardt, L. 2015. Susceptibility of various mature loblolly pine (*Pinus taeda* L.) families to root infecting fungi. Society of American Foresters National Convention, Baton Rouge, LA

*Acquah G.E., Via B.K., Eckhardt L.G., Fasina O. and Billor N. 2015. Application of NIRS in the screening of disease tolerant *Pinus taeda* families for chemistry, strength and bioenergy. Sigma Xi's Student Research Conference, Kansas City, MO

*Cole, A., Eckhardt, L., Liebold, A., and Slippers, B. 2015. A survey for *Sirex noctilio* and native woodwasps in Alabama. This is Research: Student Symposium 2015. Auburn University, Auburn, AL

*Trautwig, A., Eckhardt, L., Hoeksema, J., and Carter, E. 2015. Mycorrhizal communities in *Imperata cylindrica* invaded and non-invaded commercial *Pinus taeda* stands. SFWS Annual Advisory Meeting Student Poster Session, Auburn University, Auburn, AL

*Devkota, P., Singh, A., Nadel, R. and Eckhardt, L. 2015. Variance and tolerance of several loblolly pin (*Pinus taeda*) families to *Leptographium terebrantis* and *Grosmannia huntii* root fungi. SFWS Annual Advisory Meeting Student Poster Session, Auburn University, Auburn, AL

*Cole, A. and Eckhardt, L., Liebold, A., and Slippers, B. 2015. Prevalence of *Sirex noctilio* F. in the southeastern United States. SFWS Annual Advisory Meeting Student Poster Session, Auburn University, Auburn, AL

*Chieppa, J.J., Chappelka, A.H., and Eckhardt, L.G. 2015. Effects of tropospheric ozone on loblolly pine seedlings inoculated with ophiostomatoid fungi. SFWS Annual Advisory Meeting Student Poster Session, Auburn University, Auburn, AL

*Acquah, G., Via, B.K., and Eckhardt, L.G. 2015. Nondestructive estimation of the chemical and thermal properties of forest biomass using vibrational spectroscopy and thermogravimetric analysis. SFWS Annual Advisory Meeting Student Poster Session, Auburn University, Auburn, AL

Sayer, M.A.S., Tyree, M.C. Blazier, M.A., Sung, S.S., and Eckhardt, L.G. 2015. Is natural defense capacity correlated to the allocation of dry mass to the stem in loblolly pine? 18th Annual Biennial Southern Silvicultural Research Conference, Knoxville, TN

*Cole, A. and Eckhardt, L., Liebold, A., and Slippers, B. 2015. A survey for *Sirex noctilio* and native woodwasps in Alabama. 18th Annual Biennial Southern Silvicultural Research Conference, Knoxville, TN

*Devkota, P. and Eckhardt, L. 2015. Variance and tolerance of several loblolly pine (*Pinus taeda*) families to *Leptographium terebrantis* and *Grosmannia huntii* root fungi. 18th Annual Biennial Southern Silvicultural Research Conference, Knoxville, TN

*Trautwig, A., Eckhardt, L., Hoeksema, J., and Carter, E. 2015. Mycorrhizal communities in *Imperata cylindrica* invaded and non-invaded commercial *Pinus taeda* stands. Southeastern Society of American Foresters Annual Meeting, St Simons Island, GA

*Devkota, P., Singh, A., Nadel, R. and Eckhardt, L. 2015. Variance and tolerance of several loblolly pin (*Pinus taeda*) families to *Leptographium terebrantis* and *Grosmannia huntii* root fungi. Southeastern Society of American Foresters Annual Meeting, St Simons Island, GA

*Chieppa, J.J., Chappelka, A.H., and Eckhardt, L.G. 2015. Effects of tropospheric ozone on loblolly pine seedlings inoculated with ophiostomatoid fungi. Southeastern Society of American Foresters Annual Meeting, St. Simon's Island, GA

*Cole, A. and Eckhardt, L., Liebold, A., and Slippers, B. 2015. A survey of *Sirex noctilio* F. and native wood wasps in Alabama. Southeastern Society of American Foresters Annual Meeting, St. Simon's Island, GA

**2014**

***Talks:***

Via, B.K. and Eckhardt, L.G. 2014. A new modelling strategy for *Pinus taeda* genetic families: connection of chemistry to products and disease. The Institute for Commercial Forestry Research & The Department of Agriculture, Forestry & Fisheries 6th Forest Science Symposium, Pietermaritzburg, South Africa.

Via, B.K. and Eckhardt, L.G. 2014. Near infrared reflectance (NIR) spectroscopy: dialing stem chemistry for optimal root disease resistance and forest products. XXIV IUFRO World Congress on "Sustaining Forests, Sustaining People: The Role of Research", Salt Lake City, UT

*Chieppa, J.J., Chappelka, A.H., and Eckhardt, L.G. 2014. Interaction of altered tropospheric ozone concentrations with loblolly pine decline. XXIV IUFRO World Congress on "Sustaining Forests, Sustaining People: The Role of Research", Salt Lake City, UT

*Bauman, T.A., Eckhardt, L.G., Menard, R.D., de Beer, Z.W., Sediles, A., and Wingfield, M.J. 2014. Determining fungal communities associated with the bark beetle *Dendroctonus approximatus* in Mexico and Central America. XXIV IUFRO World Congress on "Sustaining Forests, Sustaining People: The Role of Research", Salt Lake City, UT

Eckhardt, L.G. and Neuman, R. 2014. Field trial of a controlled vapor delivery method in an IPM system. Forest Health Cooperative Annual Meeting, Americus, GA

Sword-Sayer, M.A., Singh, A., Eckhardt, L.G., and Sung, S.J. 2014. Assessment of defense capacity among 15 loblolly pine families. Forest Health Cooperative Annual Meeting, Americus, GA

Eckhardt, L.G. and Nadel, R.L. 2014. Variation in resistance of *Pinus taeda* families against *Leptographium* root infecting fungi – year three update. Forest Health Cooperative Annual Meeting, Americus, GA

*Chieppa, J.J., Chappelka, A.H., and Eckhardt, L.G. 2014. Interactions of future climate change scenarios of elevated tropospheric ozone and decreasing rainfall amounts with loblolly pine decline. Forest Health Cooperative Annual Meeting, Americus, GA

*Trautwig, A.N., Eckhardt, L.G., and Hoeksema, J.D. 2014. Mycorrhizal Communities in *Imperata cylindrica* Invaded and Non-Invaded Commercial *Pinus taeda* Stands. Forest Health Cooperative Annual Meeting, Americus, GA

Nadel, R.L., Enebak, S.A., and Eckhardt, L.G. 2014. Seed certification and pitch canker. Forest Health Cooperative Annual Meeting, Americus, GA

*Bauman, T.A., Eckhardt, L.G., Menard, R.D., de Beer, Z.W., Sediles, A., and Wingfield, M.J. 2014. Determining fungal communities associated with the bark beetle *Dendroctonus approximatus* in Mexico and Central America. Forest Health Cooperative Annual Meeting, Americus, GA

Eckhardt, L.G., Via, B.K., and Enebak, S.A. 2014. Selection of genetically superior trees for disease resistance as a function of wood chemistry. CAFS IAB Meeting, The Coeur d'Alene Resort, Idaho

*Chieppa, J.J., Chappelka, A.H., and Eckhardt, L.G. 2014. Interaction of altered tropospheric ozone concentrations with loblolly pine decline. CAFS IAB Meeting, The Coeur d'Alene Resort, Idaho

*Chieppa, J.J., Chappelka, A.H., and Eckhardt, L.G. 2014. Interaction of altered tropospheric ozone concentrations with loblolly pine decline. Research Week 2014, Auburn University, AL.

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# *INCOME STRUCTURE - FY2016*

**Dues** **Full member - $10,000 / year**
**Associate - $5,000 / year**

| **Annual Income** | | |
|---|---|---|
| | **Dues** | **$ 132,280** |
| | **Auburn** | **$ 561,431** |
| | **External** | **$ 656,500** |
| | **Total** | **$ 1,350,211** |

***For every dollar of dues, Coop members receive $135 of research and technology.***

****We are still hoping for some outstanding grants to increase our external dollar amount for FY16!****

# Income Structure

| Fiscal Year | $$ of Research and Technology per $ of dues paid |
|---|---|
| • FY2008 | • $ 41 |
| • FY2009 | • $ 59 |
| • FY2010 | • $ 62 |
| • FY2011 | • $ 69 |
| • FY2012 | • $ 78 |
| • FY2013 | • $108 |
| • FY2014 | • $125 |
| • FY2015 | • $133 |
| • FY2016 | • $135 |