

## **USDA FOREST SERVICE- FHM- EVALUATION MONITORING PROPOSAL 2014 (Continuing Project)**

**TITLE:** Evaluating the Extent and Nature of Pine Decline and Health using FIA Plots in the Southeastern U.S.

**LOCATION:** Georgia and Alabama

**DATE OF SUBMISSION:** 9/30/2013

**DURATION:** 07/30/2012-9/30/2015

**FUNDING SOURCE:** Base Plan

**PROJECT LEADER:** Dr. Kamal J.K. Gandhi, University of Georgia, Athens, GA, 706-542-4614, [kjgandhi@uga.edu](mailto:kjgandhi@uga.edu)

**COOPERATORS:** USDA Forest Service: Dr. Kier Klepzig, Dr. Bill Otrosina, Dr. John Coulston, Dr. Bill Smith, and Dr. Frank Koch. UGA: Dr. Larry Morris

**FHP SPONSOR/CONTACT:** Dr. John Nowak, USFS Southern Region, 828-257-4326, [jnowak@fs.fed.us](mailto:jnowak@fs.fed.us)

**PROJECT OBJECTIVES:** Our project goal is to evaluate the relative health of loblolly and longleaf pine trees in FIA-associated stands in Georgia and Alabama. Further, we will elucidate the relative contributions of predisposing (e.g., stand characteristics, disturbance and management history, and soil types), inciting (e.g., short-term insect activity and weather conditions), and contributing (e.g., subcortical insects and root pathogens) factors associated with pine health issues. Our overarching goal is to provide a better understanding of pine health issues to guide future management decisions for sustainable forest practices in the southeastern stands.

**JUSTIFICATION:** **a. Linkage to FHM Detection Monitoring-** Our project is directly linked to the FIA-FHM plots, as historical tree growth data collected from these plots will be analyzed first. Based on these data, we will undertake field sampling in stands that are showing slower rates of decline, and determine the associated abiotic and biotic factors. **b. Significance in terms of Geographic Scale-** Sampling will be conducted primarily in Piedmont Georgia and Alabama, regions that contain major tracts of pine stands. **c. Biological Impact and/or Political Importance of the Issue-** Problems with pine health, especially pine decline and mortality, have been reported in the southern region. This project will further push the field into refining where pine health issues are present in these states, and documenting the full-complement of associated insects and diseases. **d. Scientific Basis/ Feasibility** - Our project is interdisciplinary and interagency, with diverse personnel including spatial and soil scientists, as well as forest entomologists and pathologists. **e. Priority Issues** - The priority areas of our project are those exhibiting deviations from expected and normal levels for tree mortality and poor crown conditions.

**DESCRIPTION:** **a) Background:** During the last 20-30 years, decline and mortality of pine stands have been reported in the Piedmont Province, Atlantic and Gulf Coastal Plains, and Sandhills Fall-line region of the southeastern U.S. (1). Loblolly and longleaf pines have been the primary species showing signs of decline (2, 3). Literature indicates that the decline includes symptoms such as loss of crown, reduction in annual growth, presence of root pathogens such as *Phytophthora cinnamomi* Rands and *Heterobasidion annosum* (Fr.) Bref., and species in the genus *Leptographium*. In addition, rhizophagous (root-attacking) weevils and beetles in the genera *Hylastes* and *Pachylobius* (1-4) have been reported. In contrast, there has been little work conducted on the relative contributions of abiotic factors such as weather conditions, stand history, and soil types, and other important biotic factors such as bark beetles (*Ips* and *Dendroctonus* spp.) and woodboring beetles (*Monochamus*) that may be interacting with pine trees under varying conditions. The need to better study pine decline and mortality has become more prominent as a growing number of land-owners and forest managers are contacting the PI and collaborators about this problem. As a multi-disciplinary and multi-agency team, we propose to conduct a regional-level study to better understand pine health issues in stands associated with FIA plots, and to assess the complex of subcortical beetles and root pathogens present in these forest stands.

**b) Methods:** **i) FIA-FHM Data:** We will analyze the existing FIA plot data in Georgia and Alabama during the last 10 years to find a suite of stands that are showing decline (symptomatic) and no decline (asymptomatic) (5). The advantages of existing FIA plots are that they provide reliable measures of stand growth and changes in structure over time.

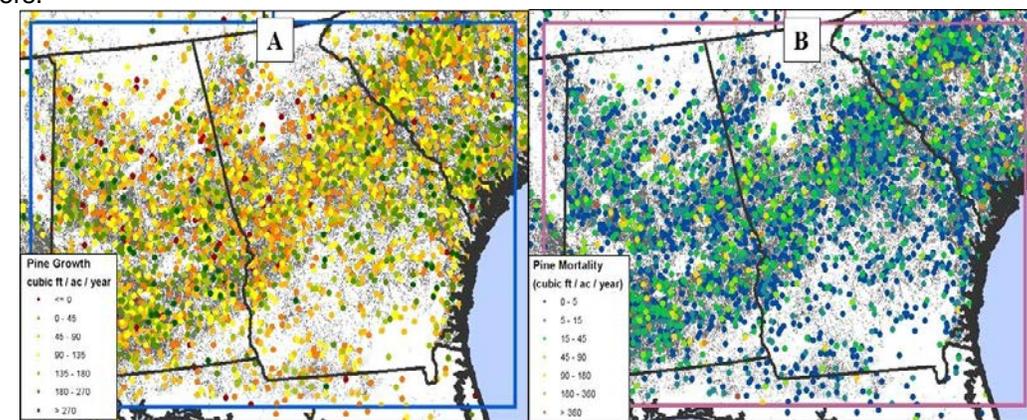
**ii) Field Sampling:** Using these FIA plots as approximate guides, we will select >50 each of both symptomatic and asymptomatic stands nearby for sampling, and non-FIA plots (primarily on public lands) will be established to allow stand-level analyses. For symptomatic stands, another adjacent stand <200 m away will also be established to allow pair-wise comparisons of pine health. Sampling of forest structure and composition, and insects and diseases

will be performed on the new non-FIA plots similarly to how it is conducted on the FIA plots (5, 6). Minimal or no sampling will be done in the FIA plots to retain their plot integrity. The following data will be collected at stand-level: stand age and area, silvicultural and disturbance history, and local weather conditions. Within each stand, we will collect the following data on each plot: 1) tree attributes including dead/alive, species, DBH, height, and crown condition, symptoms, and class; 2) % cover of each understory plants including exotic species; 3) soil samples at 0-10 cm and >10.1-cm depth to impervious layer. Soils will be analyzed for physical (e.g., texture and compaction) and chemical (e.g., pH, N, P, and K content) characteristics (6); 4) rhizophagous beetles will be sampled in each plot with 2-3 pitfall traps baited with host-attractants. We will use 2-3 window and funnel traps with baits to sample other bark and woodboring insects. Traps will be emptied every 3 weeks during the summer, and all insects will be identified to species. External evidence of insect attacks (exit/entrance holes, oviposition scars) will be noted on each tree. If insect activity is found, then bark will be peeled to further assess insect damage; 5) root pathogens will be sampled by digging up >2 lateral roots on a subset of trees. These roots will be plated on selective media for fungal pathogens such as *Heterobasidion*, *Leptographium*, etc.

**iii) Statistical Analyses:** GIS maps will be created to show relative pine health in these stands. The percentage of stands and plots showing symptoms of decline will be assessed. Multiple regression analyses will be used to determine whether pine health issues are related to soil type, stand age or area, tree density, basal area, and disturbance history (7). Insect and fungal species will be correlated with pine health issues using multivariate ordination.

**c) Products:** Our target audience will include managers and scientists working on pine health issues both locally and regionally. Results will be transferred through outreach and scientific presentations at national and international meetings, a web-site at University of Georgia, and various publications. We expect to publish 2-3 peer-reviewed papers, as well as several conference proceedings and extension papers. Results from this study can be used regionally to guide forest management practices related to pine health issues as based on soil types, stand history, and insects and pathogens likely to be present in these landscapes.

**d) Schedule of Activities:** July 2012- Jan 2013- conduct historical analyses on FIA plots, select and find stands, finalize project design; Feb 2013- May 2015- collect plot and stand-level data in GA and AL, analyze collected data, make presentations at meetings; June- Sept 2015- submit final report and manuscripts for publication, present to forest managers.



**e) Progress/Accomplishments:** Analyses of FIA Data: As the first step to delineate the extent of pine health issues and associated topographic factors, we analyzed the USDA FIA data. We acquired data for re-measured plots from all states in the southern U.S. Across the region, a total of 6,533 re-measured plots occurred in the loblolly pine and loblolly pine-hardwood forest types. We limited our analysis to the subset ( $N = 5,396$ ) of these plots that had not been harvested. For each plot, we calculated the annual rate of pine mortality, net growth, and gross growth based on differences in tree measurements between inventory cycles. We identified the re-measured plots that reported negative net pine growth (i.e., where pine mortality exceeded growth). Based on the plots' geographic coordinates, we performed two average nearest neighbor distance analyses, one for the set of negative net growth plots and the other for the set of all (i.e., non-harvested) re-measured plots. This analysis yields an index calculated as the ratio between the observed average distance and the distance expected given a hypothetical random distribution with the same number of observations over the same total area. If the index value is less than 1, this indicates a clustered spatial pattern. If the index value is greater than 1, this indicates a dispersed spatial pattern. Our objective was to determine whether the set of negative net growth plots had a similar

pattern to that observed for all plots. We found 181 plots with negative net pine growth, representing ~3% of the plots in the full data subset (Fig. 1). All but one of the 181 plots was disturbed, mostly commonly by insect activity or damaging weather events. The average nearest neighbor distance analyses produced nearly identical index values for the set of negative net growth plots (ratio = 0.673,  $p < 0.001$ ) and the set of all plots (ratio = 0.683,  $p < 0.001$ ). This indicates that both sets of plots exhibit a clustered spatial pattern, which is expected for most tree species, as their regional distributions are largely shaped by physiographic and climatic constraints. More importantly, the nearly identical index values suggest that there is no distinctive regional pattern of pine mortality which is to be expected if there are multiple factors affecting tree health.

Field Sampling in Alabama: We have sampled 10 symptomatic sites in Alabama, all in the Talladega National Forest (1 in Perry Co., 2 in Talladega Co., 2 in Cleburne Co., and 5 in Clay Co.). We have 5 additional symptomatic sites identified and ready to sample, and we are working with district rangers to identify 5 asymptomatic sites in the Talladega National Forest.

At each site we sampled 3 locations, each 250 m apart. At each location we sampled 4 subplots arranged FIA-style i.e., center plot of 10 m radius, and plots at 0, 120, and 240 degrees from the center, 50 m apart on center. We collected soil samples from each subplot. We recorded DBH of all trees in plots, and on up to three pines we also recorded height, crown condition, and insect/disease incidence, and collected a small, medium, and large root sample. These stand-level data have been entered into a spreadsheet, and we are in the process of summarizing these data. All root samples from these sites have been processed, and we have identified both *Heterobasidion irregulare* and *Leptographium* spp. All *Leptographium* isolates have been tentatively identified to morphospecies. A subset were sent to Dr. Tom Harrington (Iowa State University) and identified through molecular analyses as either *L. procerum* or *L. serpens*.

All soil samples ( $n = 239$ ) from Alabama have been processed, and we identified the soil texture (% sand, silt, clay) and sent subsamples for micronutrient analysis. Nitrogen analysis is in progress. Preliminary results indicate that micronutrients were generally low, and especially, P (3.8-8.1 ppm) and Zn (1.4-4.6 ppm) were lower than the preferred range of loblolly pine. pH was also low (3.98-4.36), as loblolly prefers pH > 5.0. Soil texture was predominantly sandy loam, sandy clay loam, or sand.

Field Sampling in Georgia: We have sampled 7 unhealthy stands (2 in Stewart Co., 2 in Burke Co., 2 in Pike Co., and 1 in Upson Co.) and 1 healthy stand (in Randolph Co.) in Georgia. We have 4 healthy and 11 unhealthy stands identified and ready to sample. Sampling was conducted identically to Alabama sites. We are in the process of entering and summarizing stand-level data for Georgia sites. We have processed root samples from six stands, and are in the process of identifying and isolating *H. irregulare* and *Leptographium* spp. We are also processing soil samples from Georgia.

Preliminary results indicate that insect damage was observed on only 0.2% of sample trees, while fire appeared to either significantly damage or kill 0.4% of sample trees. *Heterobasidion irregulare* and *Leptographium* spp. were present in 28% and 23% of sampled trees, respectively. There appeared to be no spatial patterns in the occurrence of fungi. *Leptographium* spp. were present across both asymptomatic and symptomatic stands. All analyses are ongoing, as are fungal culturing and identifications.

#### Presentations:

Coyle, D.R., Dean, J.D., Morris, L., Nowak, J., Otrrosina, W., Smith, W., Koch, F., Klepzig, K., Cameron, S., Bates, C., and Gandhi, K.J.K. 2012. Biotic and abiotic factors influencing pine health in Georgia. Joint Meeting of the Southern Forest Insect Work Conference and Southwide Forest Disease Workshop, Charlottesville, Virginia, 24-27 July 2012.

Coyle, D.R., Klepzig, K., Nowak, J., Smith, W., Koch, F., Otrrosina, W., Bates, C., Cameron, S., Morris, L., and Gandhi, K.J.K. 2013. Dieback of southern pines: etiology and management. Southern Forest Insect Work Conference, New Orleans, Louisiana, 23-26 July 2013.

#### Publications:

Coyle, D.R., Dean, J.D., Morris, L., Nowak, J., Otrrosina, W., Smith, W., Koch, F., Klepzig, K., Cameron, S., Bates, C., and Gandhi, K.J.K. 2012. Abiotic and biotic factors influencing pine health in Georgia. Proceedings of the Joint Meeting of the Southern Forest Insect Work Conference and Southwide Forest Disease Workshop, Charlottesville, Virginia, 24-27 July 2012. Pp. 37.

Coyle, D.R., Klepzig, K., Nowak, J., Smith, W., Koch, F., Otrrosina, W., Bates, C., Cameron, S., Morris, L., and Gandhi, K.J.K. 2013. Dieback of southern pines: etiology and management. Proceedings of the Southern Forest Insect Work Conference, New Orleans, Louisiana, 23-26 July 2013. *In Press*.

A draft of our manuscript "Tree Declines or Tree Health Issues? Untangling and Mitigating the Concept of Declines in North America" by David R. Coyle, Kier D. Klepzig, Frank H. Koch, Lawrence A. Morris, John T. Nowak, Steven W. Oak, William J. Otrosina, William D. Smith, and Kamal J.K. Gandhi is being revised.

**f) Relevant Citations:** (1) Eckhardt, L.G. et al. 2007. For. Sci. 35: 84-92. (2) Eckhardt, L.G. and Menard, R.D. 2009. AL Treasured Forest Magazine Volume XXV111: 10-12. (3) Eckhardt, L.G. et al. 2010. South. J. Appl. For. 34: 138-141. (4) Otrosina, W. et al. 2008. Ecological Society of America, Forest Health White Paper. (5) USDA Forest Service. 2010. The Forest Inventory and Analysis Database: Database description and User's Manual Version 4.0 of Phase 2. (6) USDA Forest Service. 2005. 3.0 Phase 3 Field Guide-soil measurements and sampling. (7) Zar, J.H. 1996. Biostatistical Analysis. Third Edition, Prentice-Hall Inc., New Jersey.

**COSTS:**

This is a three-year continuing project, and we are requesting funding for the third-year of the project as follows:

Year 9/1/2014-9/30/2015	Item	Requested FHP EM Funding	Other-Source Funding	Source
<b>Administration</b>	Salary- Research Coordinator	4,630	8,658	UGA
	Fringe benefits	1,280	2,394	
	Salary- Student Worker	5,436		
	Fringe benefits	82		
	Salary - PI - Kamal Gandhi		8,058	
	Fringe benefits		2,385	
	Overhead- 26%	5,572	5,589	
	Travel	6,600		
<b>Procurements</b>	Contracting			
	Equipment			
	Supplies	0		
	Vehicle Expense	3,400		
<b>Year Totals</b>		<b>27,000</b>	<b>27,084</b>	

**JUSTIFICATION: SALARIES & FRINGE BENEFITS:** A Project Coordinator will assist with all the laboratory and field aspects of this project (\$4,630 ~12.8% of their time or ~1.5 months). Fringe benefits are estimated at 27.65% for the Project Coordinator. About 3 undergraduate students will assist in data collection in the field (\$5,436; at \$12/hour for 453 hours). Fringe benefits are estimated at 1.5% for the students.

**TRAVEL:** Travel funds are requested to visit field sites to collect forest health data in Georgia and Alabama. Travel will be for at least 25 days at ~\$40/day per diem each for the field personnel (\$3,000) and hotel expenses at ~\$60/night/each for two rooms (\$3,000). There will also be travel to present papers at conferences each year.

Conference travel is estimated at \$600 for 1-2 conferences. Total for travel is: \$3,000 + \$3,000 + \$600 = \$6,600.

**SUPPLIES/OPERATING EXPENSE:** Vehicle expenses in a Warnell vehicle to travel to field sites for at least 25 days at a daily rate of \$20 (\$500), and ~ 5,000 miles at 0.58/mile (\$2,900). Total for vehicle expenses is: \$500 + \$2,900 = \$3,400.

**INDIRECT COSTS:** 26% for off-campus research.

**COST-SHARE:** 1:1 match