

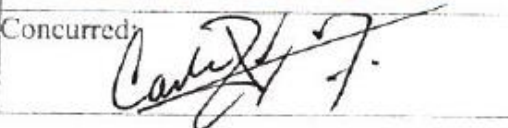


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4. Research Work Unit Title  SRS-4552: Insects, Diseases and Invasive Plants of Southern Forests (Asheville, NC; Athens, GA; Pineville, LA)		
5. Project Leader (Name and Address) Albert E. Mayfield III, 200 W.T. Weaver Blvd., Asheville, NC 28804		
6. Area of Research Applicability Regional/Global (regional native insects/diseases to global invasive pests):	7. Estimated Duration 5 years	
8. Mission To provide the basic biological and ecological knowledge and innovative management strategies required for management and control of native and non-native insect pests, disease pathogens and invasive plants in changing forest ecosystems.		
9. Justification and Problem Selection Summary		
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**SRS-4552 – Insects, Diseases and Invasive Plants of Southern Forests**  
**Asheville, NC; Athens, GA; Pineville, LA**  
**Project Leader: Albert E. Mayfield III**

## **9. JUSTIFICATION AND PROBLEM SELECTION**

The mission of the Forest Service is to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations. As identified in the Forest Service 2013 National Strategic Framework for Invasive Species Management, non-native invasive insects, pathogens, and plants are among the most significant environmental and economic threats to fulfilling this mission. Although a relatively small percentage of all species introduced from parts of the world become damaging pests, some introduced species populations proliferate dramatically due to their escape from coevolved natural enemies, and/or lack of resistance or competitive ability among our native hosts and associates. In forests, invasive species degrade or threaten ecosystem services and resources, including water quality, wood products, recreational opportunities, and wildlife habitat. More than forty percent of all federally-listed threatened and endangered species are considered at risk primarily due to negative effects of invasive species. Such adverse effects can be exacerbated by interactions with fire, native pests, weather events, human actions, and environmental change. In the US alone, three groups of invasive forest insects (borers, sap-feeders, and defoliators) are estimated to cost nearly \$5 billion annually in government and household expenditures, property value losses, and timber losses. In addition to invasive species, native pests continue to pose forest management challenges in the context of changing climates, environmental and forest conditions, land-use patterns, and markets. To protect resources, sustain ecosystem services, rehabilitate natural landscapes, and minimize taxpayer costs, a strong research effort to address insect, disease and invasive plant issues is critical to implementing the Forest Service mission.

**SRS 4552 Mission: To provide the basic biological and ecological knowledge and innovative management strategies required for management and control of native and non-native insect pests, disease pathogens and invasive plants in changing forest ecosystems.**

### **Problem 1. Insects**

Southern U.S. forests face numerous challenges associated with native and non-native insects. Due to the abundance of mature and densely-stocked pine forests, the southern pine beetle (*Dendroctonus frontalis*) and other native bark beetles of southern conifers continue to be persistent and destructive pests in the region. At endemic levels, bark beetles serve as natural mortality agents in weakened trees, but at epidemic levels they cause great economic damage and disruption of resource management practices. Projected forest conditions in the South indicate that large acreages will continue to be of high hazard for southern pine beetle (SPB) outbreaks. At the same time, changing timber markets, land development, and land ownership/management patterns are making traditional silvicultural techniques for bark beetle prevention and control (e.g., thinning, suppression harvests, etc.) increasingly difficult to implement in many areas. These factors, coupled with recent outbreaks of SPB outside the Southern region, point to a continued need to develop novel management strategies and tools for

native bark and wood-boring insects. Furthermore, insect pests of seed orchards, seedling nurseries, and young forests (including tip moths, reproduction weevils, acorn weevils, coneworms, and seedbugs) can hinder efforts to regenerate and restore forests with high-quality trees. The dynamics of some native pests and their associates may well change in unexpected ways in response to a changing climate.

The threats to Southern forest health and sustainability by non-native invasive insect pests are as acute as ever. Hemlock woolly adelgid (*Adelges tsugae*) has spread through nearly the entire Southern Appalachian range of eastern hemlock and is steadily removing this keystone species from riparian forests. To date, the emerald ash borer (*Agrilus planipennis*) has invaded more than half of the 13 Southern states and threatens to functionally eliminate all *Fraxinus* species. Movement of infested wood products are likely responsible for the arrival and establishment of the walnut twig beetle (*Pityophthorus juglandis*) and its fungal associate, which are now killing the economically and ecologically valuable eastern black walnut in Virginia and Tennessee. Although it has not yet been a damaging pest in the Northeastern US, the European wood wasp (*Sirex noctilio*) is still considered a serious threat to the Southern region due to its destructive impacts in overstocked pine plantations (including loblolly pine) in other countries. The continual intra- and international movement of wood products and live plants increase the likelihood that new destructive forest insects will become introduced and established in the Southern region in the coming decades. There is a pressing need for strategies and tools for prevention, detection, suppression, and integrated management of invasive forest insects to meet economic, ecological, aesthetic, and recreational forest management objectives.

Despite the threats posed by certain pest insects, the ecological services and benefits provided by various native insect groups are substantial. Worldwide, dead wood in forests is recognized as one of the three most important habitats for insect and fungal diversity, and it is estimated that as many as one third of all forest insects are saproxylic (directly or indirectly dependent on dead wood). Pollinating insects have been in decline in recent years and yet are critical to the reproduction of numerous plant species including food crops. The effects of various forest management practices, as well as invasive species introductions, on decomposers, pollinators, and other beneficial insects are still poorly understood.

#### **Problem 1a. Ecology, biology and management of bark beetles and other native insects.**

A lack of economic incentives for harvesting pine timber, coupled with loss of numerous synthetic pesticides for control of bark beetles, has created a need for the development of alternative management and control tactics for bark and wood boring insects. Semiochemicals (whether attractant, anti-aggregant, or anti-feedant) have shown some promise for managing bark beetles and invasive insects, as have systemic and new pesticides. However, few of these strategies have been adequately tested, deployed or optimized, thus limiting their potential use.

#### **Problem 1b. Detection, biology and management of non-native insects.**

The steady influx of non-native insect species calls for development of improved detection and monitoring strategies for important forests pest groups. Rapid detection can play a key role in preventing the establishment of new pest species. Established populations of non-native insects often spread quickly and can be extremely difficult to control. When this is due, at least in part, to a lack of effective natural enemies in the introduced range, classical biological control can be a useful long-term strategy for reducing pest populations. Because invasive insects also often

encounter limited resistance from naïve host plants, classical biological control often cannot succeed in isolation. A truly integrated management approach (i.e., combining biological, chemical and cultural control methods with host plant improvement), informed by basic biological research, will be needed to combat some of the most aggressive invasive pest problems.

### **Problem 1c. Effects of forest management and species invasion on insect biodiversity and ecosystem processes.**

Many questions remain about how native forest insect communities are impacted by management practices and invasion by exotic plant species. Two insect groups are of particular concern due to the ecosystem services they provide, their importance to biodiversity, and documented population declines. The importance of bees and butterflies to the pollination of crops is widely acknowledged, for instance, but it remains largely unknown how these organisms are affected by forest management or invasion. There is an urgent need for research in this area given documented declines in pollinator populations. Similarly, saproxylic insects (i.e., species directly or indirectly dependent on dead wood) account for about one third of all forest insect species and are also suffering population declines in many parts of the world. Although the ecosystem services provided by saproxylic insects remain largely unstudied, these organisms may contribute importantly to wood decomposition, nutrient cycling and pest control, thus promoting forest health and resilience.

### **Problem 2. Diseases**

As dramatically illustrated by the historical demise of species like American chestnut, American elm, and butternut, non-native tree pathogens have the potential to functionally eliminate tree species and drastically alter forest landscapes. Like invasive insects, forest diseases can cause substantial negative economic, ecological, cultural and aesthetic impacts. The causal factors of forest diseases can be complex and may be characterized by multiple predisposing, inciting or contributing factors. The widespread impact of laurel wilt disease, which has killed millions of redbay and sassafras trees from North Carolina to Texas over the last decade, was not anticipated even after the non-native insect vector was detected and identified. Careful study of the causal agents, pathogen genetic variability, host range, epidemiology, vector interactions, and host responses are important to the development of management strategies for forest and nursery diseases.

#### **Problem 2a. Insect-microbial associations and insect-pathogen disease complexes.**

The laurel wilt disease pathogen (*Raffaelea lauricola*) exemplifies the potential for fungal symbionts of traditionally secondary insects (e.g. ambrosia beetles) to cause catastrophic effects when introduced into novel ecosystems. Additional research on the identity, relationships and functional roles of fungi and other microorganisms associated with insects such as bark beetle (e.g. walnut twig beetle) and wood wasps (e.g. *Sirex noctilio* or native Siricidae) are needed to understand the epidemiology of certain diseases and determine appropriate management strategies for potential introductions of insect-pathogen complexes in the South.

#### **Problem 2b. Other diseases of forest ecosystems.**

In addition to diseases caused by insect-pathogen complexes, other forest disease occurrences or epidemics may occasionally demand research attention due to their complex diagnosis or impact on local or regional ecosystems, forest resources or communities.

### **Problem 2c. Forest nursery diseases.**

Historically, a variety of fungal pathogens and plant parasitic nematodes have impacted seedling production in forest tree nurseries. The introduction of fumigation with methyl bromide in the 1950's provided a means for broad spectrum control of many soil borne pest problems. Methyl bromide has been identified as an ozone depleting chemical and its use is being phased-out under the terms of the Montreal Protocol. We plan to continue our work on the influences of nursery cultural practices on pathogenic fungi and plant parasitic nematodes to minimize subsequent disease development and increase seedling production. As methyl bromide is phased out, we will continue to assess application methods, distribution, efficacy and fate of alternative soil fumigants and other pesticides.

### **Problem 3. Invasive Plants**

Non-native invasive species represent one of the most serious challenges to sustainable forest health and management in the United States and around the globe. Invasive plant species such as cogongrass, invasive privets, Chinese tallowtree, Japanese and Old World climbing ferns, and non-native honeysuckles are altering and degrading native plant communities, negatively impacting forest biodiversity and ecosystem function, and hindering management objectives in forests. The inhibition of ecosystem services by plant community shifts is under-researched, poorly understood, or poorly integrated in Forest Service research. Moreover, other non-native forest pest organisms (e.g., emerald ash borer, hemlock woolly adelgid) can threaten to largely eliminate major tree species or genera from North America, and may cause significant shifts in the plant and animal assemblages, successional trajectories, community dynamics, and ecosystem services provided by forests. Combined effects characterized by the invasional meltdown hypothesis (whereby invasion by one non-native species initiates a cascade of invasions by other non-native species from varied guilds), may occur more frequently in forest types that are of conservation or management concern.

In recent decades, substantial research progress was made in determining types, rates, and application methods of herbicides appropriate for effective extirpation of invasive plants in forest ecosystems. Newly released or reformulated herbicides require comparative testing. However, many invasive plant species remain persistent due to variable applications and/or efficacy, differential reproduction potentials and strategies, persistent propagule pressure, inter- and intraspecific hybridization, and potential novel evolutionary selection pressures or release from natural enemies, among many other ecological factors contributing to invasion success in plant species.

### **Problem 3a. Prevention, detection, and characterization of invasive plant species.**

Research is needed to contribute to prevention of entering invasive propagules, efficient detection of nascent establishing populations, and the identification and characterization of invasive plant populations.

### **Problem 3b. Invasive plant species control and management.**

Additional research is needed to optimize the types, rates, methods, timing, and frequency of herbicide applications for persistent invasive plant problems (e.g., cogongrass) under varied forest types and management. Significant research gaps exist in the integration of chemical control with other management methods including manual, mechanical, biological and silvicultural tactics. Even when a target invasive plant is eradicated or suppressed, few methods exist to rehabilitate or restore communities and the ecosystem services therein to pre-invasion levels, or at least recoup some of the losses.

## **10. Approach to Problem Solution**

### **Problem 1. Insects**

#### **Problem 1a. Ecology, biology and management of bark beetles and other native insects.**

We will develop novel control methods for bark beetles and invasive insects of southern conifers. Specifically, we aim to:

- Identify and characterize the roles of semiochemicals in host finding, mating and population dynamics of bark and wood boring insects and their associates. Develop and refine semiochemically-based management tools for reducing the impact of infestations and outbreaks.
- Evaluate and improve application of tree protectants for bark beetles or other forest pest insects.
- Develop and evaluate integrated pest management approaches that combine multiple control strategies (e.g., silvicultural, semiochemical, insecticidal) on the same forest tracts.
- Characterize trans-continental variation in the biology and epidemiology of major pests in order to understand conditions that promote their virulence and their potential to invade new areas.
- As necessary, conduct research necessary to reduce the impact of seed orchard, nursery and regeneration pests through integrated management.

#### **Problem 1b. Detection, biology and management of non-native insects.**

A truly integrated management approach (i.e., combining biological, chemical and cultural control methods with host plant improvement), informed by basic biological research, will be needed to combat some of the most aggressive invasive pest problems. In response to these needs, we aim to:

- Develop and optimize traps, lures and other tools for detecting and monitoring exotic forest insects.
- Study the biology and ecology of exotic forest insects to better understand their requirements and vulnerabilities.

- Evaluate efficacy and improve strategies for enhancing establishment, proliferation and spread of biological control agents (including parasitoids, predators, and microbial agents) to reduce impact of invasive forest insects.
- Develop and evaluate integrated pest management approaches that combine multiple control strategies (biological, silvicultural, insecticidal, semiochemical).

**Problem 1c. Effects of forest management and species invasion on insect biodiversity and ecosystem processes.**

Our unit aims to:

- Evaluate the effects of forest management practices on pollinators including the effects of prescribed fire and harvests at different spatial and temporal scales.
- Characterize the roles of saproxylic insects in wood decomposition, nutrient cycling and the suppression of pest populations with an aim to develop management recommendations for improving forest productivity, biodiversity and health.
- Evaluate the impact of invasive species and novel community assemblages on beneficial insects (e.g., pollinators and saproxylic species) and key ecosystem processes.

**Problem 2. Diseases**

**Problem 2a. Insect-microbial associations and insect-pathogen disease complexes.**

We aim to:

- Identify and elucidate the roles (e.g., nutritional, plant pathogenic, plant saprophytic) of fungal, other microbial, or nematode associates of forest insects, including introduced bark and ambrosia beetles and native or introduced woodwasps.
- Continue to characterize the etiology and epidemiology of laurel wilt, thousand cankers disease, and/or other established or emerging disease complexes on new hosts and in new environments. When possible, develop management strategies for disease prevention or suppression based on an improved understanding of these processes and relationships.

**Problem 2b. Other diseases of forest ecosystems.**

We aim to:

- Characterize the causal factors, host associations, epidemiology and impact of other tree diseases in forest ecosystems including plantations.
- Evaluate and optimize preventive and suppressive tactics for minimizing the impact of tree diseases in forest ecosystems and stands.
- Evaluate the impact of climatic conditions and seasonal weather variability on insect-pathogen complexes and tree diseases in forest ecosystems.

### **Problem 2c. Forest nursery diseases.**

We aim to:

- Evaluate management techniques, including fumigants, cover crops, and mycorrhizal applications, to minimize disease problems and improve seedling growth in forest nurseries.

### **Problem 3 Invasive Plants**

#### **Problem 3a. Prevention, detection, and characterization of invasive plant species.**

To contribute to prevention of entering invasive propagules, efficient detection of nascent establishing populations, and the identification and characterization of invasive plant populations, we aim to:

- Develop research programs to understand the quantity and frequency of propagule rain into forest systems and provide data allowing state and private cooperators to adequately assess risk of invasion by certain species.
- Develop prevention and monitoring research program(s) where primary or secondary spread may be avoided prior to establishment in new locations.
- Develop novel tools and protocols for efficient identification and risk evaluation of potential invasive plants and plant propagules entering or established in the Southern US.
- Characterize the ecology of invasive plants and determine if populations are differentially responsive to various management or control tactics. This may result in the discovery of differential responses to herbicide, due to intrinsic tolerance or the evolution of resistance.
- Determine effective strategies to maximize economic cost and ecological gain in invasive species management, including but not limited to approaches within and among interacting species, disturbance (anthropogenic and natural), and how rates of invasion may change with a changing climate in the southern US.

#### **Problem 3b. Invasive plant species control and management.**

We aim to:

- Develop and evaluate interdisciplinary approaches combining multiple strategies (e.g., herbicidal, mechanical, biological, cultural) to manage and control invasive plant populations in forest ecosystems.
- Test the host range, reproductive success and potential efficacy of biological control agents for invasive plants.
- Develop and evaluate management strategies for restoring or creating desired conditions in native plant communities and forest ecosystems degraded by invasive species.



## **11. Environmental Considerations**

The RWU-4552 program of research includes activities that are not expected to have a significant adverse effect on the quality of the human environment. The environmental effects of specific actions will be considered during the development of study plans, at which time the existence of extraordinary circumstances related to the proposed action and any categorical exclusions will be documented as a part of the study plan as described in FSH 1909.15, Chapter 30. For research involving the use of toxicants, environmental considerations will be further evaluated through Environmental Assessments or Environmental Impact Statements prepared with, and reviewed by the cooperating District or Forest staffs. For research having the potential to affect a plant or animal species that is federally listed as endangered or threatened or proposed for such listing, RWU-4156 will consult with District or Forest biologists and the U.S. Fish and Wildlife Service as per Section 7 of the Endangered Species Act of 1973, as amended.

### **Key Cooperators:**

RWU-4552 relies on strong partnerships to augment its research capacity and insure the relevance of its research. Within Forest Service Research, we collaborate with other work units within the Southern Research Station as well as collaborating across stations to supply expertise on insect, diseases and invasive plant issues from a regional and national perspective. Our scientists maintain collaborative research with the National Forest System, State and Private Forestry - Forest Health Protection, the National Park Service, Agricultural Research Service, Animal Plant Health Inspection Service (APHIS), as well as state and local government agencies including state forestry commissions, parks and nature centers, departments of environmental conservation, and wildlife agencies.

We also maintain collaborative research activities with many universities across the country including the Arkansas State University, Auburn University, Columbus State University, Cornell University, Dartmouth College, Iowa State University, Louisiana State University, Michigan State University, Mississippi State University, North Carolina State University, Oregon State University, Texas A&M University, University of Arkansas, University of Florida, University of Georgia, University of Massachusetts, University of Missouri, University of North Carolina, University of Tennessee, University of Southern Mississippi, University of Vermont, University of Wisconsin, Virginia Tech, and others.

We also maintain an excellent relationship with our international colleagues and the unit has sent scientists abroad as well as hosted several visiting scholars from research agencies in other countries. Our international partners include the Canadian Forest Service, Chinese Academy of Sciences, El Colegio de la Frontera Sur (ECOSUR, Mexico), Esencia Nacional de Ciencias Biológicas (Mexico), Japanese Forest Research Institute, Manaaki Whenua Landcare Research (New Zealand), Taiwanese Institute of Forest Research, and others.

## **12. Staff and Resources**

*Personnel:* Currently, the scientific staff of RWU-4552 consists of six research entomologists, two research plant pathologists, one research ecologist, and three additional non-paneled scientists (two entomologists and one plant pathologist). The scientific staff is supported by a professional staff of six permanent biological science technicians, four forestry technicians, and one term biological science aid. Our administrative support is served by two part-time

contractors. The unit permanent personnel levels have generally decreased since 2009, from 36 full-time equivalents (FTE's) in 2009 to approximately 23 FTE's at the end of FY 2015.

*Infrastructure:* The unit currently maintains infrastructure at four locations: Pineville, LA; Athens, GA; and Asheville, NC.

*Pineville:* The Pineville location is at the Alexandria Forestry Center (AFC) at 2500 Shreveport Highway, Pineville, LA. The AFC is one of the only facilities in the US to house units from all three branches of the Forest Service (Research and Development, National Forests, and State and Private Forestry) including scientists in RWU 4704 (Utilization of Southern Forest Resources), RWU 4158 (Restoring Longleaf Pine Ecosystems), and Forest Health Protection. Our unit occupies approximately 11,000 ft<sup>2</sup> of laboratory, shop, and offices within the AFC. Unit personnel occupy five research labs, 11 offices and a conference room. Outbuildings include a forestry lab and office, research insectary, storage buildings, and a greenhouse/climate-controlled insect rearing facility. The microbiology lab is well equipped with laminar flow hoods, growth chamber, refrigerator and microscopes. The insect ecology lab is equipped with a complete GC-EAD system for analyzing insect perception. The chemical analysis lab has two GC-MS equipped for qualitative, quantitative, and stereochemical analysis. The acarology lab is well equipped with stereo and compound scopes and a scanning electron microscope. Additional facilities allow for insect bioassays, insect rearing, seedling culture, insect taxonomic collections, and processing plant samples. Pineville is located about 2 hour drive from Louisiana State University in Baton Rouge, providing unit staff with nearby opportunities for university collaboration.

*Athens:* The Athens location is in the Forestry Sciences Laboratory (320 Green Street, Athens, GA), on the south campus of the University of Georgia. The facility also houses Forest Service scientists in RWU 4156 (Center for Forest Disturbance Science), RWU 4952 (Integrating Human and Natural Systems), and Forest Health Protection. The university's science library is located a block away and the departments of Entomology and Plant Pathology have extended adjunct faculty status to scientists in the unit. The Warnell School of Forestry, the Institute of Ecology, and the Department of Plant Biology are located across the street. In addition to opportunities to interact with the faculty, the School of Forestry provides space on the Whitehall Forest a short distance from campus, where the RWU has a small seed orchard, storage buildings, raised planting beds, and lath houses for experiments. Scientists are also permitted to conduct experiments in the forest if conditions and space allow. The FS laboratory buildings on the Athens campus were built in the 1960s. Within the north building, the project has five fully-equipped laboratories devoted to tree pathology research, and four laboratories and an insectary for entomology research. A well-equipped shop is available for fabrication of research equipment. The Athens lab is located approximately 20 miles from the Scull Shoals Experimental Forest and 60 miles from the Hitchiti Experimental Forest.

*Asheville:* The unit's acting Project Leader (research entomologist) is located in Asheville, NC at the Southern Research Station headquarters. In addition to housing the Southern Research Station leadership and other administrative departments, the facility also houses the Forest Health Protection (FHP) R8 Asheville Field Office and scientists with the Eastern Forest Environmental Threat Assessment Center (EFETAC, RWU 4854), providing

opportunity for local collaboration on forest health research and management. The facility has two small laboratories managed by FHP that receive shared use by unit staff. The facility is immediately adjacent to University of North Carolina at Asheville (UNCA) where unit staff has developed collaborative research with faculty in the Environmental Studies Department. Unit staff also utilizes storage space and conducts research at the nearby Bent Creek Experimental Forest, located on the Pisgah National Forest and hub of the Upland Hardwood Ecology and Management Unit (RWU 4157). In addition, Asheville is located about 2 hour drive from University of Tennessee in Knoxville, providing unit staff with additional opportunities for nearby university collaboration.

### 13. Budget

*Budget:* In-house station funding for RWU-4552 has declined over the past five years (Fig. 1). Our highest funding level was in 2009 and our lowest level has been the preceding two fiscal years. The biggest decrease was from 2014-2015 with the administrative transfer of the Wood Products Insects group to the Northern Research Station Forest Products Lab. Since 2010, the unit has allocated approximately \$300-500K annually toward the establishment of cooperative agreements, joint ventures, and other collaborative projects with universities and other cooperators. These agreements open substantial opportunities for unit scientists to build new research partnerships, support and mentor graduate students, hire temporary employees, and build research teams with diverse expertise.

**Fig. 1.** RWU 4552 initial funding allocations and extramural agreements awarded, 2010-2015.

