Special Technology Development Program
New Project Proposal

PROJECT NUMBER: R1-2001-03

PROJECT TITLE: Landscape level assessment of Douglas-fir beetle outbreaks and development of a monitoring system for predicting local population trends.

PROJECT STATUS: New

EXPECTED PROJECT DURATION: 3 years

EXPECTED COMPLETION DATE OF THE PROJECT: 2003

SUBJECT: Biological Control___ Invasive Species___ Methyl Bromide Alternatives___ Models_1_ Monitoring _1_ Organism Biology _2_ Pesticides: Microbial ___ Pesticides: Synthetic___ PTIPS___ Population _1_ Risk and Hazard_1_ Remote Sensing___ Semiochemicals___ Silvicultural Technology___ Social Values___ Spray Technology___
Other_____

STATUS OF SUBJECT SPECIES: Native

PROJECT OBJECTIVES: The primary objective of this study is to determine the spatial relationship among Douglas-fir beetle (DFB) infestations from year to year at the landscape level and how these infestations interact with stand conditions and hazard classifications. This information will be useful for a variety of purposes including refining existing hazard/risk rating systems, developing efficient ground-based sampling procedures, and designing mass-trapping and other management programs. In addition, we intend to develop a method for monitoring and forecasting current and future year Douglas-fir beetle population trends using pheromone-baited traps.

BRIEF DESCRIPTION OF PROJECT: This study will be conducted primarily in northern Idaho and Montana, although other regions may be included. Specific areas will be dependent upon the availability of aerial sketch maps corresponding to past Douglas-fir beetle outbreaks. There will be two components of the proposed project. First, existing aerial sketch maps will be used in a landscape analysis of Douglas-fir beetle outbreaks. Aerial sketch maps will be reviewed to identify areas for further analysis that experienced Douglas-fir beetle outbreaks in the past. If the sketch maps covering the study areas have not been digitized, then this will be completed as the first step of the analysis. From these maps, the progression of an outbreak can be followed through the course of several years. Spatial relationships will be analyzed to describe patterns of DFB population spread over time. Of particular interest will be the spatial relationships among attacked trees from year to year (i.e., generation to generation) such as average distances between beetle-killed spots in subsequent years of an outbreak, or the probability of beetle attacks occuring at various distances from previous year attacks. This data can then be overlaid onto Douglas-fir beetle hazard maps of the same areas to determine any relationships between stand hazard and beetle dispersal patterns. Specifically, we will determine if the spatial dynamics of Douglas-fir beetle outbreaks vary in high, moderate, and low hazard stands.

The second component of the study will focus on Douglas-fir beetle population estimates. Using pheromone-baited traps, we intend to develop a method for monitoring and predicting DFB population trends. Areas with and without active DFB outbreaks will be monitored with pheromone-baited traps. Numbers of DFB caught in traps over a season will be correlated with tree mortality in the areas determined from aerial sketch maps. Areas will be sampled for three years to assess the relationships among beetle trap catches and tree mortality.

FHP LEAD CONTACT (FHP person submitting proposal)**:**

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COOPERATORS:

Name	Affiliation (Office or Dept.)	Phone, E-mail, Fax
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We also anticipate a number of cooperators from National Forests in Idaho and Montana. Several people from the Nez Perce National Forest have already indicated a willingness to participate in the study, but all of the specific cooperators have not been positively identified.

COOPERATOR INVOLVEMENT:

Name	Role	Time Commitment
Kevin Dodds	Graduate Student, Data acquisition and analysis	6 months/year

JUSTIFICATION: The Douglas-fir beetle is a pest species of Douglas-fir throughout the western U.S. Beetle outbreaks cause significant impacts to a variety of resource values including recreational opportunities, watershed properties, wildlife and fish habitats, and timber. Developing effective resource management programs requires not only understanding the factors that initiate outbreaks, but also the spatial dynamics of outbreaks. Knowledge of the relationships among current and next years attacks would allow managers to better predict Douglas-fir beetle risk, more efficiently sample for currently attacked trees, and design more effective management programs. Managers need methods to predict Douglas-fir beetle population trends and occurrence of tree mortality at the landscape-scale.

URGENCY: Local DFB populations often build to epidemic levels following major forest disturbances that result in a high concentration of dead or injured trees. In the past several years, windstorms led to DFB outbreaks in Washington, Idaho, and Oregon. During the summer of 2000, many areas in the western U.S. suffered an unusually severe wildfire season. Fire or heat damaged trees are susceptible to DFB attack. In addition to the current DFB outbreaks, some fire-damaged timber is likely to become infested by DFB. Areas within or adjacent to wildfires could become epicenters of new outbreaks. To aid in the management of this potential problem, an understanding of spatial relationships of DFB infestations and the association to landscape level hazard assessments is needed. Understanding the spatial relationships of DFB outbreaks will allow prioritization of infested areas for management treatments and provide additional input for stand hazard/risk rating.

Presently, there is no technique to forecast current year DFB population levels. Aerial surveys provide estimates of beetle activity, based on crown symptoms of dead trees. Since it usually takes a year for the crowns of attacked trees to fade and become detectable from the air, these surveys actually estimate the previous years' beetle population. Consequently, a method for determining current year beetle populations would aid managers in their effort to reduce tree mortality caused by DFB and focus management actions in high priority areas. A relatively inexpensive, easily deployed, non labor-intensive, and reliable technique for monitoring population levels of DFB is needed. Pheromone-baited traps are effective at capturing large numbers of DFB as well as being relatively inexpensive and easily deployed. Data collected from pheromone-baited traps could possibly provide a reliable technique for forecasting local DFB population levels. An operational technique for estimating current year DFB populations would help managers to assess the need for immediate management actions.

NATIONAL FHP TECHNOLOGY DEVELOPMENT PRIORITY:

Priority 1: __ Priority 2: __ Priority 3: _X_ Priority 4: __

TECHNICAL COMMITTEE DEVELOPMENT PRIORITY:

Priority 1: __ Priority 2: __ Priority 3: _X_ Priority 4: __

Priority 5: __ Priority 6: __ Priority 7: __ Priority 8: __

SCOPE OF APPLICATION: Results of this research will be applicable throughout the range of the Douglas-fir beetle in the western U.S east of the Cascade Range.

RESEARCH BASIS (strength of research basis, including publication citations)**:** Little is currently known about the relationship between dispersal and host selection by DFB. Beetles are capable of extended flights of at least 7 miles and can cover up to 15-20 miles a day (Atkins, 1961). However, the extent to which beetles disperse long distances or colonize trees close to their emergence points is poorly understood. It is likely that this may be, in part, a function of stand conditions and the availability of nearby susceptible trees for colonization. Forest stand characteristics including density, mean tree age, mean tree size and proportion of Douglas-fir have been directly correlated with DFB attacks and have been incorporated into stand hazard assesments (Furniss et al., 1980). While stand conditions have been the focus of hazard classifications, DFB dispersal behavior has not been incorporated into these models. Studying bark beetle movements over large spatial scales is difficult. However, the use of historical data in conjunction with statistical procedures which analyze population growth patterns provides an opportunity to study the net effect of beetle dispersal. Knowledge of the spatial relationship among bark beetle infestations from year to year and how they relate to stand hazard conditions could provide important new information to aid land owners in policy formulation and management decisions.

To successfully manage destructive insect species, a method for monitoring and estimating population trends is essential. Currently, methods used to determine local population trends are laborious and may not adequately describe actual beetle population levels. Negron et al. (2000) developed a sequential sampling procedure for monitoring local beetle populations, however, their plan involves removing and evaluating bark samples which can be very time consuming and labor intensive. Outbreaks often occur over large areas with limited access making collection of an adequate number of bark samples to describe population trends impractical. In the western U.S., DFB-killed trees are not detectable by aerial surveys until the year after they were attacked. Because of this, the use of aerial surveys to predict DFB population trends is a year behind and does not provide information on current year population levels. A survey method is needed that will provide estimates of beetle populations and ultimately give projections of current year beetle-caused tree mortality. In the southern U.S., population trends of *Dendroctonus frontalis* (southern pine beetle) have been monitored region-wide using pheromone-baited traps for over 20 years (Billings, 1988). The relative numbers of *D. frontalis* and a predator, *Thanasimus dubius*, are used to predict beetle activity for the remainder of the season. Likely, a similar method could be developed to monitor DFB activity in the western US. Preliminary data from five years of DFB catches in pheromone-baited traps at a site in the Oregon Coast Range suggests that it is possible to monitor and forecast beetle populations and the effects of management activities on those populations over large areas with a small number of traps (DWR unpublished).

METHODS: The two objectives that will be addressed by this project are:

1. On a landscape scale, what is the spatial relationship among Douglas-fir beetle infestations from year to year (i.e., generation to generation) and does this relationship vary with stand hazard?
2. Can Douglas-fir beetle-caused tree mortality be accurately predicted from pheromone-baited trap catches?

The data that will be used to address objective 1 will be obtained from historical aerial sketch maps on file at USDA Forest Service offices in the Pacific Northwest and northern Rocky Mountain states. These maps are generated annually from Forest Health Protection aerial surveys in cooperation with state agencies and attribute forest damage to various biotic and abiotic agents including insects and pathogens. While availability and consistency of aerial sketch maps will determine where we focus this study, we anticipate working throughout Regions 1, 4, and 6. Because we intend to analyze the spatial dynamics of infestations over several consecutive years, we will work in areas where there have been active Douglas-fir beetle infestations for at least three years. Statistical procedures based on epidemiological concepts will be used to determine the relationship among individual infestations (i.e., single trees or groups of attacked trees) from one year (beetle generation) to the

next. Specifically, a stratified diffusion model will be developed to analyze DFB population spread throughout an area. There are several types of stratified diffusion models that can be used to analyze movements of organisms. The scattered colony model (Shigesada and Kawasaki, 1997) is used to analyze populations of organisms that have individuals who extend their range into surrounding areas through random diffusion and also those who disperse large distances. This type of model fits the observed behavioral patterns of DFB. Typically, some DFB attack trees in the area adjacent to their brood trees, while other beetles disperse into the surrounding forest in search of host. The model produced will allow us to describe and quantify any patterns (e.g., aggregated, dispersed, uniform) of DFB activity from year to year. The information gained from the statistical analysis will be evaluated with regard to regional stand hazard classifications. Patterns of outbreak growth and beetle activity, in conjunction with stand hazard classifications, will be studied using GIS. The spatial relationships that are identified will be incorporated into existing hazard rating systems to increase their accuracy and reliability.

Objective 2 is a field study that will be conducted in northern Idaho or Montana. Six to nine areas of predominately host type stands will be selected for the study. Each area will encompass one or several adjacent, small- to medium-sized drainages that have had similar levels of DFB activity in the past year as determined from aerial sketch maps. These areas will be selected to cover a range of current and anticipated DFB population densities. In addition to aerial sketch maps, discussions with local land managers will be used to identify potential study areas. Ideally, 2-3 areas will be located where there has been little or no measurable tree mortality over the past 5 years, 2-3 areas will be located where DFB-caused tree mortality has been moderate, and 2-3 areas will be located where DFB-caused tree mortality has been high. A small number of widely dispersed pheromone-baited traps will be placed throughout each area. Trap lures will contain 50 mg of frontalin and 25 mg of seudenol in polyvinylchloride (PVC) formulations along with a 15 ml ethanol pouch. Pheromones formulated in PVC will be prepared in our lab and ethanol pouches will be purchased from Phero Tech, Inc., Delta, BC, Canada. The number of traps in each area will depend on the size of the area and accessibility of non-host type stands and openings, but will not exceed 12 traps. Beetles will be collected from traps every 1-2 weeks throughout the summer in each area. Trap samples will be processed to determine the numbers of DFB and *Thanasimus undatulus*, a common bark beetle predator attracted to DFB pheromone-baited traps, that are captured. The mean total number of DFB collected per trap and the ratio of DFB to *Thanasimus undatulus* will be calculated for each area. Tree mortality within each area will be determined from aerial sketch maps. However, this data will not be available until the year after trapping due to the delay in fading of infested tree crowns. Potential host type in the study areas, defined as stands containing greater than 30% Douglas-fir overstory with average diameter at breast height (dbh) > 14 inches will be determined from inventory data. Tree mortality will be expessed per unit area of host type to account for differences in abundance of host type in the study areas. The relationships between both total DFB catches and percent DFB catches as independent variables and the total number of beetle-killed trees and the number of beetle-killed trees per unit area of host type as dependent variables will be evaluated through simple linear regression analyses.

MEASURES OF SUCCESS:

Standard of Success: 1) The spatial dynamics of Douglas-fir beetle outbreaks in relation to stand hazard conditions will be described and quantified. 2) The relationship between pheromone-baited trap catches and DFB-caused tree mortality at the landscape scale will be described and quantified.

Expected Outcomes: 1) The spatial relationships among DFB infested trees from generation to generation will be incorporated into existing hazard rating systems to improve their accuracy and reliability. 2) A model to estimate current year DFB-caused tree mortality from pheromone-baited trap catches will be developed.

Implementation of Products/methods: 1) Resource managers will use the refined hazard rating models to prioritize areas for management activities and to develop integrated programs to prevent beetle-caused losses. 2) Resource managers will use the pheromone monitoring system to anticipate current and next year DFB-caused tree mortality in landscape scale assessments.

PRODUCTS AND DUE DATES: Progress reports will be prepared at the end of FY2001 and FY2002. The final report including a revised hazard rating model and pheromone monitoring system will be prepared by the end of FY2003. A publication(s) reporting the results of this project will be submitted by January 2004.

PUBLICATIONS: Results of this research will be published in appropriate peer reviewed scientific journals such as *The Canadian Entomologist*, *Canadian Journal of Forest Research*, *Forest Science*, or *Environmental Entomology*. In addition, technical guides will be published to assist land managers in using the results of this project.

TECHNOLOGY TRANSFER: Results of this project will be reported annually to forest entomologists at the National Bark Beetle Steering Committee Meeting, Western Forest Insect Work Conference, and possibly the Entomological Society of America Annual Meeting. The project results will also be presented to local resource managers in the areas were the study is conducted in the hopes that they will be early adopters of the new technologies.

LONG-TERM BUDGET REQUEST:

	Item	Requested FHP STDP Funding	Other-Source Funding	Source
FIRST YEAR				
Administration	Salary			
	Overhead			
	Travel			
Procurements	Contracting	42,464		
	Equipment			
	Supplies			
Year Totals		42,464		
SECOND YEAR				
Administration	Salary			
	Overhead			
	Travel			
Procurements	Contracting	47,029		
	Equipment			
	Supplies			
Year Totals		47,029		

THIRD YEAR				
Administration	Salary			
	Overhead			
	Travel			
Procurements	Contracting	48,216		
	Equipment			
	Supplies			
Year Totals		48,216		
PROJECT TOTALS		137,709		

Funds budgeted for contracting will go to Oregon State University where the project will be conducted. These funds will be allocated as follows:

First Year

Salaries	
GRA (0.5 FTE), Ph. D. student	15,050
Student workers	2,500
Other Payroll Exp.	
GRA (1%)	150
Student workers (5%)	125
Travel	5,000
Supplies	5,000
Total Direct Costs	27,825
Indirect Costs (26%)	7,235
Tuition	7,404
TOTAL	42,464

Second Year

Salaries	
GRA (0.5 FTE), Ph. D. student	15,652
Student workers	7,000
Other Payroll Exp.	
GRA (1%)	156
Student workers (5%)	350
Travel	4,000
Supplies	4,000
Total Direct Costs	31,158
Indirect Costs (26%)	8101
Tuition	7,770
TOTAL	47,029

Third Year

Salaries	
GRA (0.5 FTE), Ph. D. student	16,278
Student workers	7,000
Other Payroll Exp.	
GRA (1%)	163
Student workers (5%)	350
Travel	4,000
Supplies	4,000
Total Direct Costs	31,791
Indirect Costs (26%)	8,266
Tuition	8,159
TOTAL	48,216

BENEFIT AND COST:

STDP PRODUCTION FUNCTION

PROJECT NUMBER: R1-2001-03

PROJECT COST: $137,708

PROJECT OBJECTIVE (BRIEF DESCRIPTION OF THE PROJECT AND EXPECTED OUTCOME):

The primary objective of this project is to develop a risk rating system for the Douglas-fir beetle that incorporates existing hazard rating systems plus knowledge of the spatial dynamics of outbreaks at the landscape scale. A secondary objective is to develop a pheromone-based monitoring system to predict current year beetle-caused tree mortality from trap catches. The benefit of this project used in the economic analysis is to increase timber volume at harvest. Other benefits not quantified include protection of wildlife and fish habitats, watershed health, biodiversity, cultural resources, scenic quality of the landscape, and other social, cultural, and ecological values. All of the following calculations are based on the value of lumber in trees killed by the Douglas-fir beetle with and without the hazard rating and monitoring systems. However, the Douglas-fir beetle infests the larger and more mature trees in the forest. In many cases, these trees are far more valuable for social, cultural, and ecological values than they are for lumber at the present time. Therefore, all of our calculations actually underestimate the value of resources that are saved as a result of this STDP.

ASSUMPTIONS:

- The risk rating and monitoring systems developed by this project will lead to better resource management planning, prescription, and treatments resulting in forests with larger components of mature Douglas-fir trees in healthy condition than would be present without the systems.
- Implementation of the risk rating and monitoring systems will improve application of silvicultural and pheromone-based management strategies for the Douglas-fir beetle resulting in a 5% reduction in annual tree mortality.
- This technology will be fully implemented in 4 years, the year after the project ends.
- Benefits from implementing the project will not begin to accrue until the year following implementation.

BACKGROUND DATA:

- Based on FHP reports of "Forest Insect and Disease Conditions in the United States" for 1995-1998 and severity of wildfires in the interior PNW during summer 2000, we predict average annual Douglas-fir beetle-caused mortality of 150,000 mature trees for the next 10 years.
- Estimated volume loss per year is 75 mmbf
- The current value of Douglas-fir timber is estimated to be $425/mbf.

CALCULATIONS

EXPENDITURE & OUTPUT VALUES (EOV) WITHOUT PROJECT:

We will not perform this calculation or the next. Instead we will calculate under the heading "Benefit Attributable to Project" the value of the increase in timber production that will occur with the project. This is equivalent to calculating the EOV With Project – EOV Without Project. In other words, we will calculate the value of the increased timber produced as a result of the project.

EXPENDITURE & OUTPUT VALUES (EOV) WITH PROJECT:

See comments above.

BENEFIT (CHANGE IN EOV) ATTRIBUTABLE TO PROJECT:

Annual timber loss * percent reduction in loss with project * timber value

75 mmbf * (0.05) * $425/mbf = $1,593,750

Benefit over a 10 year period starting 5 years from now discounted at 4% = $11,049,980

BENEFIT/COST RATIO:

$11,049,980/$137,708 = 80.24

BENEFIT ATTRIBUTABLE TO STDP:

$137,708 * 80.24 = $11,049,980

PNV OF PROJECT:

$11,049,980 - $132,262 = $10,917,718

PNV OF STDP:

$11,049,980 - $132,262 = $10,917,718

LITERATURE CITATIONS:

Atkins, M.D. 1961. A study of the flight of the Douglas-fir beetle *Dendroctonus pseudotsugae* Hopk., (Coleoptera: Scolytidae). III Flight capacity. The Canadian Entomologist. 93: 467-474.

Billings, R.F. 1988. Forecasting southern pine beetle infestations trends with pheromone traps, pp. 295-306. *In* T. L. Payne and H. Saarenmaa (eds.), Intergrated Control of Scolytid Bark Beetles, Proceedings of the IUFRO Working Party and XVII International Congress of Entomology Symposium, Vacouver, B.C., Canada, July 4, 1988.

Furniss, M.M., R.L. Livingston, and M.D. McGregor. 1980. Development of a stand susceptibility classification for Douglas-fir beetle, pp. 115-128. *In* R.L. Hedden, S.J. Barras, J.E. Coster (tech. coords.), Hazard-rating Systems in Insect Pest Management, Symposium Proceedings, Athens, Georgia, July 31-August 1, 1980.

Negrón, J.F., W.C. Schaupp, and E. Johnson. Development and validation of a fixed-precision sequential sampling plan for estimating brood adult density of *Dendroctonus pseudotsugae* (Coleoptera: Scolytidae). The Canadian Entomologist. 132: 119-133.

Shigesada, N. and K. Kawasaki. 1997. Biological invasions: theory and practice. Oxford University Press, Oxford. 205 pp.