Special Technology Development Program
New Project Proposal

PROJECT NUMBER: R6-2002-04

PROJECT TITLE: Improving methods and cost efficiency for detecting exotic wood-boring ambrosia beetles.

PROJECT STATUS: New

EXPECTED PROJECT DURATION: 2 years

EXPECTED COMPLETION DATE OF THE PROJECT: FY04

SUBJECT:

1. Total Suppression/Prevention Technology	%		2. Survey and Monitoring Technology	**100%**	
a. Total Biological Control i. Microbial % ii. Parasitoides % iii. Synthetic hormones/pheromones % iv. Other %		%	a. Advancements in Detection Technology		100%
			b. Landscape Level Assessment Technology i. Data Visualization		%
b. Total Modeling i. Pesticide (Insecticide) Application % ii. Disturbance % iii. Growth and Yield % iv. Organism % v. Population % vi. Terrain %		%	c. Remote Sensing i. Aerial % ii. Hyperspectral % iii. Satellite %		%
			d. Other		%
c. Genetic, Cultural and Silvicultural Innovations For Controlling Pest Species i. Fire % ii. Methyl Bromide Alternatives % iii. Thinning/Regeneration Techniques and other Silvicultural Guidelines % iv. Resistance, Screening, and Breeding %		%	3. Assessment Technology	%	
			a. GIS % b. Spatial Analysis % c. Landscape Analysis % d. Decision Support % Risk and Hazard % Expert Systems %		
d. Pesticide Application (Spray) Technology i. Equipment innovations % ii. Methods and Guidelines %		%	4. Social Values	%	
			5. Technology Transfer Innovations	%	
e. Other		%	6. Other	%	

STATUS OF SUBJECT SPECIES: non-native invasives

PROJECT OBJECTIVES:

1. Assess the efficacy of trap design and lure release rates for the detection of exotic wood-boring ambrosia beetles. Attainment of this objective will result in a) a trap type being recommended for use at industrial sites considered at high risk for introductions, b) comparison of trap effectiveness between conifer and hardwood forests, leading to c) comparison of effectiveness of lure release rates in forests. Portions b and c within this Project Objective both contribute to development of the cost assessment addressed in Project Objective 2.

2. Compare costs of trapping methodologies and evaluate the trade-offs between trapping cost and efficacy. This objective will result in a trap type and lure release rate being recommended for use in forests.

3. Provide baseline information on the extent of invasion of exotic ambrosia beetles into native forests. These data are a direct by-product of work performed attaining Project Objectives 1 and 2. Although this objective does not lead to technology development per se, it does provide a framework upon which future technology development can be based. In particular, these data could be used to characterize interactive impacts of non-native insects with forest ecosystem structure and function.

BRIEF DESCRIPTION OF PROJECT:

FY 02: Four trap types will be compared within industrial sites, conifer forests and hardwood forests to determine the efficacy of trap design (measured by diversity and abundance of beetles collected).

FY 03: Using the trap most effective in FY02 (in terms of efficacy and cost), four lure type and release rate combinations will be compared within conifer and hardwood forest sites. A report of trap design comparisons with recommendations for trap use at industrial sites will be prepared.

FY 04: A final report will be prepared summarizing all trapping data, providing a cost assessment of trapping methodology, and making recommendations for trapping in native forests.

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FHP LEAD INVOLVEMENT:

Name	Role	Time Commitment
Dave Bridgwater	FHP coordination	2 wks/yr

PRINCIPAL INVESTIGATORS:

Name	Affiliation (Office or Dept.)	Phone, E-mail, Fax
Christine Niwa	PNW Research Station, Corvallis, OR	541-750-7370, cniwa@fs.fed.us 541-758-7760
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PRINCIPAL INVESTIGATORS INVOLVEMENT:

Name	Role	Time Commitment
Christine Niwa	Project coordination	8 wks/yr
Robert Peck	Field and lab coordination	10 wks/yr
James LaBonte	Site selection and taxonomy	4 wks/yr

COOPERATORS:

Name	Affiliation (Office or Dept.)	Phone, E-mail, Fax
Kathleen Johnson	Oregon Dept. Agr., Salem, OR	503-986-4662, 503-986-4786 kjohnson@oda.state.or.us
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COOPERATOR INVOLVEMENT:

Name	Role	Time Commitment
Kathleen Johnson	Project coordination & consultation	2 wks/yr
Alan Mudge	Project coordination & consultation	2 wks/yr
Dave Overhulser	Consult & advise, site selection	2 wks/yr

JUSTIFICATION: Ambrosia beetles are important pests of both coniferous and hardwood trees. Damage to live trees or lumber from exotic ambrosia beetles is a concern nationwide. Recent work in the Pacific Northwest highlights both the prevalence of established exotic species and the concern for the introduction of new species. During 1999-2000, 80% of scolytid beetles trapped at 17 high-risk industrial sites in western Oregon were exotic ambrosia beetles (Mudge et al. 2001, Oregon Dept. Agriculture unpubl. data). Of these exotics, *Xyloborinus alni* is new to North America, *Xyleborus pfeili* is new to western North America, and *Xylosandrus germanus* and *Xylosandrus crassiusculus* were detected for the first time in Oregon. These species are known to attack a variety of coniferous and hardwood trees.

The success of a detection program is influenced by both trap effectiveness (number and diversity of beetles captured) and intensity (number of traps used). Often, a detection program must consider tradeoffs between these aspects of trapping success. For monitoring in sites that are at high risk of introduction (e.g. ports, mills, wood recycling centers), are generally small in size, and require relatively few traps, maximum trap effectiveness generally outweighs costs associated with trap intensity. In contrast, programs aimed to detect exotic beetles in the forested landscape require many more traps to be placed over a much larger area. Trap efficiency is still important in this program, but trapping costs may directly influence detection success by limiting the number of traps that can be used. Costs for both traps and lures can differ considerably, with standard combinations ranging from $15 to nearly $50. Although existing methodologies used to detect ambrosia beetles appear to be productive, abundant data suggest that trapping efficiency, in terms of both effectiveness and cost, can be greatly improved.

The proposed work will strengthen FHP program delivery by increasing the ability to detect a wide variety of exotic species of ambrosia beetles. The work will be accomplished by 1) increasing the ability to detect exotic ambrosia beetles at industrial sites considered to be at high risk of introduction and in native conifer and hardwood forest habitats, and 2) testing the efficacy of trapping methods that range widely in price to provide a cost assessement important to developing detection programs in forests. Identifying traps that will detect a wide variety of beetles is important because although certain 'target species' are of concern, it is often difficult to determine which exotic species will become important new pests. It is also important to assess trap efficacy and cost in both conifer and hardwood forests as exotics may find hosts in both forest types. Finally, this work will provide unique baseline data describing the extent of invasion of exotic ambrosia beetles into forests within western Oregon. This is important in that it can facilitate future work that would allow interactive impacts of native and non-native insects to be determined (STDP technical committee refined area of emphasis).

URGENCY: Exotic ambrosia beetles present a serious threat to forest integrity, production and health. Recent detection trapping by the Oregon Dept. Agriculture (ODA) and other agencies has demonstrated both intra- and intercontinental establishments of numerous wood-boring insects. Both the lack of rigorous trade regulations in the past, and the likely increase in world trade in the future, contribute to the probability of continued detection, introduction and establishment of exotic insects. Because it is not known which species have or will become established, it is not possible to predict the future impact of these organisms. Damage, from a variety of species (e.g. *X. crassiusculus* on hardwoods), is potentially extensive. To date, detection trapping has mostly been restricted to a relatively small number of industrial sites considered to be at high risk for new introductions. Little trapping of ambrosia beetles has taken place in forest habitats; thus the extent of establishment is poorly known. Improving trapping methods and cost efficiency will advance our ability to detect new exotic species, contribute to determining the extent to which they have colonized forest habitats, and allow us to begin to understand their impact on ecosystem structure and function.

NATIONAL FHP TECHNOLOGY DEVELOPMENT PRIORITY: Priority 4: _X_

The proposed work will directly address Priority 4 by improving the technology available to detect exotic ambrosia beetles at industrial sites and in forested habitats. Improving trapping efficacy at industrial sites will accelerate our ability to identify newly established populations, possibly leading to eradication or effective control measures. Improving cost efficiency will result in more cost-effective landscape-level survey techniques that can help delimit distributions and determine the extent to which these beetles are established in forests.

TECHNICAL COMMITTEE DEVELOPMENT PRIORITY: Priority 4: _X_
The proposed work addresses Priority 4 by providing baseline data that can be used to characterize interactive impacts of exotic and native ambrosia beetles on forest ecosystem structure and function. Once established exotic populations have been identified, ecosystem studies that identify impact of these species can be developed and employed.

SCOPE OF APPLICATION: This project aims to develop standardized techniques and recommendations that are widely applicable and long lasting. Since industrial sites at risk of introduction are generally similar across the country, improving trap effectiveness can have immediate and wide-ranging applicability. Comparison of trap efficacy to cost within both conifer and hardwood forests is intended to extend the breadth of inference to include the widest variety of species and forest types as possible, also benefiting efforts nationwide.

RESEARCH BASIS: Trapping methodology can differ significantly in terms of both effectiveness and cost. For example, Flechtmann et al. (2000) showed that trap size and shape (which likely mimics the profile of a tree) greatly affected the number and type of ambrosia beetles collected and that a small, relatively inexpensive trap, performed as well as larger, more expensive traps for some species. Similarly, lure type and release rate (e.g. Borden et al. 1982, Schroeder and Lindelow 1989, Byers 1992, Flechtmann et al. 1999) can influence capture rates. For many species of ambrosia beetles, ethanol and alpha-pinene (both tree volatiles), alone and in combination, are effective attractants. Ethanol appears to be a critical component for both hard- and soft-wood feeders while alpha-pinene combined with ethanol is important for many conifer feeders. A wide range of release rates have been studied, but rates between 0.5 to 1.0 gm/day are most commonly used. Type of lure and release rate determine operational costs. While fewer beetles may be attracted to a lower release rate, it is possible that lower costs may outweigh a minor reduction in trapping effectiveness.

During 1997-2000, the ODA used 12-unit multi-funnel traps baited with ethanol and alpha-pinene (alone and in combination; a 1 gm/day release rate for each lure) to survey exotic ambrosia beetles and other woodboring insects. This work resulted in the capture of over 20,000 ambrosia beetles representing 11 species. Exotic species collected include those long-established as well those previously unreported from North America. This combination of trap type and lure release rate represents the standard used by ODA in their current and proposed surveys, as well as the recently established Rapid Detection Pilot Test Protocol project (APHIS and USFS). While it appears to be an effective trap/lure combination, it is also relatively expensive to implement; it is the most expensive combination that will be tested. Other combinations will be evaluated against this benchmark.

METHODS: The experimental design will follow the approach developed over the past 30 years for testing trap and lure efficacy. During the first year (FY02), four trap types, representing a range of shapes, surface areas and costs, will be compared. In western Oregon, traps will be placed in industrial sites considered to be at high risk for introductions and in conifer- and hardwood-dominated forests also likely to contain exotic species. Ten replicates of each site type will be selected for trapping. Trap types will include: 12-unit multi-funnel trap (Lindgren trap); panel trap (IPM Technologies); German style slot trap (Theyson trap); and Brazilian style panel trap (similar to a Japanese beetle trap). All traps will be baited with high release rate ethanol and alpha-pinene (1.0 gm/day for each). Differences among designs will allow trap efficacy to be compared to costs. Traps can be purchased from manufacturers or easily constructed from available materials. Traps will be monitored bi-weekly for 20 consecutive weeks, approximately March through July (encompassing known peaks of ambrosia beetle activity in western Oregon). Analysis of the data will provide a better understanding of the phenology of individual species, further increasing trapping efficiency by identifying best times to place traps in the field. All ambrosia beetles will be identified to species level.

During the second year (FY03), cost effectiveness will be further assessed by comparing a selected trap type with lures that vary in combination, release rate, and cost. Lures tested will include: high ethanol + high alpha-pinene (1.0 gm/day for each); high ethanol; moderate ethanol + moderate alpha-pinene (0.5 gm/day for each); moderate ethanol. The trap type identified in FY02 to be most effective in terms of cost and the number and diversity of ambrosia beetles captured, will be used. Lure comparisons will be made in 10 conifer- and 10 hardwood-dominated sites. Lures are commercially available from sources in the U.S. and Canada. Trapping again will take place between March and July.

A split-plot design (split within site type) will be used to test null hypotheses that no differences exit among trap type, lure combination and release rate, and site type. Beetle catches will be compared using PROC GLM (SAS Institute 1990). A significant interaction between trapping treatment and site type will suggest that site specific responses have occurred. Where significant differences exist, treatment means will be separated using Tukey tests.

While project objectives are to improve trapping methods and cost efficiency for exotic ambrosia beetles, the objectives can be met using both native and exotic species. Developing methods aimed at trapping a wide range of species is important because it is unknown which species (nearly a thousand species worldwide) are likely to become invasive. Comparison of trap efficacy using beetle diversity will consider native as well as newly- and long-established exotic species.

Quality assurance and control will be maintained in the following ways: ambrosia beetle identifications will be verified by taxonomic authorities and a voucher collection maintained at the USDA Forest Service, Western Forest Insect Collection (Oregon State University, Corvallis, OR); lure release rates will be measured during each trap period; statistical analyses will be supported by a professional statistician; and data and prepared outputs will be archived at PNW Research Station, Corvallis, OR.

MEASURES OF SUCCESS:

Standard of Success: The project will be successful if clear recommendations can be made based on trap efficacy and costs. The likelihood of success is high because the work is based on standard methods (for both traps and lures; ODA has successfully used these methods for the past 5 years) and ambrosia beetles are widespread and diverse. Project objectives can be met using both native and exotic ambrosia beetles.

Expected Outcomes: Differences in beetle abundance are expected among trap types and lure combinations due to differences in trap and lure effectiveness. However, it is unknown whether differences in the diversity of beetles captured, or in trap effectiveness between forest types, will be found. Based on differences in trap efficacy and cost, trapping recommendations are expected to be able to be made.

Implementation of Products/Methods: If results are significant, acceptance should be high because methods tested are modifications of existing protocols. Implementation can be easily made because traps are available directly from manufacturers or are easily constructed, and lures can be purchased from suppliers.

PRODUCTS AND DUE DATES:

FY03: Report of trap design comparisons with recommendations for trap use at high risk, industrial sites and forests.

FY04: Final report of lure release rate comparison and trapping cost assessment with recommendations for trapping in native forests.

PUBLICATIONS: Results will be published in peer-reviewed journals and in the form of a General Technical Report.

TECHNOLOGY TRANSFER: This work is primarily targeted toward 1) state and federal agencies responsible for surveying for exotic beetles at sites at risk for introduction; and 2) private, state and federal woodland resource managers. Technology will be transferred via peer-reviewed journal articles, a General Technical Report, and presentations at regional and national meetings and workshops.

PRODUCT LEVERAGING: This project continues a long line of advances in the detection of ambrosia beetles. It is unique in that it compares cost effectiveness with multiple trap designs, lure combinations and trapping sites. It also stands out in that it aims to recommend trapping methods effective at the landscape-level. In both time and method, this work compliments the Rapid Detection Pilot Test Protocol project initiated nationwide in 2001. This project supports and builds upon the ODA's efforts to monitor exotic wood boring insects conducted since 1997. In addition to examining ambrosia beetles, specimens of other wood boring insects collected during the survey will be shared with the ODA to determine the response of these taxa to the trapping strategies. Improved trapping methodologies for ambrosia beetles and other wood-boring insects in coniferous and deciduous forest support the Forest Health Monitoring program.

LONG-TERM BUDGET REQUEST: (PNW=PNW Res. Sta.; ODA=Oregon Dept. Agr.)

	Item	**Requested FHP STDP Funding**	**Other-Source Funding**	**Source**
FY 2002				
Administration	Salary	23,975	11,168/10,000	PNW/ODA
	Overhead	2,938	14,544/3,832	PNW/ODA
	Travel	1,362	0	

Procurements	Contracting	0	0	
	Equipment	2,598	2,953	PNW
	Supplies	5,305	900	ODA
YEAR TOTALS		36,178	28,665/14,732	PNW/ODA

FY 2003				
Administration	Salary	25,116	11,616/10,300	PNW/ODA
	Overhead	2,969	15,126/3,985	PNW/ODA
	Travel	1,416	0	
Procurements	Contracting	0	0	
	Equipment	1,846	2,953	PNW
	Supplies	2,498	936	ODA
YEAR TOTALS		33,845	29,695/15,221	PNW/ODA
PROJECT TOTALS		70,022	58,360/29,953	PNW/ODA

LONG-TERM BUDGET REQUEST EXPLANATION: Two years of fieldwork are required to complete this project; work during the second year builds upon that completed the first year. A final report will be produced during the third year (FY04; no funds are requested for that year).

BENEFITS:

1. Improved trapping effectiveness at high-risk, industrial sites will enhance our ability to detect populations of exotic ambrosia beetles at the earliest time possible. Early detection may lead to eradication or effective control measures.
2. Forest type and landscape-level trapping recommendations, based on cost and trap effectiveness, will lead to effective trapping programs designed to determine the extent to which exotic ambrosia beetles have become established in native forests. Further work can then aim to understand their effect on ecosystem structure and function.

LITERATURE CITED:

Borden, J. H., C. J. King, S. Lindgren, L. Chong, D. R. Gray, A. C. Oehlschlager, K. N. Slessor, and H. D. Pierce, Jr. 1982. Variation in response of *Trypodendron lineatum* from two continents to semiochemicals and trap form. Environ. Ent. 11: 403-408.

Byers, J. A. 1992. Attraction of bark beetles, *Tomicus piniperda*, *Hylurgops palliatus*, and *Trypodendron domesticum* and other insects to short-chain alcohols and monotermenes. J. Chem. Ecol. 18: 2385-2402.

Flechtmann, C. A. H., M. J. Dalusky, and C. W. Berisford. 1999. Bark and ambrosia beetle (Coleoptera: Scolytidae) responses to volatiles from aging loblolly pine billets. Environ. Ent. 28:638-648.

Flechtmann, C. A. H., A. L. T. Ottati, and C. W. Berisford. 2000. Comparison of four trap types for ambrosia beetles (Coleoptera, Scolytidae) in Brazilian Eucalyptus stands. J. Econ. Ent. 93:1701-1707.

Mudge, A. D., J. R. LaBonte, K. J. R. Johnson, and E. H. LaGasa. 2001 (in press). Exotic woodboring Coleoptera (Micromalthidae, Scolytidae) and Hymenoptera (Xiphydriidae) new to Oregon and Washington. Proc. Entomol. Soc. Wash.

Schroeder, L. M. and A. Lindelow. 1989. Attraction of scolytids and associated beetles by different absolute amounts and proportions of a-pinene and ethanol. J. Chem. Ecol. 15:807-817.