RESEARCH WORK UNIT DESCRIPTION Ref: FSM 4070	1. Number FS-SRS-4501	2. Station Southern Res. Stn
	3. Unit Location Pineville, Louisiana	

4. Research Work Unit Title
Ecology, biology and management of bark beetles and invasive forest insects of southern conifers.

5. Project Leader (Name and address)
Kier D. Klepzig, 2500 Shreveport Hwy, Pineville, LA 71360

6. Area of Research Applicability	7. Estimated Duration
Principally the southern and southeastern United States.	5 years.

8. Mission
To provide the basic biological and ecological knowledge and innovative management strategies required for management and control of bark beetles and invasive insects of conifers in changing forest ecosystems.

9. Justification and Problem Selection
This RWUD covers the planned research and technology development activities of Research Work Unit SRS-4501, which has south-wide responsibility for research and prediction technology on the southern pine beetle (Dendroctonus frontalis), as well as other bark beetles attacking conifers in the southern and southeastern United States. The southern pine beetle (SPB) is the most destructive insect pest in southern forests. SPB, especially when considered with other bark beetles, cause great economic damage and disruption of resource management practices. While at endemic levels, bark beetles serve as natural agents or tree mortality, especially of lightning struck or weakened trees. However, at epidemic levels, bark beetles pose serious threats to forest ecosystem health. Acting as invasive agents in susceptible host type, bark beetles may seriously affect the function and sustainability of forest ecosystems.

This unit will potentially address emerging, critical invasive insects of threat to southern forests, especially non-native invasive species. Recent estimates for economic loss due to non-native invasive species across sectors each year total more than $ 137 billion (Pimental et al. 2000). The U.S. has more than 400 established exotic insects that feed on trees and shrubs (Mattson et al. 1994), and this number has increased dramatically with increased global travel and trade. Reccnt introductions of great threat to U.S. forests include the Asian longhorned beetle, *Anoplophora glabripennis*, the smaller Japanese cedar longhorned beetle, *Callidiellum rufipenne* and the pine shoot beetle, *Tomicus piniperda*. Of particular concern to southern forests are the balsam wooly adelgid, the hemlock wooly adelgid, Asian ambrosia beetle, among others. A thorough understanding of the impacts, biology and ecology of invasive insects is vital in developing effective management and control strategies for these increasingly important insects. This research goal is intentionally broad, to allow unit flexibility in responding to a new invasive species threats, in keeping with the government-wide mandate under Executive Order # 13112 that calls for enhanced research and management of invasive species.

10. Approach to Problem Solution (Start at conclusion of item 9.)

Signature	Title	Date
Recommended:	Assistant Director for Research	
	Assistant to Staff Director	
	Staff Director	
Approved:	Station Director	
Concurred:	Deputy Chief for Research	

10. Approach to Problem Solution

Problem 1. -- Ecology and biology of bark beetles and invasive insects in forest ecosystems. Research on Problem 1 will be divided into several different areas.

a. Biological and ecological interactions of bark beetles and invasive forest insects with their associated organisms.

The focus of research on native, invasive insects will continue to be SPB. Additionally, other bark beetles (e.g., *Ips* spp. pine engravers, *Hylastes* spp. root beetles) and weevils (e.g, pales weevils – *Hylobius pales*, pitch eating weevils – *Pachylobius picivorus*) impacting the ecological function of southern conifers may will be addressed. The effects of inter-relationships among bark beetles, their phoretic mites, and the fungi they both vector, on bark beetle biology and ecology will be examined through field and laboratory-based studies. The implications of these interactions will be quantified through manipulative experiments and modeling. Research on bark beetle parasitoids and predators will focus on their chemical ecology related to host finding cues, modeling, and biological control see Problem 2).

Although the unit's research is aimed at native invasive species, questions pertaining to biology and ecology are equally important for addressing non-native invasive species threats. Accordingly, the unit will initiate additional efforts for emerging non-native species threats, as these may arise and pending funding.

Accomplishments anticipated over the next 5 years include:
1. New knowledge about the manner in which competitive interactions among native bark beetles (southern pine beetle, *Ips* pine engravers, *Hylastes* root beetles) and fungi are mediated by biotic (mites) and abiotic (water, nutrition, temperature, antibiosis) factors.
2. New knowledge about the degree to which interactions with fungi and mites impact the population dynamics of native bark beetles.
3. Identification of host selection cues utilized by parasitoids and predators of native bark beetles.
4. New knowledge about the life history, biology, and chemical ecology of bark insects (esp. *Hylastes* spp.) in roots of southern conifers.
5. Impact(s) of non-native invasive insects on southern forests, including studies of movement and biology, described and quantified.

Environmental consideration: Most of the research described here falls into the area of categorical exclusion (FSM 1950). For research involving the use of hazardous chemicals and toxic substances, environmental considerations will be evaluated within individual study plans, or by Environmental Assessments or Environmental Impact Statements prepared with and approved by appropriate staffs of the Forest Service.

b. Bark beetles and invasive forest insects in intensive forestry.

Intensive management of loblolly pine for increased growth and biomass has dramatically increased in recent years. Accordingly, there has been a need to better understand the effects of intensive management of pines on the abundance of, and tree resistance to, bark beetles (southern pine beetle, *Ips* pine engravers, *Hylastes* root beetles) and their associated organisms. For example, management inputs such as fertilizer and water will be studied for their effect on pine defense via their oleoresin system. Such studies will be aimed at native pests, but may also be initiated for non-native species pending emerging threats and available funds.

Accomplishments for the next 5 years include:
1. New knowledge about the impacts of various levels of intensive management on resistance of loblolly pine to bark beetles (southern pine beetle and *Ips* pine engravers) and non-native invasive insects.
2. New knowledge about the impacts of intensive management on oleoresin flow in loblolly pine resistance to bark beetles (southern pine beetle and *Ips* pine engravers).
3. New knowledge about the effects of invasive insects on productivity characteristics of intensively managed southern forests or plantations.

Environmental consideration: Most of the research described here falls into the area of categorical exclusion (FSM 1950). For research involving the use of hazardous chemicals and toxic substances, environmental considerations will be evaluated within individual study plans, or by Environmental Assessments or Environmental Impact Statements prepared with and approved by appropriate staffs of the Forest Service.

c. Bark beetles and invasive forest insects at the urban-wildland interface.

We will conduct research on the effects of biotic urban stressors on tree resistance to bark beetles and their associated organisms, and non-native invasive insects. Due to encroachment of development into forested areas, insects which are typically forest pests are becoming significant in urban trees. To address the need for knowledge on these interactions, we will conduct research involving the effects of urban stresses on forest tree species and their insect pests. Studies will be conducted with seedlings in controlled atmosphere growth chambers to expose southern conifers to various air pollutants and subsequently quantify their resistance to fungi associated with bark beetles and to non-native invasive insects. We will conduct studies with saplings of southern forest trees to determine the impacts of soil factors (low fertility, compaction, waterlogging and/or drought) on southern conifers, and subsequently expose the trees to attack by bark beetles (e.g, southern pine beetles, *Ips* pine engravers) and invasive insects (e.g., asian longhorned beetle, Asian ambrosia beetle).

Accomplishments for the next 5 years include:
1. Determine the effects of sulfur dioxide, ozone, nitrogen dioxide, and particulate pollution on the resistance of seedlings of southern conifers to bark beetle associated fungi.
2. Determine the effects of soil compaction, excess water, drought, and low fertility on the ability of southern conifers to resist attack by bark beetles, root beetles and associated fungi. Where relevant, interactions of the factors in 1 and 2, above, will be addressed as well.

Environmental consideration: Most of the research described here falls into the area of categorical exclusion (FSM 1950). For research involving the use of hazardous chemicals and toxic substances, environmental considerations will be evaluated within individual study plans, or by Environmental Assessments or Environmental Impact Statements prepared with and approved by appropriate staffs of the Forest Service.

d. Fire and interactions between trees, bark beetles and invasive forest insects.

We will investigate the effects of fire on southern conifers, especially on the abundance of, and on tree resistance to, bark beetles and their associated organisms, and invasive insects. (e.g., asian longhorned beetle, Asian ambrosia beetle). Fires, especially growing season burns, are being increasingly associated with subsequent mortality due to bark beetles. To better utilize fire as a management tool, and minimize unwanted effects it may have on trees, we need to better understand the conditions under which fire may become injurious to trees and/or predispose them to insect caused mortality.

Accomplishments for the next 5 years include:

1. Determine the impacts of burns conducted at various points in the year on southern conifers and their subsequent susceptibility to bark beetles and non-native invasive insects.
2. Determine the effects of burns on conifers as related to attractiveness or resistance characteristics.

Environmental consideration: Most of the research described here falls into the area of categorical exclusion (FSM 1950). For research involving the use of hazardous chemicals and toxic substances, environmental considerations will be evaluated within individual study plans, or by Environmental Assessments or Environmental Impact Statements prepared with and approved by appropriate staffs of the Forest Service.

Problem 2. -- Management of bark beetles and invasive insects of southern conifers.

Research on Problem 2 will be divided into 2 areas.

a. Development of novel control methods for bark beetles and invasive insects of southern conifers.

The unit will conduct research activities aimed at the development of novel or improved biocontrol, host resistance and pesticide based control methods. With the loss of synthetic pesticides for control of forest insects in recent years (coupled with concerns about non-target impacts), has come a call for the development of alternate management and control tactics. 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 new strategies have been tested or deployed adequately, thus limiting their potential use. We will use laboratory assays to identify candidate compounds and follow these assays with field tests of efficacy. In addition, we will continue efforts to develop artificial diets and mass rearing techniques for natural enemies of bark beetles and invasive insects. Finally, host resistance (genetically and environmentally based) to bark beetles and invasive insects, remains underused and poorly understood within southern conifers.

Accomplishments for the next 5 years include:
1. Determine the identity and utility of semiochemicals for the management and control of bark beetles and invasive insects, including as tools for the manipulation of natural enemies.
2. Determine the effects of semiochemicals on bark beetle and invasive insect host selection behavior.
3. Develop artificial diets and mass rearing techniques for natural enemies of bark beetles and invasive insects.
4. Determine the identity and mode of action of fungal competitors of bark beetles and their fungal symbionts as related to bark beetle control.
5. Determine the efficacy of systemic injectable and novel pesticides as applied to southern conifers for the control of bark beetles and invasive insects.
6. Determine the heritability of resistance to bark beetles (via increased resin flow) within southern conifers, especially the progeny of those classified as SPB escape trees.
7. Determine the ability of loblolly pine to exhibit induced resistance and identify elicitors of induced resistance in loblolly pine.

Environmental consideration: Most of the research described here falls into the area of categorical exclusion (FSM 1950). For research involving the use of hazardous chemicals and toxic substances, environmental considerations will be evaluated within individual study plans, or by Environmental Assessments or Environmental Impact Statements prepared with and approved by appropriate staffs of the Forest Service.

b. Development of landscape level predictive models as tools for management of bark beetles and invasive insects of southern conifers.

We will conduct research and analytical activities to develop models predicting the population dynamics and movement of bark beetles (southern pine beetle, *Ips* pine engravers) and invasive insects (e.g, asian longhorned beetle, asian ambrosia beetle) of southern conifers. Models are especially needed at this stage to predict SPB levels on larger spatial scales, far enough ahead of time to allow for allocation of resources to SPB suppression in advance of an outbreak. Likewise, models and quantitative field studies would be needed to predict the spatial spread of non-native invasive insects and any introduced natural enemies.

Accomplishments for the next 5 years include:
1. Develop predictive models for SPB population levels in southern conifers.
2. Develop predictive models describing the movement and spread of invasive insects in southern forests.

Environmental consideration: Most of the research described here falls into the area of categorical exclusion (FSM 1950). For research involving the use of hazardous chemicals and toxic substances, environmental considerations will be evaluated within individual study plans, or by Environmental Assessments or Environmental Impact Statements prepared with and approved by appropriate staffs of the Forest Service.

11. Cooperation

The research objectives will be attained through cooperation with other RWU's in this and other stations, through universities, and through representatives of states, industry, and other federal agencies.

Close cooperation with Forest Health, especially with the Alexandria Field Office personnel, and with the National Forest System, Region 8 (again, especially with the local Kisatchie National Forest personnel), will be essential to timely completion of the research objectives.

Cooperation on research on biological and ecological interactions of bark beetles and invasive forest insects and their associated organisms may include: Dartmouth College, University of Wisconsin, University of Montana, Southern Research Station, Louisiana State University, Tom Harrington Iowa State University, Forest Products Lab, University of Kentucky, University of Georgia, University of Arkansas, and the Texas Forest Service.

Cooperation on research on bark beetles and invasive forest insects in intensive forestry may involve: North Carolina State University, Southern Research Station, Rich Goyer.

Cooperation on research on bark beetles and invasive forest insects at the urban-wildland interface may involve: Southern University, Virginia Tech University, North Carolina State University, Forest Health.

Cooperation on research on fire and interactions between trees, bark beetles and invasive forest insects may involve: Louisiana State University, Florida Division of Forestry, Southern Research Station.

Cooperation on development of novel control methods for bark beetles and invasive insects of southern forests may involve: USDA Agricultural Research Service, University of Montana, Dartmouth College, University of Wisconsin, University of Minnesota, University of Georgia, Louisiana State University, Tree Injection Products, Mauget Inc., Forest Health, Forest Health, Southern Research Station, North Carolina State University, Pacific Southwest Research Station, Pacific Northwest Research Station, , Forest Health.

Cooperation on development of landscape level predictive models as tools for management of bark beetles and invasive insects of southern forests may involve: Virginia Tech University, University of Connecticut, Texas Forest Service, Forest Health.

12. Staffing

	Problem 1.	**Problem 2.**
SY		
Klepzig	0.8	0.2
Vacant	0.4	0.6
Strom	0.4	0.6
Sullivan	0.6	0.4
TOTAL	2.2	1.8

Problem #	**Scientist Year per year of the RWUD**				
	1	2	3	4	5
1	2.2	2.2	2.2	2.2	2.2
2	1.8	1.8	1.8	1.8	1.8
Total	4.0	4.0	4.0	4.0	4.0

13. Economic Assessment

Problem #	**Projected Costs/ Year (in $1,000)**				
	1	2	3	4	5
1	550	550	550	550	550
2	450	450	450	450	450
Total	1,000	1,000	1,000	1,000	1,000

References

Pimentel, D., L. Lach, R. Zuniga and D. Morrison. 2000. Environmenal and Economic Costs of Non-indigenous Species in the United States. BioSciences 50: 53-65.

Mattson, W.J., Niemela, I. Millers and Y. Inguanzo. 1994. Immigrant phytophagous insects on woody plants in the United States and Canada; an annotated list. USDA Forest Service, North Central Forest Experiment Station, General Technical Report NC-169. 27 p.