USDA-Forest Service RESEARCH WORK UNIT DESCRIPTION Ref: FSM 4070	**1. Number** SRS-4502	**2. Station** Southern Research Station
	3. Unit Location Starkville, Mississippi	

4. Research Work Unit Title
Wood Products Insect Research

5. Project Leader (Name and Address)
Terence L. Wagner, 201 Lincoln Green, Starkville, MS 39759

6. Area of Research Applicability	**7. Estimated Duration**
National	5 years

8. Mission
To improve the protection of wood from insect pests and understand the impact of these organisms on forest productivity, sustainability, and health.

9. Justification and Problem Selection:

The United States is one of the world's leading consumers of wood and wood products. Yet diminishing forest resources worldwide, increasing demand for wood from foreign markets, and difficulties harvesting on National Forests make it imperative that we to protect wood in use from insect pests. Replacing wood damaged by insects causes a serious drain on wood resources, and thousands of acres of trees are cut annually to meet this demand. Wood-destroying insects include termites, beetles, ants, and bees. Many of these pests are non-indigenous to this country and as global trade and travel increases, so too will the threats from these exotic pests. Recognizing that the pest status of individual species can change rapidly in a global society, and in keeping with the Forest Service National Strategy and Implementation Plan for invasive species and the government-wide mandate under Executive Order 13112 that calls for enhanced research and management of invasive species, SRS-4502 supports a broad mission so that it can respond to important emerging research issues.

Of the wood-destroying insects, termites pose the greatest threat to wood in use. The costs of controlling termites and repairing damage are estimated at $1.5 billion annually in this country. Losses incurred from the invasive Formosan subterranean termite and by the Department of Defense greatly contribute to these costs. Control and repair costs from drywood termites are difficult to estimate but are substantial in California, Hawaii, Florida, and along the Gulf Coast. Wood-boring beetles are found in several families including Lyctidae, Anobiidae, and Bostrichidae (powderpost beetles), Cerambycidae (roundheaded borers), Bupresidae (flatheaded borers), and Scolytidae (bark beetles and Ambrosia beetles). Losses from these pests exceed $50 million annually and many are invasive species. Some of these groups of pests are understudied, and few experts continue to work on them. Extensive research and technology transfer are needed in many of these areas to improve wood protection.

Signature	Title	Date
Recommended:/s/ Bruce L. Jewell	Assistant Director for Research	9/21/05
/s/ Mary Ellen Dix	Assistant to Staff Director	9/28/05
/s/ Jimmy L. Reaves	Staff Director	9/30/05
Approved: /s/ Peter J. Roussopoulos	Station Director	10/28/05
Concurred:/s/ Ann Bartuska	Deputy Chief for Research	11/2/05

9. Justification and Problem Selection (continued):

Subterranean termites are found throughout most of the U.S. and its territories. They are destructive pests when infesting wooden structures and damage both wood and non-wooden building components and contents. Termite control commonly involves treatment of the soil under and around building foundations with a liquid pesticide that kills and/or repels termites. Older termiticides typically provided many years – even decades – of protection; however, since 1984 many of these products are no longer registered for use by the U.S. Environmental Protection Agency (EPA). These compounds include the chlorinated hydrocarbons and cyclodienes (no longer registered since 1988), carbamates (2000), and organophosphates (all uses to end in 2005). The newer termiticides generally are effective for shorter periods and require more frequent re-treatments. Because re-treatments are expensive, home and business owners want products that remain effective for as long as possible while minimizing human health and environmental concerns.

Heightened awareness of the risks associated with pest management has prompted many of the recent changes in termite control. For example, newer termite control products may have reduced risks associated with their use, and many affect termites in different ways. Traditional soil-applied liquid termite control products typically repelled termites, but the newer compounds are often non-repellent and may exhibit delayed toxicity to the termites. Many are passed to some degree among colony members. These characteristics complicate efforts to evaluate efficacy but may also provide new opportunities for control. Alternative control methods such as insect growth regulators (IGRs), baits, chemically-impregnated barriers, wood preservatives, biological control, etc. are becoming more prominent partly because of their perceived reduced risks. These and other control tactics and strategies need investigation. Extensive behavioral and ecological studies are needed if novel management systems are to be developed. New information generated from these studies will be applied to current and emerging techniques for termite control and protection of wood against damage.

Unlike most insecticides, efficacy data are required for the registration of all termite control products containing insecticides as legislated by federal and state agencies (e.g., EPA's OPPTS 810.3600 and 810.3800 and the Florida Department of Agriculture's Termiticide Efficacy Rule, 5E-2.0311 FAC). In addition, new and potentially effective products are continually being developed by manufacturers. Chemical companies have responded to the demands for safer products with an array of new and reformulated active ingredients. Because of the continual demand, <u>there is a need to provide independent efficacy data for the registration of termite control products</u> (Problem 1). SRS-4502 has been testing chemicals for termite control since the 1930s, and this research was the first of its kind to support the development of liquid products applied to the soil for termite control. The research expanded over the decades, and today the Termiticide Testing Program provides expertise and infrastructure for product testing, registration, and labeling that is trusted by regulators and registrants alike. Most termite control products registered in the U.S. have undergone Forest Service testing, and SRS-4502 continues to be the primary source of this information. Efficacy data generated by an independent and reliable source bolsters consumer confidence in products by eliminating the appearance of bias. Screening for effective insecticides, rate combinations, and alternative products provide safer and more dependable ways to protect wooden structures including homes, which are the largest single investment of American families.

The primary ways to protect wood from insect damage is to prevent attacks and quickly control infestations. These activities are not unrelated because effective treatments used to prevent attacks are often also used to control infestations. Understanding pest biology, ecology, and behavior is essential to developing efficacious, safe, and economical management tactics and strategies. Understanding how, why, and under what circumstances treatments are effective is also crucial. Effective insect pest prevention and control is limited by inadequate knowledge of treatment effects on pest biology, ecology, and behavior as well as the environmental effects on treatments (Problem 2).

Beyond evaluations of efficacy, little is known of the complex biological interactions between termites and control technologies. This situation limits our ability to use products effectively. Termites often respond differently to the newer termiticides compared to the chlorinated hydrocarbons, organophosphates, and pyrethroids. Some new compounds do not repel termites at pre-construction application rates, but they affect termite behavior in other ways or are transferred among colony members. Improved understanding of how active ingredients are transferred among termites may allow researchers to exploit this behavior. Currently, only baits are thought to kill termites indirectly, and possible transfer of liquid termiticides could allow applications similar to baits. This area of research has grown in importance as more of these compounds have reached the marketplace. Insecticide degradation and mobility influence product longevity, and few studies report the fate and longevity of active ingredient at termiticidal application rates. Understanding these factors will help predict the conditions promoting effective application. An understanding of the mechanisms involved in detoxification of termiticides by termites is needed to provide a means for defeating these processes.

Termites are highly efficient and beneficial reducer-decomposers in the forest environment. They play an important role in temperate, subtropical, and tropical ecosystems, yet their impacts are poorly understood partly because of the challenges of studying termites in their subterranean habitat. Due to their destructive nature as structural pests, the majority of the literature on termites centers on control in urban environments. Little literature exists on the role and impact of native subterranean termites in North American forests. Knowledge of termite longevity, movement, foraging, and feeding are critical for understanding the role of termites in forest ecosystems, but also contribute to the understanding and development of control strategies. Additionally, determining native termite interactions with other wood decomposers (such as fungi, beetles, Formosan subterranean termites, and other organisms) would add to our understanding. For example, termites and wood decay fungi are intimately associated, and their interactions are complex and largely unknown. Fungi can elicit or inhibit termite colonizing, foraging, and/or feeding.

Coarse woody debris (CWD) is a large source of carbon and other nutrients that are relatively unavailable to the forest ecosystem. Termites along with fungi, bacteria, and a handful of other invertebrates utilize these resources and move nutrients into the soil where they become available for plant growth. Termites are also important in the movement of energy in forest ecosystems, as well as providing for soil aeration and water percolation. Little information is available on energy movement in North American forests. Studies of termite contributions to these systems would be invaluable.

These and other ecological studies are hampered, however, by inaccurate termite identification. The largest and most important group of termites in the U.S., *Reticulitermes* species, is in need of taxonomic revision. Improved diagnostic techniques leading to correct species identification of termites are needed. Once species can be distinguished, studies can be undertaken on diversity, habitat delineation, colony size, foraging patterns, and wood consumption rates. In addition, virtually nothing is known of the effects of the invasive Formosan subterranean termite (FST) on southern forest trees and native termite populations. This species is moving into Mississippi forests with unknown speed and consequences. Encroachment into forests will virtually guarantee the permanent establishment of the pest in an area. FST attacks trees in urban environments leading to their ultimate death, and it surely will do the same in forests. It will also compete with native subterranean termites in forests, leading to their disruption or possible displacement. Thus, inadequate knowledge of the biology, ecology and behavior of wood-decomposing insects in natural habitats limits understanding of forest ecosystems, productivity, and health (Problem 3).

10. Approach to Problem Solution:

Problem 1. There is a need to provide independent efficacy data for the registration of termite control products.

The chemical industry is constantly producing new compounds as potential termiticides or bait active ingredients, and product performance data are required for their registration. SRS-4502 has a long history of providing efficacy data to federal and state agencies, and we will continue to do so. The first step in the process with soil-applied termiticides generally involves the generation of two years of laboratory screening data. Promising candidates must then undergo six years of field evaluation that produces five years of required registration data. Field tests are currently performed at four sites in Arizona, Florida, Mississippi and South Carolina. These sites vary in climate, soil, and termite species (e.g., *Reticulitermes* spp. in the Southeastern states and *Heterotermes aureus* and *R. tibialis* in Arizona). Federal and state regulators are familiar with these test sites and have confidence in the results.

Termite baits have become a popular management tool during the last decade, although usually as a remedial measure. EPA's new OPPTS 810.3800 guideline now requires product performance data for the registration of these products. Consequently, there is a need to test baits in the laboratory and field. Lab tests must demonstrate whether the baits are readily fed upon by termites and cause 100% mortality between 2-10 weeks at proposed label concentrations with an alternative food source concurrently available. Given our current capabilities, we will conduct laboratory bait tests only.

Only research specified for the purpose of generating efficacy data for federal and/or state registration will be considered under this Problem Area.

Accomplishments planned for the next five years include:

1. Contribute to the delivery of effective termite control products by providing registrants with product performance data used in federal and state registration of termiticides, chemically-impregnated barriers, baits, and alternative products designed to protect wood from subterranean termites (Manage and Mitigate Established Invasive Species: tools and methods long-term efficacy assessments and evaluations).
2. Develop and refine testing tools, methods, technologies, and guidelines for assessing the efficacy of termite control products to provide regulators, pest control industry, and the

American public with reliable indicators of product performance (Manage and Mitigate Established Invasive Species: tools, methods and guidelines developed).

3. Provide technical assistance to federal and state regulators in interpreting efficacy data on candidate termite control products to allow officials to make informed regulatory or policy decisions. The same assistance will be provided to the pest management industry and the American public in making informed consumer decisions on registered products (Manage and Mitigate Established Invasive Species: consultations).

Environmental Consideration: Ongoing and proposed studies have little or no impact on the environment. Environmental effects of specific actions will be considered during the development of study plans, and procedures for categorical exclusion will be followed in accordance with FSH 1909.15. As needed, Environmental Assessments or Impact Statements will be prepared and approved by the appropriate staff of the Forest Service.

Problem 2. Effective insect pest prevention and control is limited by inadequate knowledge of treatment effects on pest biology, ecology, and behavior as well as the environmental effects on treatments.

Unit scientists will examine the biological and toxicological effects of termiticides and alternative control methods. Studies will be conducted on the sub-lethal effects of non-repellent delayed-action termiticides on termite activity. Non-intrusive measures of termite activity using acoustical technology will be assessed with a goal of providing a means to quantify toxicity and efficacy. Measuring the effects of termiticides on termite colonies is nearly impossible using undisturbed resident populations in nature. Confining termites to underground cages in the field may allow direct measures of dose response of colonies to termiticides. Toxicological modeling, such as the structure-activity relationships between physico-chemical parameters of termiticides and biological activity, will be addressed for existing and emerging chemistries. Studies examining the toxicological responses of termites to insecticides will be undertaken to identify specific detoxification mechanisms, and additional studies could examine the means for defeating these mechanisms.

New termiticides will be tested for transfer using a donor-recipient bioassay. Additional studies will examine the amount of material acquired by donor termites as a function of termiticide concentration in the soil, influences on donor and recipient activity over time, and estimates of time to death of donors. Although difficult, this phenomenon ultimately will require field validation.

We recently completed a survey of wood decay fungi isolated from coarse woody debris in four forest habitats in Mississippi. The survey produced a large number of candidate fungi for study. Bioassays of fungal infested wood and fungi themselves on chemotaxis of termites will be investigated. Subsequently, bioassay-directed fractionation, followed by identification via HPLC or GC, will be used to seek out active components. Individual components may then be analyzed for activity. This work may lead to the identification of attractant components for refinement of termiticidal baits. Identifying attractant or repellent fungi in the environment will improve our understanding of habitat associations of termite species in forests, an effort that will overlap with Problem Area 3. Examining the physical and chemical changes in wood as a result of fungal infection may increase our knowledge of termite-fungi-wood interactions.

Degradation and mobility are two important factors determining longevity, and some newer active ingredients are more degradable and mobile than older compounds. The environmental properties of termiticide formulations will be examined to determine which factors affect longevity. Studies to examine movement in the greenhouse and field are underway.

Accomplishments planned for the next five years include:

1. Determine the effects of termiticides on termite biology (e.g., chemical transfer among nestmates, effects of chemical properties on toxicity, detoxification capabilities of termites, etc.) providing scientists, pest managers, and the American public with improved knowledge for assessing efficacy and use (Manage and Mitigate Established Invasive Species: new science findings, method and tools efficacy evaluation).
2. Determine the effects of the environment on termiticides (e.g., longevity, mobility, etc.) providing scientists, pest managers, and the American public with improved knowledge for assessing efficacy and use (Manage and Mitigate Established Invasive Species: new science findings, method and tools efficacy evaluation).
3. Investigate the effects of wood-decay fungi on termite behavior to provide scientists and pest managers with improved knowledge and tools for preventing termite attack or controlling infestations (Manage and Mitigate Established Invasive Species: new science findings, method and tools efficacy evaluation and development).
4. Assess acoustical and olfactory technologies to provide scientists and mangers with new detection techniques in support of termite research and control (Detect, Respond and Eradicate Invasive Species: new science findings, tools and methods evaluations; Manage and Mitigate Established Invasive Species: tools and methods developed).

Environmental Consideration: Most of the research falls in the area of categorical exclusion (FSH 1909.15). For research involving the use of toxic substances, environmental considerations will be evaluated during the development of study plans, or by Environmental Assessments or Impact Statements prepared with and approved by appropriate staff of the Forest Service.

Problem 3. Inadequate knowledge of the biology, ecology, and behavior of wood-decomposing insects in natural habitats limits understanding of forest ecosystems, productivity, and health.

Measures of termite prevalence in CWD in different stages of decay will help define the wood decay stage(s) most preferred by termites. Termite infestation rates of wood in different forest habitats will help determine the extent of termite participation in the decomposition process. Determining the role of termites in CWD decomposition is greatly hampered by the lack of non-destructive techniques. Preliminary studies examining the rates of infestation are currently underway using acoustical detection to determine the presence of termites in logs.

Investigations will measure calories of wood consumed by termites. Studies will examine differences in caloric content of wood damaged and undamaged by termites in an effort to estimate the amount of energy converted by termites at various densities. This information will provide a starting point for estimating the impact of termites on energy movement in forests. In addition, termite influences on soil composition and water percolation will be measured in greenhouse and field tests.

A survey is currently underway to identify the native subterranean termite species found in Mississippi forests and describe the specific habitat characteristics associated with each species. Global positioning system (GPS) data were collected with samples of termites from the forest. A large group of termites was found that could not be identified using traditional keys. Species identification is very difficult and uncertain, complicating ecological studies.

There is evidence that Formosan subterranean termites are moving into forests in southern Mississippi, and due to its ability to attack live trees, there is potential for damage in forest ecosystems. If populations are found in southern forests, infested areas will be delineated and their impact on living trees and native termite species determined.

Accomplishments planned for the next five years include:

1. Investigate the role of termites in CWD decomposition, movement of soil nutrients and water, and energy consumption to provide scientists, land managers, and policy makers with improved knowledge of long-term carbon and nutrient capital of the soil, forest carbon credits and energy nets, and the effects of intensive harvesting practices for biomass production leading to improved management tactics to favor desired conditions (Mission Related Work to Improve Productivity and Efficiency: new science findings).
2. Define the forest habitat characteristics associated subterranean termite species in Mississippi to provide scientists and managers with improved knowledge for effective management and control (Mission Related Work to Improve Productivity and Efficiency: new science findings; Manage and Mitigate Established Invasive Species: new science findings, tools and methods developed).
3. Identify forest infestations of Formosan subterranean termite and evaluate its impact on living trees and native termite populations to provide scientists, managers, and policy makers with improved knowledge of the potential spread and impact of this invasive insect (Detect, Respond and Eradicate Invasive Species: new science findings, tools and methods evaluations; Manage and Mitigate Established Invasive Species: new science findings, tools and methods evaluations).

<u>Environmental Consideration</u>: The planned work is categorically excluded from documentation or environmental analysis (FSH 1909.15).

11. Cooperators (partial list):

<u>Problem 1</u>: The Termiticide Testing Program has a long list of cooperators that represent numerous product manufacturers, state and federal agencies, representatives from universities, the pest management industry and organizations. Test sites are located on National Forests and other Forest Service property in Region 8, the University of Arizona (Santa Rita Experimental Range), and Mississippi State University (John Starr Forest).

<u>Problem 2</u>: Examine detoxification ability of termites in cooperation with Jan Chambers, Mississippi State University, College of Veterinary Medicine. Termite detection using acoustical and olfactory technologies will be accomplished in cooperation with Shane Luttrell, Creare Design Group, LLC and Dan Wilson, SRS-4155, Stoneville, MS. Studies on the interaction of termites and decay fungi will be done in cooperation with Susan Diehl, Department of Entomology and Plant Pathology, Mississippi State University and Barbara Illman, Forest Product Laboratory, Madison, WI. Statistical consultations provided by Pat

Gerard, Mississippi State University, Experimental Statistics, MAFES. Some transfer and other research will be conducted with industry cooperators under confidential agreements.

Problem 3: Statistical consultations provided by Pat Gerard, Mississippi State University, Experimental Statistics, MAFES.

12. Staffing by Year (Scientist Years):

	2006	2007	2008	2009	2010
Problem 1	1.5	1.5	1.0	1.0	1.0
Problem 2	1.5	1.5	1.5	1.5	1.5
Problem 3	1.0	1.0	1.5	1.5	1.5
TOTAL	4.0	4.0	4.0	4.0	4.0

13. Estimated Performance by Year (e.g., Consultations, Progress Reports, Publications, Presentations, Tools, etc.):

	2006	2007	2008	2009	2010
Problem 1	50	50	50	50	50
Problem 2	4	4	4	4	4
Problem 3	3	3	4	4	4
TOTAL	57	57	58	58	58